

A MAGYAR TUDOMÁNYOS AKADÉMIA
TIHANYI BIOLÓGIAI KUTATÓINTÉZETÉNEK ÉVKÖNYVE
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Szerkesztő:

S.-Rózsa Katalin

CONTRIBUTIONS TO THE MECHANISM OF ACTIVATING LIGHT CATION EFFECT ON GLOCHIDIA

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Adductor response of mussel larva (*Anodonta-glochidium*) was observed in the presence of alkali and alkaline earth metal ions. Previously, we (LÁBOS and SALÁNKI 1963) reported about the K^+ ion evoking an extremely long lasting rhythmic activity and have shown some features of Na^+ , Li^+ , Cs^+ , Rb^+ , Ca^{2+} and Mg^{2+} -e effects, too. Furthermore, the difference between K^+ - and tryptamine-responses in the susceptibility to cholinotropic pharmacons and SH-inhibitors also was pointed out (LÁBOS and his co-workers 1964a, 1964b).

In the present paper we attempt to answer some of the problems of K^+ -effect from a pharmacological aspect. Mainly the tonic response of larvae was examined. We focussed our attention on the following questions:

1. activity-sequence of ions and its changes,
2. ion-antagonisms and synergisms,
3. metabolic inhibitors and ion-effect,
4. heavy water isotope-effect.

Method and materials

In groups of mussel-larvae rhythmic contractions were counted and the number of closed glochidia was noted by a method described previously (LÁBOS and SALÁNKI 1963). In general, observations were compared originating from experiments with at least 100—100 glochidia. As different measures of effects the number of contractions accomplished by 100 larvae in 1 or 10 minutes (a/min , Σa), the ratio of closed glochidia after the application of the agents with t minutes (c_t) were used.

The applied substances were: KCl, NaCl, $CaCl_2$, $MgCl_2$, RbCl (BDH), CsCl (Fluka), LiCl (BDH), $SrCl_2$ (Merck), ouabain (Ph. Hg. IV.), 2,4-dinitrophenol, (2,4-DNP; Reanal), 2,4-DNP-hydrazine (Reanal; 2,4-DNPH), NaF, KCN, NaN_3 (BDH), digitonin (BDH), cetylpyridine-bromide (EGYT) papaverin-HCl (Chinoïn), ethanol, parachloromercuri-benzoic acid (PCMB; Light), N-ethyl-maleimide (BDH; NEM), D_2O , NaSCN, veratrine-sulphate (Merck), histamine-diHCl (Light), guanidine- HCO_3 (Fluka), tryptamine-HCl (Fluka), serotonin-creatinine-sulphate (Fluka; 5-HT), dopamine-HCl (Fluka), d-tubocurarine-HCl (d-TC; Schuchardt), tetramethylammoniumiodide (BDH;

TMA), tetraethylammoniumchloride (BDH; TEAC), tetra-n-butylammonium-iodide (BDH; TnBA). Experiments were carried out on about 30,000 glochidia. The concentrations refer to the salts.

1. The order of activity of alkali metal ions

The sequence of the effect concerning the dose-effect curves of rhythmic activity (*Fig. 1*) is the following:

$$\text{Rb}^+ > \text{K}^+ > \text{Cs}^+ > \text{Li}^+ > \text{Na}^+$$

but the order concerning the peak-values and average of the mentioned curves is different:

$$\text{K}^+, \text{Cs}^+ > \text{Rb}^+ > \text{Li}^+, \text{Na}^+$$

The rhythmic activity was characterized by the amount of reversible contractions performed by a given duration (10 min). There is a maximum site on the dose-effect curves owing to the tonic closure occurring at high concentrations. The K^+ and Cs^+ curves are striking, but the curves of Rb^+ , Na^+ and Li^+ run through lower values.

The tonic closure was characterized by the ratio of closed animals in a given time after the application of a given concentration (1–100 mM). The activity-sequence mainly depends on these two factors. For low concentrations and short durations the

$$\text{Rb}^+ > \text{K}^+ > \text{Cs}^+, \text{Na}^+, \text{Li}$$

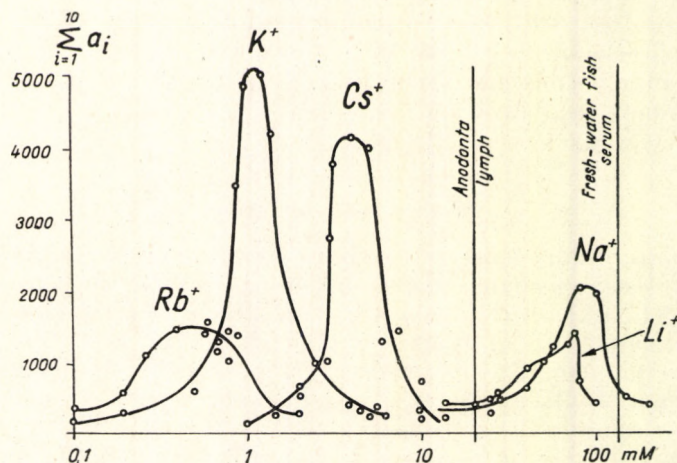
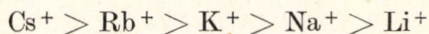


Fig. 1. Dose-effect curves of alkali metal ion chlorides. *Abscissa:* concentration in mM/lit. *Ordinate:* number of contractions of 100 animals in 10 min (each point represents result originating from observations on 100 animals). Vertical lines mark the osmotic pressure of *Anodonta* lymph and host-fish-blood. Populations from November

1. ábra. Dózishatás görbék alkáli fémkloridok jelenlétében. *Abszcissza:* koncentráció mM/lit-ben. *Ordináta:* a 10 perc alatt teljesített ritmikus kontrakciók száma 100 állatból álló csoportban (minden pont 100 állaton végzett megfigyelés eredménye). A függőleges vonalak az anyai limfa, ill. a gazdahalak vérének ozmotikus nyomását jelentik. Novemberi populációk

sequence is typical. At such conditions Na^+ and Li^+ do not cause contracture and for this reason the order cannot be demonstrated.

In solutions of higher concentrations of all the alkali metal ions and after a longer time a secondary relaxation is produced. The secondary attribute is used to distinguish from the relaxation following the phasic contractions. It is chiefly expressed in the case of Li^+ , then Na^+ , K^+ , Rb^+ , and Cs^+ in the following. The order observable in 50 mM solutions and after 120 min is partly the consequence of this fact:



The relation of Li^+ and Na^+ in the 70–100 mM range of concentrations firstly is $\text{Li}^+ > \text{Na}^+$, then it becomes reversed (*Fig. 2*). For this reason the curves of different ions cross each other whether the ratio of closed larvae is plotted against time or concentration. Thus, there are the following crosses: $\text{K}^+ - \text{Cs}^+$, $\text{Rb}^+ - \text{Cs}^+$, $\text{Na}^+ - \text{Li}^+$. The crosses can be observed at higher values of time and concentration carrying out measurements at increasing values of concentration and time, respectively. For example in an experiment in November the times of $\text{K}^+ - \text{Cs}^+$ inversion in 1–1.5–2 mM solutions are 46, 20 and 15 minutes. All inversions are not concerned to the secondary relaxation. In general after the critical time and concentration values the effect may

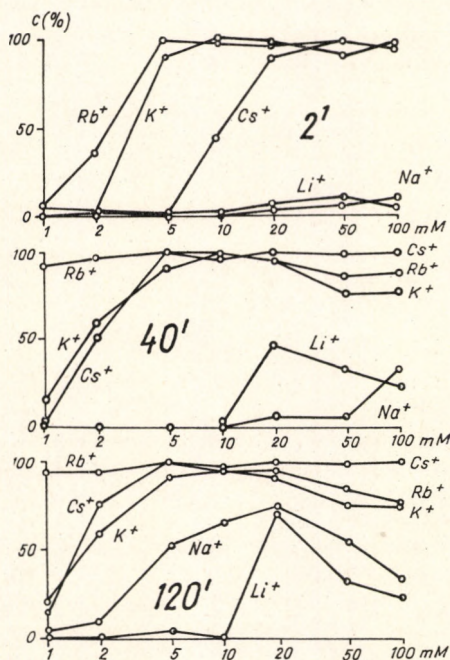


Fig. 2. Tonic effect of alkali chlorides. *Abscissa:* concentration in mM/lit. *Ordinate:* ratio of closed larvae after 2, 40 and 120 min of the salt application. Populations from April

2. ábra. Alkáli fémkloridok tónus-kiváltó hatása. *Abszcissza:* koncentráció mM/literben. *Ordináta:* tónusarány az anyag adását követő adott időpontokban (2, 40, 120 min). Áprilisi populációk

increase in the case of K^+ and Cs^+ . However, the $Rb^+ - Cs^+$ and $Na^+ - Li^+$ inversions are related to the secondary relaxation. The course of curves of tonus-ratio and the site of inversions is varying in different populations, which are discussed as concerned to the susceptibility changes.

Summarizing the observed sequences:

$$Rb^+ > K^+ > Cs^+ > Na^+, Li^+$$

$$Rb^+ > Cs^+ > K^+ > Na^+, Li^+$$

$$Cs^+ > Rb^+ > K^+ > Li^+ > Na^+$$

$$Cs^+ > Rb^+ > K^+ > Na^+ > Li^+$$

One can observe that the Li^+ and Cs^+ anomaly appear under different conditions.

2. The sequence of the effect of alkaline earth metal ions

The order of ability to evoke the rhythmic action among the alkaline earth metal ions is: $Ba^{2+} > Sr^{2+} > Mg^{2+} > Ca^{2+}$. The capacity to cause tonus has a different sequence: $Ba^{2+} > Sr^{2+} > Ca^{2+} > Mg^{2+}$. In 60 min 50 per cent of the total tonus can be achieved by 70 μM $BaCl_2$ (Fig. 4), 50 mM $SrCl_2$, 50 mM $CaCl_2$; for $MgCl_2$ this concentration is significantly higher than 100 mM. Tonus evoking capacity of Ca^{2+} and Sr^{2+} is very close to each other. Usually the two curves are intersected by each other (Fig. 3).

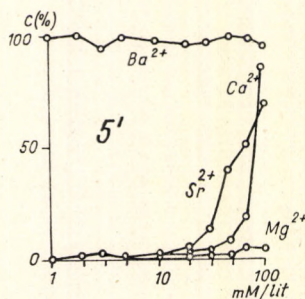


Fig. 3. Tonic effect of alkaline earth metal ions plotted against concentration; (c_s) values
3. ábra. Alkáli földfémionok tónuskiváltó hatásának (c_s) koncentrációfüggése

The initial activation described for $MgCl_2$ (LÁBOS and SALÁNKI 1963) was not observed in the case of $CaCl_2$, $SrCl_2$, $BaCl_2$. According to an experiment carried out on 100 animals 100 mM $MgCl_2$ caused an initial closure lasting for 46 ± 25 sec.

3. Antagonistic and synergetic effect of cations

The glochidia can adapt themselves to a wide range of osmotic pressure (fresh water 0.05 atm; maternal lymph 0.5 atm; serum of fishes 3.5 atm) and ionic composition of the medium. They are in closed state in the fish-blood,

but in opened state in the mussel lymph continuously. These facts give reason to examine the effect of ion-mixtures. The activator ion obtained from the K^+ , Rb^+ , Cs^+ Ba^{2+} group, the inhibitor is in the Na^+ , Li^+ , Mg^{2+} , Ba^{2+} group.

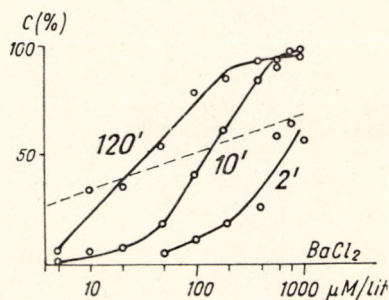


Fig. 4. Tonus-ratio in 5–1000 $\mu M/lit$ $BaCl_2$ after 2, 10 and 120 minutes. Abscissa: concentration in $\mu M/lit$. Ordinate: tonus-ratio in per cent. The effect of each concentration was observed on 100 animals

4. ábra. $BaCl_2$ 5–1000 $\mu M/lit$. koncentrációjának tónuskiváltó hatása az adást követő 2., 10. és 120. percen. Abszcissa: koncentráció $\mu M/lit$ -ben. Ordináta: tónusarány %-ban. Minden koncentráció hatását 100 állaton vizsgáltuk

3–1. K^+/Na^+ and related antagonisms

The contracture inhibiting effect of Na^+ and Li^+ may demonstrate in an experiment of 120 min if a not too concentrated KCl solution is used causing tonus alone, too. The effect depends on the ratio of counter-ion-concentrations and also on the absolute quantities. Thus at 53 mM $NaCl$ concentration the Na^+/K^+ ratio was changed between 0.1–1.8. The maximal relaxation was reached at $Na^+/K^+ = 0.76$. In such a case the effective range of Na^+ concentration is very closed.

In less concentrated KCl to achieve an approximately equal inhibition 10–25 mM $NaCl$ was needed. In such a case the Na^+/K^+ ratio must be above 10. Thus at conditions 3 mM KCl and $Na^+/K^+ = 2.2$ is not significant inhibition; in 2 mM KCl and at $Na^+/K^+ = 11.2$ the K^+ , Rb^+ and Cs^+ -tonus can be inhibited markedly (Fig. 5). The inhibitory effect of $NaCl$ has a transitional phase of 2–10 min, then the inhibition becomes constant.

At the same concentrations and ratios there is an order of counter-ion-pairs according to which the inhibition increases. Thus in the case of Fig. 5.

ion-pair	Rb^+/Na^+	Rb^+/Li^+	Cs^+/Na^+	Cs^+/Li^+	K^+/Li^+	K^+/Na^+
inhibition	6%	13%	42%	35%	45%	84%

3–2. K^+/Ca^{2+} and K^+/Mg^{2+} antagonism

Similarly to the previous cases the antagonism can be observed only if the inhibitor ion concentration is not too high and it will not take part in a synergism. The tonus evoked by KCl of 2 mM is half-inhibited in 1 min by 3–3.5 mM, in 120 min by 1–1.5 mM $CaCl_2$. The marked quickness of $CaCl_2$ -effect is remarkable. It is stronger than that of $NaCl$. Using 100–100

glochidia and 2 mM KCl then concentrations of CaCl_2 were applied. The inhibition is increasing along an S-shaped curve. The linear stretch of it can be approached. The percentage inhibition at 1 and 120 min can be expressed by the following regression-equations: $i_1 = 84 - 64 \lg [\text{Ca}^{2+}]$ and $i_{120} = 55 - 80 \lg [\text{Ca}^{2+}]$. The CaCl_2 concentration is given in mM/lit.

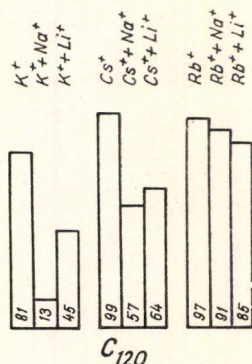


Fig. 5. Tonus-ratio values after 120 min. Each column represents observations on 100 animals. Concentrations: KCl, RbCl, CsCl 1.5 mM; NaCl 22.5 mM

5. ábra. Tónusarány a 120. percben. Minden oszlop 100 állat megfigyelése alapján készült. KCl, RbCl, CsCl 1,5 mM; NaCl 22,5 mM

At the same conditions 3–5 times higher concentrations are necessary from MgCl_2 than from CaCl_2 in order to obtain equal effect. The observation at the 120th minute shows that 5 mM MgCl_2 is equipotent with 1–1.5 mM CaCl_2 .

Summarizing the ion-ratios inhibiting half the 2 mM KCl-effect we get: $\text{Na}^+/\text{K}^+ = 6.8$; $\text{Ca}^{2+}/\text{K}^+ = 0.5-0.8$; $\text{Mg}^{2+}/\text{K}^+ = 2-3$.

3–3. Synergisms among the cations

Using some of the cation combinations in which ions with similar effect (K^+ , Rb^+ , Cs^+ , Ba^{2+}) are mixed appear real potentiations. However the similarity is only a necessary but is not a sufficient condition of the synergism.

In order to demonstrate the phenomena we applied concentrations of ineffective or of partial effect. The combinations of 20 μM BaCl_2 , 200 μM RbCl , 500 μM CsCl and 500 μM KCl were used. In the given populations these concentrations show nearly equal effect. The total equipotentia can be hardly realized, thus the conclusions are semiquantitative. The sum of the effect of different ions compared to the effect of combinations generally proved to be higher than 1:

Rb^+/Cs^+	K^+/Rb^+	K^+/Cs^+	$\text{K}^+/\text{Ba}^{2+}$	$\text{Ba}^{2+}/\text{Cs}^+$	$\text{Ba}^{2+}/\text{Rb}^+$
3.92	3.02	2.16	1.18	0.76	0.55

The effect is the average tonus-ratio at the first 120 min.

4. The action of metabolic inhibitors on the K^+ -tonus

20–25 $\mu\text{g/ml}$ ouabain, 2,4-DNP, 2,4-DNPH are not effective. NaF in 100 $\mu\text{g/ml}$ concentration has a small effect.

NaN_3 and KCN in suitable concentrations produce significant effect. The pure effect of KCN is disturbed in high concentrations mainly by the alkaline hydrolysis and not by the presence of K^+ . The application of buffer solutions also has a disturbing effect. Thus the KCN-action was evaluated only in low concentrations. 57–67 per cent contracture was produced in 1.5 mM KCl after 1–120 min. The development of the contracture was observed without and with 15–300 μM KCN (Fig. 6). It seemed to be typical for the KCN-effect

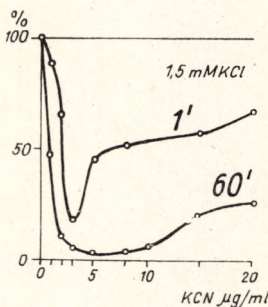


Fig. 6. KCN-effect. Abscissa: KCN-concentration. Ordinate: tonus-ratio expressed by per cent of cyanide-free control. Each concentration was tested on 100 animals

6. ábra. KCN-hatás. Abszcissza: KCN-koncentráció. Ordináta: tónusarány a CN^- mentes kontroll %-ában kifejezve. 100–100 állat koncentrációnként

that at 5 $\mu\text{g/ml}$ (75 $\mu\text{M/lit}$) concentration there is an almost total inhibition after 60 min. The inhibitory effect in lower and higher concentrations is the smallest; half inhibition is at 20 and 225 $\mu\text{M/lit}$ KCN. At low concentrations (15 μM KCN) sometimes an increase of tonus was observed. The KCN-effect is significant already in the 10th min, moreover, after 1–1.5 min develops a steady state. Thus 80–85 per cent steady state inhibition is produced by 45–120 $\mu\text{M/lit}$ KCN. At 2 mM KCl concentration only 40 per cent inhibition was observed. To clarify the significance of the KCl concentration a dose-effect curve of KCl was produced without and with 75 $\mu\text{M/KCN}$ between 0.5 and 2.5 mM KCl (Fig. 7). The curve is shifted by the KCN parallel to the direction of higher concentrations. The shift increases between 1 and 30 minutes. Simultaneously the parallelism of the curves grew worse.

Depending on the KCl and NaN_3 concentrations potentiation and inhibition of the KCl-effect could be observed (Fig. 8).

Applying 20–70 mM KCl concentrations which cause secondary relaxation 50–100 $\mu\text{g/ml}$ NaN_3 decreases this relaxation thus the level of the tonus was higher (110–270%) than in the control. This potentiated tonus was inhibited by 0.1 mM CdCl_2 even below that of the control.

The necessary condition of tonus-inhibition with NaN_3 is the sufficiently small KCl concentration. Thus the tonus evoked by 1–2 mM KCl may be inhibited by 50–100 $\mu\text{g/ml}$ NaN_3 . Consequently, there must be a KCl concen-

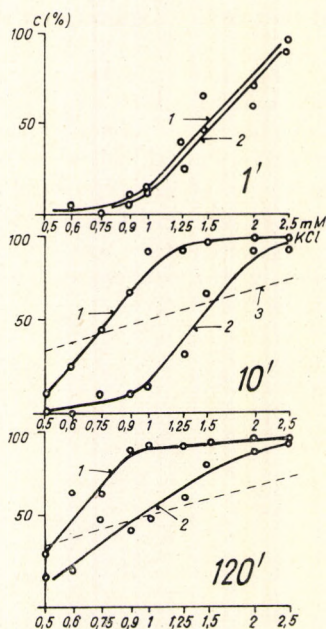


Fig. 7. KCN-effect. Abscissa: KCl-concentration. Ordinate: c_t (%) value 1—0 μ M, 2—75 μ M KCN. Each KCl concentration was tested on 100—100 glochidia

7. ábra. KCN hatás. Abszcissa: KCl koncentráció, ordináta: c_t (%) értéke 1—0 μ M, 2—75 μ M KCN. 100 glochidium minden KCl koncentrációnál

tration at which the tonus cannot be inhibited by a given concentration of NaN_3 .

Tonus caused with 1.5 mM CsCl and 0.6 mM RbCl is also blockable by NaN_3 at similar conditions to those mentioned above.

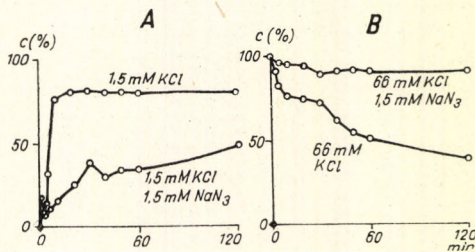


Fig. 8. Inhibitory (A) and potentiating (B) effect of NaN_3 on K^+ -tonus. Abscissa: time. Ordinate: tonus-ratio. 100—100 animals for each solution

8. ábra. A NaN_3 K-tónus-gátló (A) és potencírozó (B) hatása. Abszcissa: idő, ordináta: tónusarány. 100—100 állat oldatonként

5. The action of surface active agents on the potassium tonus

Digitonin alone perceptibly increases the change of contracture already in $1 \mu\text{g/ml}$ ($0.8 \mu\text{M/lit}$) concentration. After 120 min, with the application of this agent, the ratio of closed larvae is about 10%. In spite of this it inhibits the tonus evoked by 1 mM KCl already in very low concentration. It seems to be evident that similarly to some other tonus evoking agents the inhibition of tonus can be realized only at low concentrations. We have observed half-inhibition in the 60th min with $0.4\text{--}0.8 \mu\text{M/lit}$ digitonin. There is a moment (between 5 and 10 min) at which the inhibition of 1 mM KCl-effect is at its maximum (95%).

Cetyl-pyridine-bromide (CPB) alone already in $0.5\text{--}1 \mu\text{g/ml}$ concentration increases perceptibly the ratio of closed animals after 30 min. Similarly to digitonin CPB also can block the K^+ -tonus in this low concentration. But the inhibition reaches 50% only in the first 10 minutes then the steady state value is only 10–25%.

In low concentration ethanol also blocks the KCl-tonus. The measure of this inhibition at nearly steady state conditions, i.e. after 60–120 min is 35–60%. This effective range of ethanol concentration is very narrow because the known tonus evoking action appears.

$0.2\text{--}0.4 \text{ mM}$ papaverin practically entirely overthrows the 100 per cent tonus evoked by 2 mM KCl

6. The effect of SH-inhibitors

Owing to the bad solubility of PCMB in water the combination of KCl and PCMB without Na^+ can hardly be realized because NaOH must be used. In such a case Na^+ disturbs the KCl-effect.

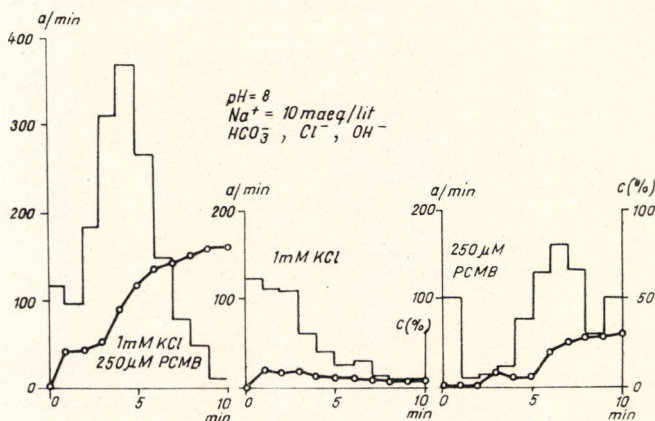


Fig. 9. PCMB-effect. Abscissa: time in minutes. Ordinates: tonus-ratio, $c(\%)$ and frequency of rhythmic activity, a/min resp. 100–100 animals

9. ábra. Paraklórmerkuribenzoát (PCMB) hatása. Abszcissza: idő, ordináták: tónus-arány $c(\%)$, illetve a ritmikus aktivitás frekvenciája (a/min). 100–100 állat

PCMB alone possesses activity increasing and tonus evoking effects. Applying $250\text{ }\mu\text{M}$ PCMB together with 1 mM KCl in the presence of Na^+ ions we observed activity of high frequency and tonic closure. One part of this originates from the own effect of PCMB but there is a real potentiation, too (Fig. 9). A possible alternative is still the protection against the antagonistic effect of Na^+ .

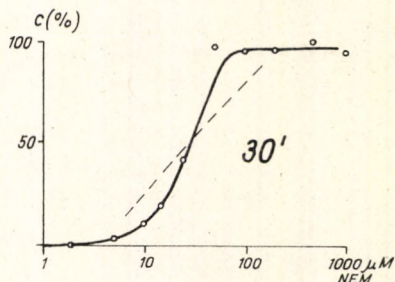


Fig. 10. NEM-effect. Abscissa: concentration. Ordinate: tonus-ratio. 100—100 animals for each concentration

10. ábra. N-etilmaleimid hatása. Abszcissa: koncentráció, ordináták: tónusarány. 100—100 állat koncentrációnként

As NEM at neutral pH is a water-soluble SH-inhibitor the K^+ -effect can be well examined in a Na^+ -free medium. The tonus increases itself already at $5\text{ }\mu\text{M}$. $8\text{--}10\text{ }\mu\text{M}$ in 120 min application evokes closure of 50% of glochidia. In an experiment carried out on 500 glochidia $1\text{ }\mu\text{M}$ NEM does not influence the tonus evoked by 1 mM KCl. $40\text{ }\mu\text{M}$ NEM alone elicits a rhythmic activity of high frequency. The curve of tonic effect is S-shaped (Fig. 10). The last concentration markedly increases the potassium-tonus. The rhythm in the mixture in the first two minutes is pronounced then concerned with the closing it is damped (Fig. 11).

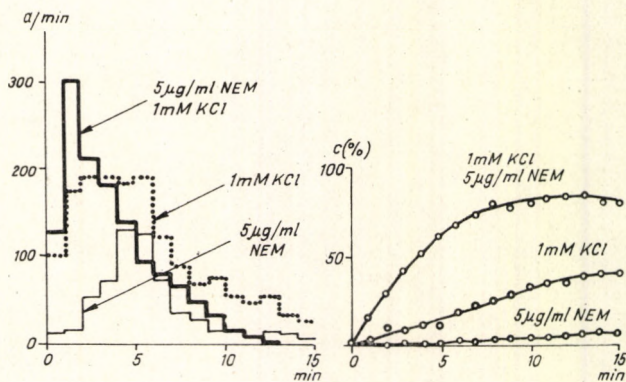


Fig. 11. Potentiation of K^+ -effect by NEM. Marks see in Fig. 9

11. ábra. A K^+ -hatás potenciózása NEM-del. Jelölés mint a 9. ábrán

7. The effect of D_2O on the Li^+ , Na^+ , K^+ , Rb^+ , Cs^+ , Mg^{2+} , Ca^{2+} , Sr^{2+} and Ba^{2+} response of glochidia

The effect of heavy water was examined in a 50–50% mixture of H_2O and D_2O . This solvent resulted in a tonus ratio considerably smaller than 2% after two hours.

D_2O significantly depresses the action of 1 mM KCl (*Fig. 12*). Both K^+ -rhythm and K^+ -tonus is touched by the inhibitory effect. The degree of inhibition depends also on the actual response of the population to 1 mM KCl. Thus the inhibition increased with decreasing KCl reaction. Thus it is evident that the response elicited by a concentration of higher than 3 mM cannot be blocked. Some characteristic data for the rhythm-inhibition: in 10 min at 1 mM KCl 1134 or 600 reversible contractions were produced in natural or heavy water, respectively. The effect of the remaining activator cations (Cs^+ , Rb^+ , Ba^{2+}) also is inhibited by the D_2O . The time needed to 50% closing is doubled by 0.5 mM RbCl, 1 mM CaCl and 200 μ M $BaCl_2$ (*Fig. 12*).

The change of tonus evoked by 25–100 mM LiCl, NaCl, $MgCl_2$, $CaCl_2$ and $SrCl_2$ in heavy water of 50 per cent is essentially different. Opposite to the inhibition of activator ion-effects a strong potentiation of tonus was observed preceded by inhibition lasting for a short time (*Fig. 13*). The biphasicity is the most evident in case of LiCl. The surplus of tonus is most pronounced after 20 min.

The K^+ -specificity in D_2O is damaged. On the base of the cases demonstrated in *Fig. 13* we estimated the change in the specificity of K^+ as compared to Li^+ . Taking into account the changes in tonus ratio at 120 min and the ratios of concentrations we obtained the following informatory "specificity-constants":

$$\begin{array}{l} H_2O \\ k = 63 \\ KLi \end{array}$$

$$\begin{array}{l} D_2O \\ k = 30 \\ KLi \end{array}$$

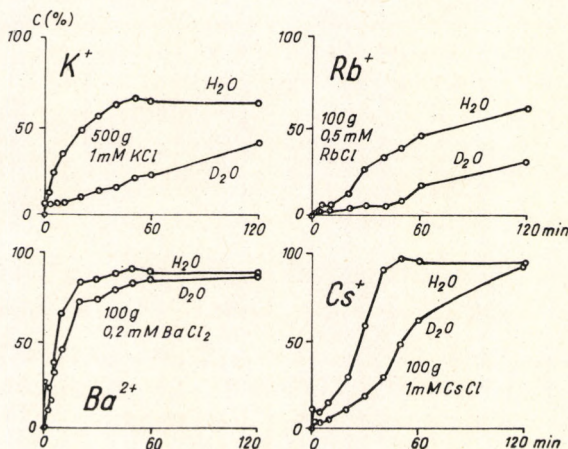


Fig. 12. Effect of D_2O on the K^+ , Cs^+ , Rb^+ and Ba^{2+} -response. Marks see in *Fig. 9*

12. ábra. D_2O hatására a K^+ , Cs^+ , Rb^+ , és Ba^{2+} válaszra. Jelölés mint a 9. ábrán

The contrary changes of initial and steady state response observable sometimes are remarkable. Thus, for example, in Li^+ inhibited, in Ba^{2+} promoted initial activations are shown (Fig. 13). Summarizing the phenomena

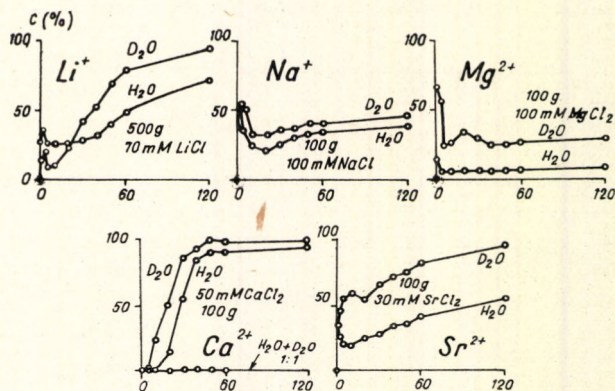


Fig. 13. Effect of D_2O on the Ca^{2+} , Mg^{2+} , Sr^{2+} , Li^+ and Na^+ response. Marks see in Fig. 9

13. ábra. D_2O hatása a Ca^{2+} , Mg^{2+} , Sr^{2+} , Li^+ és Na^+ tónusra. Jelölés mint a 9. ábrán

observed in D_2O it can be stated that the ion-effects producible at most in 1 mM range are inhibited, but those produced with solutions of 10–100 mM are enforced.

8. The action of K^+ -sensors

At 1 mM KCl and CsCl the actions of 100 $\mu\text{g}/\text{ml}$ veratrine, 20 $\mu\text{g}/\text{ml}$ histamine, 50 $\mu\text{g}/\text{ml}$ guanidine were studied. These substances in the used concentrations are well-known sensors of the vertebrate cross-striated muscle concerning the potassium contracture (BACQ 1947).

Only the veratrine displayed a significant effect. NaSCN , histamine inhibited, guanidine in a small degree have potentiated only the K^+ -tonus. 20 $\mu\text{g}/\text{ml}$ veratrine alone increased the tonus. However, the time course of the proper effect of veratrine shows clearly that it is not responsible for the excess-tonus.

9. Previous and synchronous applications of tryptamine, serotonin, dopamine, d-TC, TMA, TEA, TnBA. Their effect of K^+ -tonus

Earlier we reported the KCl and tryptamine given together can cause an increased tonus (LÁBOS 1966). The situation is different when the glochidia preincubated and driven with tryptamine were forced to produce tonus. Already 5 min preincubation in 100 $\mu\text{g}/\text{ml}$ tryptamine significantly increased the secondary relaxation observed in 30 mM KCl. When we performed preincubation of 40 min in 100 $\mu\text{g}/\text{ml}$ tryptamine, serotonin and dopamine the following KCl-incubation of 60 min produced a final inhibition of tonus of 92, 50 and

47%, respectively. The degree of such effect of d-TC is similar to that of dopamine.

The combination of 1 mM KCl with 1 mM TMA, TEA and TnBA showed decreased tonus-ratios: 95—13.5—8.5 and 60% tonus was observed in the control TMA, TEA, TnBA solutions, respectively.

10. Changes and differences in potassium susceptibility

It is an unquestionable experience of some years that under seemingly same conditions significant differences are observable in the K^+ , Na^+ and Li -responses of glochidia.

The possible factors which could be responsible for the differences are: ontogenetic stage, season, the finer composition of the medium, keeping conditions, species. The significance of season and in a hidden mood the ontogenesis and a seasonally changing medium was well shown, by a summary of experiments carried out in the years, of 1960—67. Working with lake water it seemed to be clear that the K^+ -sensitivity is increasing in autumn, the top is reached in December then a decrease could be observed. Some seasonal shift is possible but the maximum in winter was frequent. The pH of lakewater is varying between 7.8 and 8.4. However, solutions with artificially changed pH could not reproduce the observed differences. The changes in the antagonistic ion-composition may be one of the real factor. The low susceptibility in October may be connected to the early larval stage.

The highest sensitivity to potassium means a detectable reaction sometimes in 100 μ M/lit KCl.

The significance of changes in the keeping conditions also cannot be neglected. In an experiment we observed a very marked decrease in the susceptibility after a large and sudden temperature step (nominally: $+6^\circ C \rightleftharpoons +37^\circ C$).

11. Ion-effects and electric excitability

The electric excitability of larval adductor was examined with a method described previously (LÁBOS 1964). In the isotonic (20 mM/lit) solutions of $MgCl_2$ and $CaCl_2$ the excitability decreased, then disappeared. In 20 mM NaCl the threshold slowly decreases or is unchanged. In 20 mM LiCl for 10—40 min the excitability decreases or increases a little then suddenly significantly increases. Finally, inexcitability results. The contractions in $MgCl_2$, $CaCl_2$, NaCl and LiCl are very quick and are not complete.

In KCl, after the secondary relaxation there is no excitability. Low, subcritical concentrations of KCl and $BaCl_2$ (0.2—0.05 mM) increase the excitability. The lowest and most constant thresholds were observed in KCl of low concentration and in physiological solution of MARCZYNSKY (1959). In distilled water a real decreased excitability was observed.

Discussion

The problem of alkali metal ion-specificity was elucidated with remarkable results by LING (1960), EISENMANN (1961), and by LING and OCHSENFELD (1966). They give also experimental support to the anion-field and ion-exchange

hypotheses. The sequence of $Rb^+ > K^+ > Cs^+$ is equivalent to the III-rd order of EISENMANN. He explained 11 types of the possible 120 (5!) lyotropic orders only by the strength differences of anionic field binding the cations. LING and OCHSENFELD (1966) determined association constants on the basis of his association induction hypothesis in frog-sartorius; the obtained sequence of constants was: $Rb^+ > K^+ > Cs^+$. Thus a real significance must be attributed to their discussions, namely for example to the β - and γ -carboxyl groups and to the desolvation process of cations.

However, the total tonus-sequence ($Na^+ < Li^+ < Cs^+ < K^+ < Rb^+$) and even the rhythm-order $Cs^+, K^+ > Rb^+, Na^+, Li^+$ cannot be explained alone by the changes in the strength of anionic field. That is to say, such sequences are not among those of EISENMANN. We believe other factors to be the causes of the described facts, for example enzyme-activation could play an explicit role in forming such sequences of the rhythmic activity and it is not based alone on the ion-uptake. This is supported by SKOU's finding (1960) on K^+ -activated ATP-ase in the presence of Mg^{2+} . He obtained a part of our sequence in question: $Na^+ < Li^+ < K^+, Rb^+, Cs^+$. (This is similar to EISENMANN's Xth sequence.) It is more important to take into account also that EISENMANN's hypothesis is of an equilibrium-type. On the other hand, in our experiments the glochidia are in the transient phase of ion-uptake especially concerning the rhythmic activity which is a typically transient phenomenon. Nevertheless, after the secondary relaxation nearer to the equilibrium the "normal" lyotrop sequence appears ($Cs^+ > Rb^+ > K^+ > Na^+ > Li^+$).

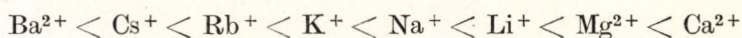
In spite of these a steady-state-discussion similar to that of EISENMANN has proved to be useful in the interpretation of K^+ -inhibitory and Li^+ -potentiating effect of heavy water (see in Appendix). It must be supposed that D_2O damages the mechanisms responsible for K^+ -specificity. It causes this partly by the different changes in the hydration energies of potassium (lithium and) of the counter-ion and partly by the new properties of the D_2O -modified exchange-phase. The possible modified groups because of further causes may be $-COOD$ and $-SD$.

Another possible explanation of D_2O -effect can be based not on the ion-exchange-type discussion but on the common and coupled diffusion of ions and solvents. Thus, according to ONSAGER's hypothesis (1945) of solvent drag influence the solvent accelerates or retards the movement of ions through the porus according to the direction of its stream. If this is right an opposite net change in the direction of solvent flow must take place in the two groups of ions. KOEFOED-JOHNSEN and USSING (1953) used D_2O successfully to measure influx of water through biological membrane. However, theories reckoning with equivalent porus in an old sense cannot explain sufficiently all the anomalies of ion cation-sequences. For this reason we incline to give a more general ion exchange model (see Appendix).

In the case of alkaline earth metal ions the sequence for the tonus is a normal HOFFMEISTER-series. In the order for the rhythmic activity there is the anomaly: $Mg^{2+} > Ca^{2+}$; it is probable that its transient character is which is responsible. The Ba^{2+} susceptibility of glochidia similarly to other smooth muscle preparation is about at $10 \mu M$. Therefore the glochidia are suitable for testing spasmolytica. The dose-effect curve does not cover a process of binding of the first order. The dissociation constant is $pK = 4.5$ (Fig. 4). The same process is characteristic also for potassium but $pK = 3$.

The antagonistic and synergetic action effects similarly to $K^+ - H^+$ competition observed by CONWAY and his co-workers (1963) on K^+ -uptake of yeast cells in a first approximation can be explained by a binding to the same sites. According to this, if we take the effects as being in direct connection with the uptake (which is plausible with regard to the effect = time diagrams then the antagonisms and synergisms could be considered as competitions on the sites of binding. All the K^+ -inhibiting actions applying them alone even also Li^+ decrease the electric excitability, too.

But it is remarkable that there are significant differences in the degree of cooperations. The orders obtained by antagonisms and synergisms are not the same as the above reviewed ones. Thus, for example, the strength of Na^+ -inhibition on the activator cations is: $K^+ > Cs^+ > Rb^+$. Likewise, one hardly could explain that the Mg^{2+} causing weak tonus inhibits the K^+ -tonus to a less degree than Ca^{2+} . Therefore, it must be supposed that the antagonistic ion effects interfere partly at different sites. The double effect of Mg^{2+} also argues for this mechanism: initial closing and rhythm and inhibition of proper and potassium tonus. The secondary relaxation observable in the case of all the cations also argues for a double effect. The sequence based on its degree is:



In the extreme cases (Ba^{2+} , Mg^{2+} , Ca^{2+}) the tonus was not observed (Ca^{2+}) or only for a short time (1–2 min, Mg^{2+}) or the secondary relaxation was missing. Accordingly with the last sequence the quickest and strongest inhibitions were achieved by Ca^{2+} . The order of K^+ -inhibition is $Ca^{2+} > Mg^{2+} > Na^+ > Li^+$.

Kinetically at the given conditions the ion-effects are nearer to the non-competetive self-inhibition than to the competetive one. In the first case characteristic plateaus of different extent are observable on the dose-effect curves (ARIENS 1964). Furthermore, it is desirable to observe that these diagrams somewhat resemble to those of the negative adsorption.

The extreme sensitivity to KCl sometimes 10^{-5} M/lit is the threshold calls the attention to a specialized chemoreceptive mechanism, too.

Analysing the effect of metabolic inhibitors we wish to emphasize the tonus-inhibition displayed by KCN and the block of relaxation as well as the own activation effect shown by the SH-inhibitors PCMB and NEM. The tonus increasing effect of specific PCMB and NEM can be contrasted with the tonus-decreasing effect of Cd^{2+} (LÁBOS and co-workers 1964a) being considered as nonspecific SH-inhibitor but can be compared to the closing action of the also nonspecific Zn^{2+} and Hg^{2+} heavy metal ions. Therefore we may conclude the partial and indirect role of SH-groups, beside other groups, in the excitation. Previously we (LÁBOS and co-workers 1964b) supposed the role of SH-groups in the K^+ -action. The skeletal muscle myosin contains SH-groups (KIELEY 1965). The potassium outflow of red blood cells are increased by NEM (TOSTESON and JOHNSON 1957). Thus, it does not seem to be unreasonable to suppose about the SH-groups to have an indirect role in the fastening mechanism of K^+ -selectivity and the reversibility of contractions.

NaN_3 inhibits the action evoked by K^+ in low concentrations and potentiates the effect displaying in high concentrations. There must be a neutral point in the K^+ -concentration. The cyanide block is regarded as a proof for a close but a possible indirect coupling of K^+ -action and the terminal electron-

transport. In plant cells and frog skeletal muscle LUNDEGÅRDH (1939, 1960), CONWAY (1951), CONWAY and MULLANEY (1960) suggested their well-known redox-pump model mainly on the base of cyanide-sensitivity of salt-respiration terminal electron transport. In plant cells and frog skeletal muscle the cyanide-sensitive cytochromoxydase at LUNDEGÅRDH (1939) is Cl^- mediator, according to CONWAY is K^+ -carrier (1951). In our case the small effective CN^- -concentration and the inhibition apparently taking place competitively are remarkable (parallel shift of the curves of *Fig. 7*. The deterioration of parallelism in the equilibrium is taken as a sign of non-competitive connection of K^+ and CN^- effects. As the observed reaction is produced by a group of animals and in such cases the incorrect forming of mean values is a possible source of mistake leading to a gently sloping curve (see ARIËNS 1964, Vol. I. p. 144) for this reason the slope of curves have to be analysed. It is evident that the experimentally observed slope is far greater than the expected one on the base of a reaction of the first order and of the mass-effect law (on the figures they are drawn by dotted lines). For this reason an averaging with the mentioned mistake is not possible. Furthermore, the reaction of apparently higher order may be a sequence of the first order reactions and its nearly threshold-character leads to the steeply sloping curves. This kind of distorsion refers to the curves measured with and without cyanide, too.

The final conclusion is: cyanide acts at the essential point of the complex reaction graph of the potassium-response.

The K^+ -tonus inhibiting effect of quaterner and tertier amines, furthermore, the sensibilization evoked by veratrine hardly fits into the metabolism. It is greatly probable that these amines do not act as mediators or as their antagonists, however, the effect of tryptamine is striking. The positively charged amines can modificate the binding or carrying anionic field nonspecifically and as it is known that veratrine can cause K^+ -outflow (SZENT-GYÖRGYI and co-workers 1939, BACQ 1947, GOFFART and BACQ 1952). Nevertheless, this mechanism does not lead by any means to a K^+ -sensibilization.

In order to obtain a clearer picture of certain double and/or opposite effects we must discuss mainly the N_3^- -inhibition and potentiation. It is a good example for the apparently contradictory effect of the same substance. There is no essential problem for example in Rb^+/K^+ and Cs^+/K^+ synergisms. They can be regarded as competitive agonists. But the K^+/N_3^- "synergism" was observed at other conditions. It is evident that a possible cause of the double azide-effect (opposite action at low and high potassium concentration) is the fact the two K^+ -responses can be regarded as two different phenomena. Thus azide would inhibit the tonus and potentiate the true contracture. The D_2O -effect may also be accounted for such a mechanism. It increases the contracture achieved by high cation-concentrations and inhibits those obtained in low concentrations. Unfortunately this wide-spread view (BETHE and FRANKE 1925, FUJIMO and FUJIMO 1964) is disturbed for example by the fact that veratrine-sensitization opposite to that of azide can be obtained already at low (1 mM) KCl and CsCl concentrations. It is not probable that the K^+ -response observable at low concentrations is a true contracture. The fact that the anion N_3^- and the cation Cd^{2+} show antagonistic effects is a clear proof for the complexity of the reacting system. Consequently, it seems to be a reasonable conclusion that the double response is an attribute of the highly organized system.

Appendix

In the following exposition a simplified possible thermodynamic explanation of the D_2O -inversion is given. Internal energy values are used instead of free energy because the living system is supposed to be open and the direction of reactions is not shown always by an increase of entropy or by a decrease of free energy. From the two groups of ions K^+ and Li^+ are selected as extreme examples. Let us suppose the difference between the internal energy values of X^+ cation to be in B and in isolated state in vacuum (0-state) is ΔU_X^{OB} . Let ΔU_X^{OH} and ΔU_X^{OD} be the internal energy of the same cation in normal and heavy water, respectively. Furthermore, let K^+ and for Li^+ be the changes of internal energy attending with a transition from the H_2O and D_2O solvents to the state B by ion-exchange: ΔU_{KX}^{BH} , ΔU_{KX}^{BD} , ΔU_{LiX}^{BH} , ΔU_{LiX}^{BD} . It can be written

$$\Delta U_{KX}^{BH} = \Delta U_X^{OH} - \Delta U_K^{OH} + \Delta U_K^{OB} - \Delta U_X^{OB}$$

$$\Delta U_{KX}^{BD} = \Delta U_X^{OD} - \Delta U_K^{OD} + \Delta U_K^{OB} - \Delta U_X^{OB}$$

$$\Delta U_{LiX}^{BH} = \Delta U_X^{OH} - \Delta U_{Li}^{OH} + \Delta U_{Li}^{OB} - \Delta U_X^{OB}$$

$$\Delta U_{LiX}^{BE} = \Delta U_X^{OD} - \Delta U_{Li}^{OD} + \Delta U_{Li}^{OB} - \Delta U_X^{OB}.$$

where X^+ is the exchange-cation. Experimentally it has been observed that D_2O inhibits the effect of K^+ and after a transitional block it increases that of Li^+ . Let us suppose that the action of a cation is in direct connection with its binding and the effect is more explicit if the change of internal energy accompanying the binding is smaller. In such a case the experimental facts can be written thus

$$1. \Delta U_{KX}^{BH} < \Delta U_{KX}^{BE}$$

$$2. \Delta U_{LiX}^{BH} < \Delta U_{LiX}^{BE} \text{ then } \Delta U_{LiX}^{BH} > \Delta U_{LiX}^{BD}$$

Supposing that the exchange-cation is K^+ . In such a case for K^+ and similar ions there is no, or only a small, difference between the internal energies of the hydrated exchanging ions. Therefore the K^+ -inhibition is caused, above all, by the change of B-state that is by the modified exchange phase. This is possible only in that case if the exchange-phase is not absolutely free of water and/or protons therefore it must be inferred a K^+ -binding phase of B'-state. For this reason

$$\Delta U_K^{OB} - \Delta U_X^{OB} < \Delta U_{K'}^{OB'} - \Delta U_X^{OB}$$

from where

$$\Delta U_X^{OB} < \Delta U_{K'}^{OB'}$$

If the water were completely excluded from the exchanger-phase the D_2O -effect could not be explained only by an EISENMANN type model (1961). If the K^+ is the exchange ion the effect of water cannot be neglected. In order to explain the firstly similar but finally opposite behaviour observed in the case of Li^+ and related ions let us further suppose that K^+ is the X^+ exchange-cation

which assumption, on the other hand, is an equivalent of the well-known K^+ -outflux during a tonic excitation. For this reason and as $X^+ \neq Li^+$

$$(\Delta U_X^{OH} - \Delta U_{Li}^{OH}) - (\Delta U_X^{OD} - \Delta U_{Li}^{OD}) \neq 0$$

In the case of Li^+ the modification of exchange-phase can not be neglected, that is

$$\Delta U_{Li}^{OB} \neq \Delta U_{Li}^{OB*}$$

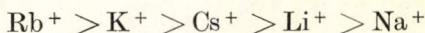
Thus the inhibitory effects are explained primarily by the alteration of exchanger, the potentiations by the increased difference between the hydration energies of acting and exchanging cations. In the latter case the change of B-phase also must be taken into account. The biphasic change of Li^+ -effect clearly shows this postulation.

We desire to emphasize that the binding to the exchange-phase is not an explicit argument for the alteration theory or contra membrane theory of ionic phenomena. Namely, the exchanger could be itself an ion-carrier system into the intracellular phase. Thus the binding would be only transitional but could influence the cation fluxes. Furthermore, there is an alternative exchange-hypothesis when Ca^{2+} localized into the membrane is the exchange-ion itself. In this case the hydration energy-difference would be responsible for D_2O action displayed on K^+ and related ion effects while the modification of exchange-phase would cause the changes of Ca^{2+} and related cationactions. It is also believed that the ion-exchange model could be compatible with the ONSAGER's solvent drag hypothesis.

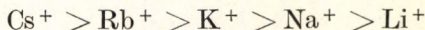
Summary

The rhythmic movements and tonic closure of the freshwater clam larvae (*Anodonta-glochidia*) were studied.

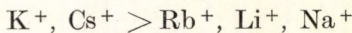
1. Anomalous lyotrop order was observed at low concentrations in the tonus-evoking effect:



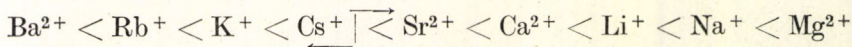
which transforms in the course of relaxation into the following order:



Also an irregular sequence can be observed concerning to the frequency of rhythm:

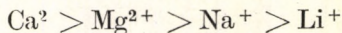


2. The united sequence of the equipotent concentrations of alkaline earth metal ions is:

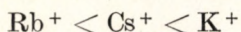


The arrows mark the point of D_2O -effect-inversion (see below).

3. At the same conditions the sequence in K^+ -antagonism is:



Inhibitory effect of Na^+ increases according to this order:



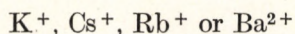
4. The ions with similar effect act as synergists. The sequence of synergisms: $\text{Rb}^+/\text{Cs}^+ > \text{K}^+/\text{Rb}^+ > \text{K}^+/\text{Cs}^+ > \text{K}^+/\text{Ba}^{2+}$. Ba^{2+} hardly increases the K^+ -effect, moreover the Cs^+ and Rb^+ effect are inhibited.

5. The K^+ -effect is not or is a little sensitive to the following metabolic inhibitors: ouabain, 2,4-DNP, 2,4-DNPH, NaF. But NaN_3 depending on the ratio of concentrations can increase or depress the K^+ , Rb^+ and Cs^+ -tonus. KCN in 10 μM /lit can inhibit definitely the effect of 0.1–2 mM KCl. PCMB and NEM potentiate the K^+ -effect. This SH-inhibitors can activate alone, too.

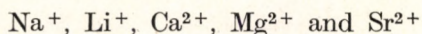
6. In the groups of K^+ -sensitizers NaSCN, guanidine, histamine are hardly effective but veratrine highly increases the K^+ and Cs^+ effects.

First of all tryptamine, but dopamine and serotonin also strongly block the tonic K^+ -response, by a previous application. TMA, TEA and TnBA in 1 mM strongly decrease the K^+ -tonus. Surface active agents — digitonin, papaverine, cetylpyridine-bromide, ethanol — in low concentrations inhibit the K^+ -tonus, in higher concentrations evoke tonus.

7. In solvents containing 50% D_2O and 50% H_2O the tonus evoked by



is inhibited, but the tonus evoked by



is increased really. In point 2 the given sequence is intersected by a line marking the inversion of D_2O effect; to left inhibition, to right potentiation was observed.

8. Approximately isotonic solutions of Ca^{2+} , Mg^{2+} , Li^+ , Na^+ decrease, K^+ increases the electric excitability of larval adductor.

9. Some of the possible factors which could be responsive for the observed seasonal changes in the K^+ -susceptibility were studied experimentally. On the base of these experiments the ionic-composition of medium (water from the Lake Balaton), the keeping conditions in laboratory (sudden changes in the temperature), ontogenetic stage are real possibilities; pH changes between 5.5–8.5 are not effective in the influence of tonus at high K^+ -concentration.

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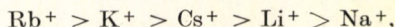
ADATOK ALKÁLI FÉM ÉS FÖLDFÉM IONOK AKTIVÁLÓ HATÁSÁNAK MECHANIZMUSÁHOZ ANODONTA LÁRVÁN

Lábos Elemér

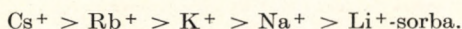
Összefoglalás

Édesvízi kagylólárvák (*Anodonta*-glochidiumok) alkáli fém és földfém ionokkal kiváltható ritmusát és tónusát vizsgáltuk,

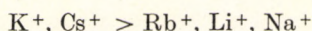
1. Anomális liotrop sort figyeltünk meg, kis koncentrációknál a tónusokozó hatásban:



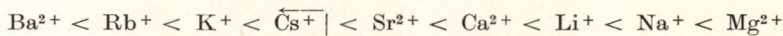
ami az ionok által kiváltott tartós tónus megszűnésekor átmegy a



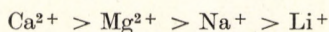
A ritmus frekvenciája szerint szintén anomális a sorrend:



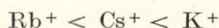
2. Az alkáli földfémek és alkáli fémek azonos tónust kiváltó koncentrációinak a sorrendje a következő:



3. Azonos feltételek mellett a K^+ -hatás antagonizálása tekintetében az alábbi a sorrend:



A Na^+ antagonizáló hatása az alábbi sorrendben erősödik:



4. Hasonló hatású ionok szinergistaként hatnak. A szinergizmus sorrendje: $\text{Rb}^+/\text{Cs}^+ > \text{K}^+/\text{Rb}^+ > \text{K}^+/\text{Cs}^+ > \text{K}^+/\text{Ba}^{2+}$. A Ba^{2+} alig potenciroz, sőt a Cs^+ és Rb^+ hatást gátolhatja.

5. A K^+ -tónus nem vagy alig érzékeny az alábbi anyagcseregátlókra: ouabain, 2,4-DNP, 2,4-DNPH, NaF. NaN_3 -dal a koncentrációarányoktól függően a K^+ , Cs^+ és Rb^+ -tónus gátlása és potencirozása is észlelhető. KCN 10 μM /lit körüli koncentrációkban 0,1–2 mM KCl hatását jelentősen gátolja. A PCMB és NEM potencirozza a K^+ -tónust. Ezek az SH-gátlók önmagukban is aktíválnak.

6. K^+ -szenzitorok közül alig hatásos a NaSCN, guanidin, hisztamin, míg a veratrin a K^+ és Cs^+ hatást erősen potencirozza. Elsősorban a triptamin, de a dopamin és serotonin előzetes alkalmazása is jelentősen gátolja a K^+ -választ. TMA, TEA, TnBA 1 mM koncentrációban gátolják a K^+ -tónust. Felületaktív anyagok (digitonin, papaverin, cetilpiridinbromid, etanol) kis koncentrációban gátolják a K^+ -tónust, nagyobb koncentrációban általában tónust okoznak.

7. 50%-os D_2O tartalmú vizes oldatokban a K^+ , Cs^+ , Rb^+ , Ba^{2+} -tónus és K^+ -ritmus gátlását, a Li^+ , Ca^{2+} , Mg^{2+} és Sr^{2+} -tónus valódi potencirozását észleltük. A 2. pontban adott szekvencia jelzett helyétől jobbra fokozza, balra gátolja a nehézvíz az ionhatást.

8. Az anyai limfával közel izotóniás koncentrációban a Ca^{2+} , Mg^{2+} , Li^+ , Na^+ csökkenti, K^+ fokozza a lárvális izom elektromos ingerlékenységét.

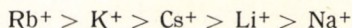
9. A K^+ érzékenység „szezonalis” változásait előidéző lehetséges faktorokat kísérletesen vizsgáltuk. Ennek alapján szóba jöhet a balatonvíz ion-összetétele, az egyed-fejlődés, tartási körülmények (hőmérsékletugrások); pH-változások hatása nem valószínű

ДАННЫЕ К МЕХАНИЗМУ АКТИВИРУЮЩЕГО ЭФФЕКТА ИОНОВ ЩЕЛОЧНОГО И ЩЕЛОЧНО-ЗЕМЕЛЬНОГО МЕТАЛЛОВ НА ГЛОХИДИЯХ БЕЗЗУБКИ

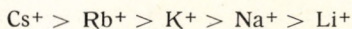
Элемер Лабош

Были изучены ритмическая и тоническая активности глохидиев беззубки, вызванные ионами щелочного и щелочно-земельного металлов.

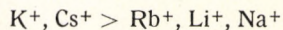
1. — В тоническом эффекте был обнаружен аномальный лиотропный ряд:



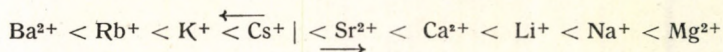
который при прекращении продолжительного тонуса, вызванного данными ионами переходит в следующий ряд:



По частоте ритма ряд тоже аномальный:



2. — Концентрационный ряд щелочного и щелочно-земельного металлов, вызывающих одинаковый тонический эффект был следующим:



3. — При прочих равных условиях в отношении антагонистического действия эффекта калия был получен следующий ряд: $\text{Ca}^{2+} > \text{Mg}^{2+} > \text{Na}^+ > \text{Li}^+$ Антагонистическое воздействие натрия увеличивалось по следующему ряду: $\text{Rb}^+ < \text{Cs}^+ < \text{K}^+$.

4. — Ионы со сходным влиянием действуют как синергисты по следующему ряду: $\text{Rb}^+/\text{Cs}^+ > \text{K}^+/\text{Rb}^+ > \text{K}^+/\text{Rb}^+ > \text{K}^+/\text{Cs}^+ > \text{K}^+/\text{Ba}^{2+}$. Ионы бария почти не вызывают усиление, а эффект Cs^+ и Rb^+ тормозится при даче этого агента.

5. — Тонический эффект, вызванный калием, почти нечувствителен к следующим ингибиторам обмена веществ: оуабаин, 2,4-ДНФ, 2,4-ДНФХ, NaF, NaN_3 в зависимости от концентрации вызывает или снижение или усиление тонуса, наступающего под влиянием K^+ , Cs^+ , Rb^+ . KCN в концентрации 10 $\mu\text{M}/\text{л}$ значительно снижает эффект калия (0,1—2 мМ). ПХМБ и NEM не увеличивают калиевый тонус. Эти ингибиторы SH-групп сами по себе являются активаторами.

6. — Из сензиторов калия NaSCN, гуанидин и гистамин почти неэффективны, а вератрин сильно увеличивает эффект K^+ и Cs^+ . Предварительная дача прежде всего триптамина, но и допамина и серотонина тоже значительно снижает калиевый эффект. ТМА, ТЕА и ТВА в концентрации 1 мМ понижают калиевый тонус. Поверхностно-активные вещества (дигитонин, папаверин, цетилпиридинбромид и этанол) в низких концентрациях снижают тонус, вызванный калием, а в больших концентрациях сами вызывают тонус.

7. — В водных растворах 50%-ного D_2O наступало торможение тонуса, вызванного K^+ , Cs^+ , Rb , Ba^{2+} и калиевого ритма, а тонус, вызванного Li^+ , Ca^{2+} , Mg^{2+} и Sr^{2+} увеличивался. В ряде, данном во втором пункте, тяжелая вода вызывает усиление эффекта ионов, расположенных в правой стороне, а в левой — торможение.

8. — В изотонических составах лимфы материнского организма в концентрациях Ca^{2+} , Mg^{2+} , Li^+ и Na^+ снижают, а K^+ увеличивает электрическую возбудимость личиночной мышцы глохидиев.

9. — Изучались факторы, вызывающие «сезональные изменения» калиевого эффекта. Из возможных факторов надо принимать во внимание ионный состав Балатона, индивидуальное развитие и условия придерживания животных (температурные изменения) — изменение pH вероятно не имеет значения.

HISTOLOGICAL, HISTOCHEMICAL AND ELECTRON-MICROSCOPICAL STUDIES ON THE CYTOSOMES OF THE NERVE CELLS IN ANODONTA CYGNEA L. (MOLLUSCA, LAMELLIBRANCHIATA).

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Received: 1st March, 1967.

Granules containing yellow pigment, stainable with paraldehyde-fuchsin, cited as NS I. and described in the nervous system of molluscs by several authors (KRAUSE 1960, FÄHRMANN 1961, JUNGSTAND 1962, KUHLMANN 1963) correspond according to NOLTE and co-workers (1965) to cell constituents of a specific submicroscopic structure. In order to separate them from the neurosecretum (NSm) these latter authors called them cytosomes, taking their presence in the nervous system of invertebrates for granted and attributing them the functions of a "Stoffwechseldepot". According to SAKHAROV and co-workers (1965) the yellow pigment of these granules in the nervous system of *Tritonia diomedea* (Gastropoda) belongs to the lipochrome-group, it cannot be interpreted as NSm and its considerable part disappears in the course of histological embedding. It is also known that in nerve cells of *Helix pomatia* the carotenoid-containing pigmented area is at the same time the place of the respiratory enzymes of maximum concentration (CHALAZONITIS and GOLA 1964). ANTHEUNISSE (1963) and BARANYI (1964) reported the changes in the yearly cycle of the quantity of PF-positive material in mussels.

In the knowledge of these findings the following problems seemed to be of interest for investigation in connection with the cytosomes in the nervous system of *Anodonta cygnea*:

1. Is there an agreement with the ultrastructure of cytosomes described by NOLTE and co-workers (1965) in Gastropods and what type of mitochondria are to be found in the neurons?

2. Which components of the cytosomes are related to the PF-positivity and how do they behave from the viewpoint of alcohol solubility?

3. Are the respiratory enzymes (cytochrome-oxidase and succinate-dehydrogenase) localized in the cytosomes themselves?

Material and Methods

Our material were the cerebral, visceral and pedal ganglia of *Anodonta cygnea* L. of 13—20 cm samples.

The "neurosecretory" stainings were carried out throughout the whole year and at least once a month. The animals were kept in aquaria supplied with Lake Balaton-water of natural temperature.

For electron microscopic investigations ganglia were fixed at 0 °C in a mixture of hemolymph taken from the mussel's heart and 2 per cent OsO_4 for 1–2 hours. Then the material was embedded in Durcupan ACM (Fluka). Contrasting was achieved with uranylacetate and/or lead citrate (REYNOLDS 1963). Photos were taken with Tesla BS 413 A electron microscope.

Among the "neurosecretory" stainings we applied:

1. Chrome-haematoxylin-phloxin (CH) after BARGMANN (1949).
2. Paraldehydefuchsin (PF) after GABE (1953).

Preparation of ganglia for staining

A) The usual paraffin embedding after Bouin's fixation, where we changed the time of alcohol dehydration between 30 min and 48 hours.

B) Cryostat-sections of 8 μ on slides were after 1–2 min drying fixed in Bouin. Subsequently to fixation one part of the sections were washed for 30 min in tap water, then stained with CH as well as with PF. After fixation the parallel sections were transferred into 80, 90 and 96% alcohol and kept there for a time varying between 30 min and 20 hours.

Before the PF-staining we applied Lugol-oxydation recommended by GABE (1953) on the cryostat material as follows:

- a) fixation for 4–6 hours in Bouin
- b) washing for 30 min in tap water, or alcohol treatment
- c) 5–20 min Lugol-oxydation (ROMEIS 1948, 705. §)
- d) 5 min in 2.5% Na-thiosulphate
- e) rinsing in aqua dest. for 3 min
- f) KMnO_4 oxydation after GABE, altering between 3–10 min.

From this on GABE was followed but we omitted the picroindigo-carmin after-staining and in single cases even the nuclear-staining. The sections were covered from water with glycerine-jelly.

C) Paraffin-embedding after freeze-drying and treatment with gaseous HCHO according to FALCK (1962). The method was applied after the description of FALCK and OWMAN (1965) differing only so much that quenching took place in isopentan cooled with liquid air. The freeze-drying was carried out in HVG 1 (Hochvakuum-Gefriertrocknungsanlage) equipment. In 8 μ sections the above-mentioned stainings were carried out after a deparaffinization with 2×2 min xylol and 2×1 min alcohol treatment.

To demonstrate cytochrome-oxidase (CO) BURSTONE's method (1959) was used by applying 1-hydroxy-2-naphtic acid (Light) and 1-phenyl-p-phenylene-diamine (BDH). The cryostat sections were incubated at room temperature for 3–5 hours then post-chelated with ammonium molybdenate. Effects of $\text{KCN } 10^{-3} \text{ M}$, respectively, NaN_3 were tested as control and also the peroxidase reaction according to DE ROBERTIS and GRASSO was carried out (PEARSE 1960).

Succinate dehydrogenase activity (SDH) was investigated with Nitro-BT method of NACHLAS and co-workers (1957) on cryostat as well on in paraffin-embedded material subsequent to in total incubation of ganglia. Sections were incubated for 1–3 hours, ganglia for 6–8 hours at room temperature. Effect of a pre-incubation with iodoacetate in 10^{-1} – 10^{-3} M on the enzyme activity was also tested.

Results

No significant differences could be found among the cerebral, visceral and pedal ganglia, thus the following statements concern all three of them:

1. Electron microscopic findings

In the nerve cells of all three ganglia the following formations were present (*Fig. 1*) described by FÄHRMANN (1961) as A and B types of NS I., re-

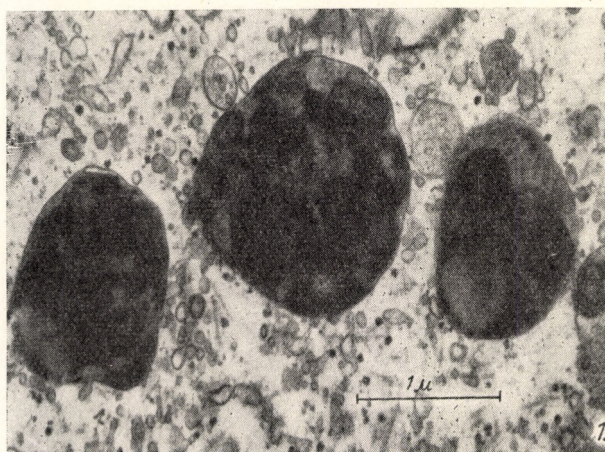


Fig. 1. Detail of perikaryon from cerebral ganglion. Lead citrate staining

1. ábra. Cytosomák a cerebrális ganglionból. Ólomcitrát kontrasztosítás

spectively, reported by NOLTE and co-workers (1965) as cytosomes. Latter authors demonstrated the extremely varying structure of these pictures in Gastropods. In ganglion cells of *Anodonta cygnea* the cytosomes greatly resemble to those of Gastropods but differ from them that they reach an enormous size up to 10–12 μ . These big cytosomes seem to be always manyfold complexes.

Two kinds of mitochondria are present in the cytoplasm. The one is that described in Gastropods by NOLTE and co-workers (1965), a form containing a very clear matrix and short tubuli mitochondriales (*Fig. 2*). The other contains a matrix of much higher density and more and longer tubuli. This latter form is present everywhere in the axons of the neuropile (*Fig. 3*). Common property of both forms is their size varying between 0.3–1.0 μ . A mitochondrion bigger than this size occurred only randomly.

2. Investigations on normal histological sections

In the sections of in BOUIN fixed, after alcohol dehydration in paraffin embedded ganglia PF-positive, mainly vacuolized granules of 1–5 μ can be demonstrated. The quantity of these granules is inversely proportional to the

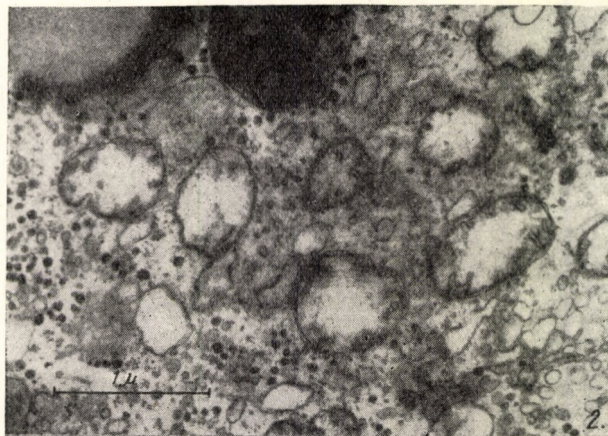


Fig. 2. Mitochondria with clear matrix and short tubuli in a nerve cell of the cerebral ganglion. Lead citrate staining

2. ábra. Világos matrixú és rövid tubulusokat tartalmazó mitochondriumok a *cerebrális ganglion* egy idegsejtjében. Ólomcitrát kontrasztosítás

time of alcohol treatment during dehydration. Apart from spring, already after 2—3 hours of dehydration we found hardly no such granules and if the process was continued they completely disappeared. In spring (May—June) these granules are seen in several nerve cells even after 48 hours of dehydration. They could be stained with CH only faint grey and by prolonging the time of dehydration by alcohol, staining reacts in conformity with PF-positivity.

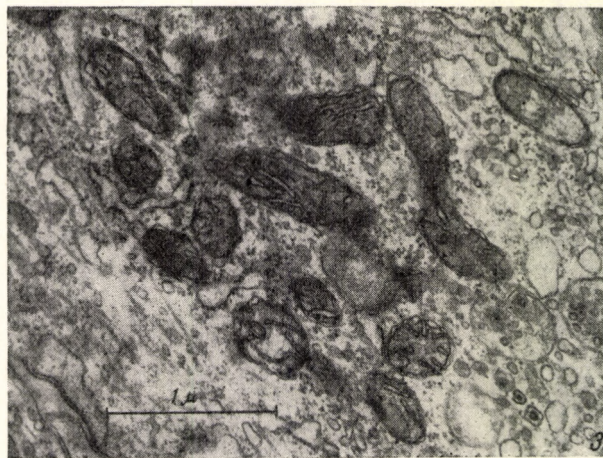


Fig. 3. Mitochondria with dark matrix and longer tubuli from the cerebral ganglion, detail of which shown in Fig. 2. Lead citrate staining

3. ábra. Sötét matrixú és hosszabb tubulusokat tartalmazó mitochondriumok ugyanazon *cerebrális ganglionból*, amelynek részletét a 2. ábra mutatja. Ólomcitrát kontrasztosítás

3. Investigations on cryostat and freeze-dried materials

In cryostat sections the cytosomes can be demonstrated with PF also in unfixed state, practically in all cells in great quantities and in dense, granuled form. The granules are situated so densely that their borders become indistinct. Since in unfixed state the real NS is soluble in alcohol, too, we fixed the section in Bouin at least for 4 hours. In the fixed sections the cytosomes are also well stainable with PF and their appearance is similar to that found in unfixed material (*Fig. 4*). In unfixed as well as in fixed material the intensity of stain-

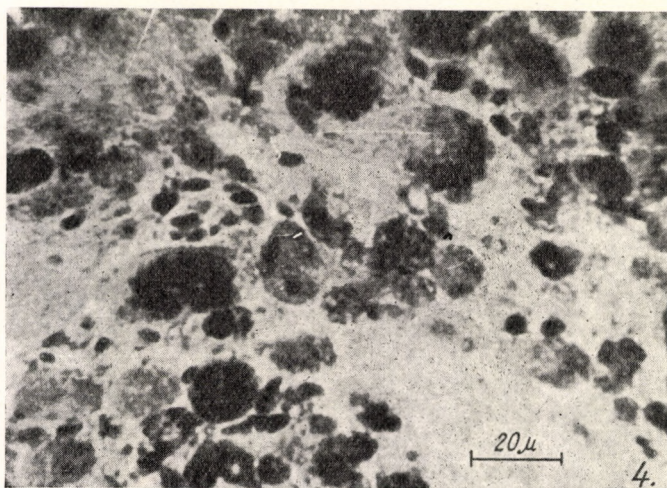


Fig. 4. Part of cryostat section of the *visceral ganglion*. January. PF + nuclear staining

4. ábra. Kryostát metszet részlete *viscerális ganglionból*, januári időszakban. PF festés

ing depends on the time of Lugol-oxidation. In the individuals the optimum varies in general between 5–20 min using a section of 8 μ . Likewise in individuals the optimum time of KMNO_4 -oxidation differs between 3–10 min. In case of insufficient oxidation the periphery of the granules stains stronger than their center or we obtain in general a weaker staining. After optimum oxidation time the majority of cells stains uniformly but in this case a number of weakly stained cells also occur.

In most nerve cells (*Fig. 5/a*) we could observe in unfixed cryostat sections a golden-yellow pigment. While photographing the section in native state and stained after fixation with PF and CH, the connection between the localization of the pigment granules and of the materials demonstrable by staining can well be investigated in the same cells. By this method it could be stated that the PF-positivity is similarly localized like the pigment granules (*Figs 5a and b*), with CH these granules stain greyish-blue.

If the cryostat sections are exposed after fixation for 10–10 min to a 80, 90 and 95% alcohol treatment and the PF-staining is carried out afterwards, we find, parallel to the solution of the lipochrome, considerably less PF-posi-

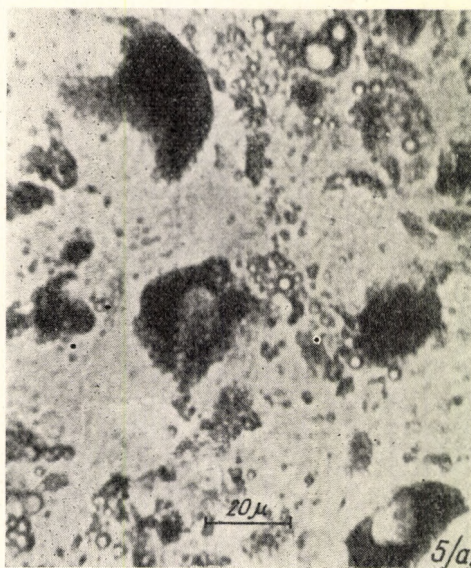
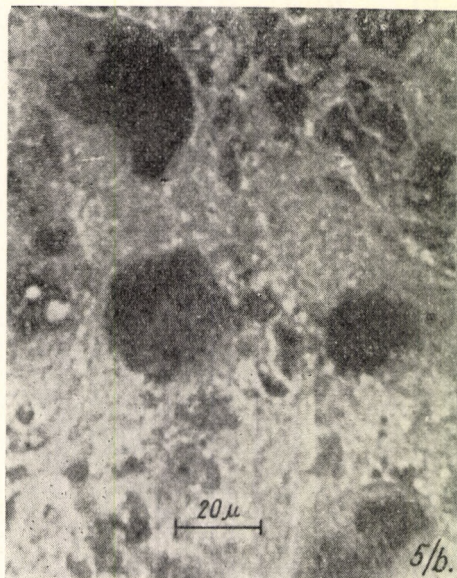


Fig. 5. a) Part of cryostat section of cerebral ganglion immediately after sectioning, photographed in uncovered state. In cells only the pigment is visible. January
b) The same field as Fig. 5/a, after Bouin fixation and PF staining.

5. ábra. a) Cerebrális ganglion részlete közvetlenül a kryostát-metszés után fedetlen állapotban fényképezve. A sejtekben csak a pigment látható. b) Ugyanazon terület, mint az 5/a ábrán, Bouin fixálás és PF festés után, január hónapban



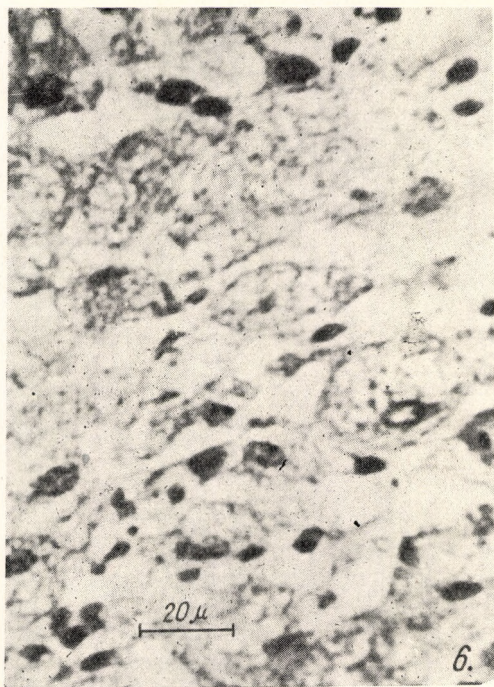


Fig. 6. Another cryostat section of the *visceral ganglion* shown in Fig. 4, treated for 30 min with alcohol after fixation. PF + nuclear staining

6. ábra. A 4. ábrán látható *viscerális ganglion* egy másik kryostát metszete, amelyet a fixálás után 30 perccig alkohollal kezeltünk, majd PF-nal festettünk meg

tive material (Fig. 6). Similarly decreases in the quantity of material stainable with CH. In general to the complete solution of lipochrome and to the disappearance of the PF-positivity a 30–60 min long alcohol treatment is sufficient, but in spring (May–June) only one part of the yellow pigment dissolves under the same time and the PF-positivity is also observable to a significant extent. To dissolve the yellow pigment completely not even an alcohol treatment of 20 hours was sufficient in spring, as it remained still well observable in the cells, even if its quantity was only a fraction of the original-one. Similarly, the PF-positivity remains weaker than the original mainly in form of vacuolized granules in the cells after 20 hours of alcohol treatment.

Analogous to the observations on cryostat material the cytosomes appear similar on freeze-dried and with dry gaseous HCHO fixed, in paraffine embedded ganglia, too. The nerve cells contain a lot of PF-positiv material (Fig. 7), always visible in granulous structure. No vacuolization phenomena were observed in the case of deparaffinization with 2×2 min xylol and 2×1 min alcohol treatment and when the sections were covered with glycerin-jelly. The vacuolized form can be obtained during all seasons after a longer alcohol treatment as well as the complete solution, too, but in spring.

When photographing in freeze-drying sections the yellow autofluorescence localized in the nerve cells in granules (DAHL and co-workers 1962, 1966;

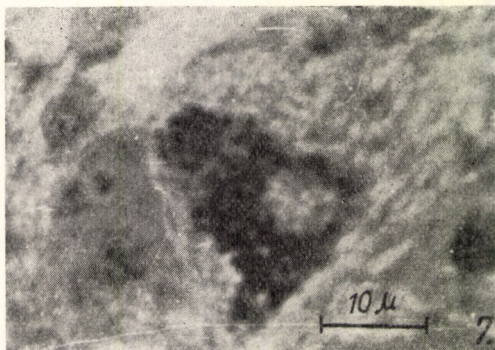


Fig. 7. Part of freeze-dried visceral ganglion. PF staining. January

7. ábra. Liofilizált *viscerális ganglion* egy részlete. PF festés, január hónapban

Zs.-NAGY 1967) then after PF-staining it could be stated that both auto-fluorescence and PF-positivity were identically localized.

The PF-staining is present also in other tissues. In the connective tissues surrounding the ganglia (*Fig. 8*) in certain cell formations of gametogenesis in the sexual organs, in epithelial cells and in other places, too, we obtain vivid PF-positivity in cryostat as well as in freeze-dried sections. These tissues also contain lipochrome pigments even if less amount than the nerve cells. In these places one part of the positivity remains also in the embedded material and here it resists more to alcohol treatment throughout the year than in the nerve cells.

The PF-positivity can be observed in nerve cells and also apart of them only after oxydation. Without oxydation certain glands are faintly stainable with PF.

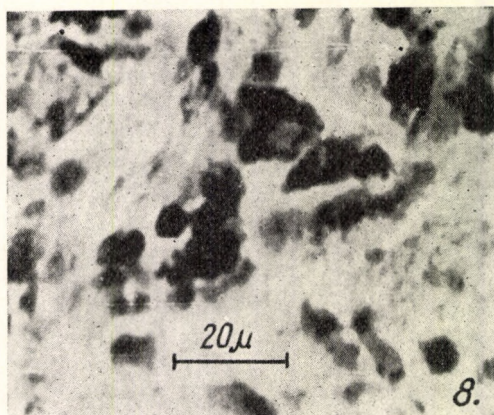


Fig. 8. Part of the connective tissue ensheathing the visceral ganglion. PF staining. January

8. ábra. A *viscerális ganglion*t környező kötőszövet egy részlete, liofilizálás után, január hónapban. PF-festés

4. Localization of respiratory enzymes

Cytochrome-oxidase: two kinds of pictures showing CO-activity could be made visible with the applied method, namely:

- a) brownish-black or black granules of some μ size are present in the cytoplasm of the nerve cells corresponding to the lipochrome granules (*Fig. 9*),
- b) granules much smaller and fainter than the aforementioned ones, present in the lipochrome granule-free parts of the cytoplasm and in the axons of the neuropile. These granules may correspond to the mitochondria with regards to their size and situation (*Fig. 9*).

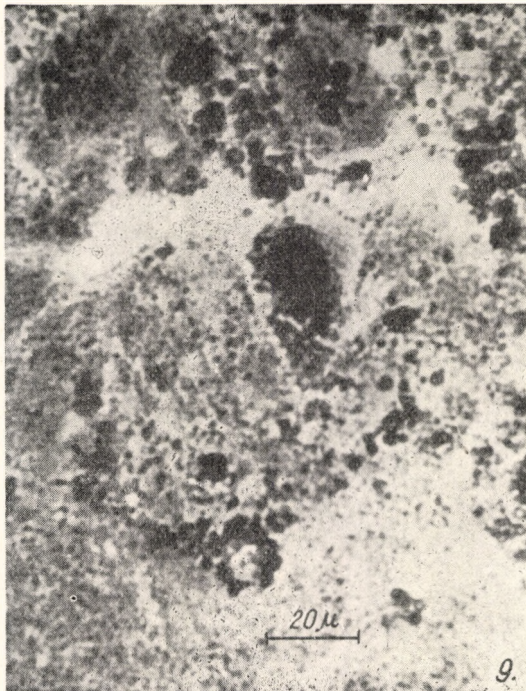


Fig. 9. Picture of cytochrom oxidase in *pedal ganglion*, Burstone reaction.

9. ábra. Cytochrom oxidase reakció hisztokémiai képe a *pedális ganglionban*. A nagy sötét szemcsék a cytosomáknak, a halvány kicsik a mitochondriumoknak felelnek meg

Related to vertebrate tissues the enzyme activity is weaker here, in good agreement with the results of KROMPECHER and co-workers (1966), hence the reason of a longer incubation time. The specificity of reaction is demonstrated by the fact that the inhibitors (KCN, NaN_3) in 10^{-3} M concentration completely inhibits the reaction both in lipochrome granules and in mitochondria. By adding inhibitors the yellow colour of the lipochrome pigment prevails, in contrary, in their absence it completely disappears. So far it cannot be evaluated whether the reaction-product only covers the yellow colour or the pigment itself is submitted to a colour change. The presence of peroxidase is

excluded by the completely negative result of benzidine reaction within the ganglion.

Succinate-dehydrogenase: SDH positivity obtained by Nitro-BT method is localized in the cytoplasm in deep-blue, often confluent granules of some μ size (*Fig. 10*). These granules range into the magnitude of lipochrome gran-



Fig. 10. Localization of succinate dehydrogenase in cerebral ganglion. NBT reaction, cryostat section.

10. ábra. Succino-dehidrogenase lokalizációja cerebrális ganglionban. Kryostát metszet NBT-reakció

ules, but especially in the bigger ones it can well be seen that SDH-positivity occupies only one part of them. There are also such nerve cells which show no SDH-positivity at all. In the neuropile and in the lipochrome granule-free part of the cytoplasm an SDH activity of granules much more fine than the before mentioned ones is also observable. Therefore, the picture strongly resembles to the localization of CO.

Sections and ganglia were incubated also without substrate in order to control the specificity of reaction. In these cases we could demonstrate a positive reaction, identically localized but weaker than the normal. However, when the sections or ganglia were kept before incubation for 10, resp., 30 min in Ringer, the result of incubation without substrate was negative, while when applying a substrate, it was normal. Thus, it is obvious that the positive result of an incubation without substrate originates in the presence of an endogenous substrate, which gets washed out by the Ringer or is

used up and cannot be restored again. On the other hand, the specificity of the observed reaction is further demonstrated by the fact that a preincubation with iodoacetate in 10^{-1} and 10^{-2} M resulted in a total inhibition (NACHLAS and co-workers 1957), whereas the effect of iodoacetate in 10^{-3} M caused only a partial inhibition.

Discussion

Cytosomes described in Gastropods by NOLTE and co-workers (1965) show a completely identical submicroscopic structure with the lipochrome granules of nerve cells in *Anodonta cygnea*. The PF-positivity is identically localized with the lipochrome granules. In cryostat section the vacuolized form of these granules occurs only if the sections are exposed during preparation to alcohol treatment or they were insufficiently oxydized. Our data on freeze-dried material also had shown that the vacuolization of these granules is not a secretory phenomenon (FÄHRMANN 1961, ANTHEUNISSE 1963, BARANYI and SALÁNKI 1963, BARANYI 1964), but a by-product of preparation. With a prolonged alcohol treatment the total disappearance of the PF-positivity from the cells — except in spring months — could be obtained. In the alcohol used for extraction, the lipochrome pigment as well as the autofluorescence material are well observable (LÁBOS et al 1966). We believe that this demonstrates conclusively that the PF-positivity is a property bound to the alcohol-soluble components of the lipochrome granules. However, the alcohol solubility of these components varies seasonally, as for instance in May they do not dissolve completely even after a much longer period of time than usually. This seasonal cycle obviously is of importance and if we consider that the alcohol solubility of the carotenoids bound to protein (chromoproteid) decreases significantly (PEARSE 1960) it is evident that the seasonal changes have their origin in the changes between the lipochrome and protein relation. This seasonal cycle reflects in the data concerning the yearly cycle of the PF-positive material obtained by ANTHEUNISSE (1963) and BARANYI (1964). The data giving account of the fact that in the ultrastructure of the cytosomes sometimes homogenous osmiophil fields then lipoprotein membrane systems of definite myelin figure can be observed also refer to the changes of the lipochrome-protein relation.

In principle, naturally the possibility might be realised that the PF-positive material, insoluble in alcohol already in May, does not correspond to the at another time, alcohol soluble components of lipochrome granules, but to a different material, appearing only then in the lipochrome granules. As such material some in SH groups rich protein or a pigment of lipofuscin character can be taken into account. The first one cannot be excluded, the latter, however, is opposed by the fact that the lipofuscin formation is an irreversible process (PEARSE 1960) which is out of question here. Alcohol solubility is not characteristic for real NSm, and especially not after fixation (SCHARRER and SCHARRER 1954). Furthermore, considering the ultrastructure of the lipochrome granules and their ubiquiter occurrence it is obvious that the separation of cytosomes from NSm (NOLTE and co-workers 1965, SAKHAROV and co-workers 1965, GABE 1966) is entirely justified.

Possible functions of cytosomes were discussed in detail by NOLTE and co-workers (1965). Our present histochemical investigations on the localization

of respiratory enzymes may serve as further evidence of the so-called "Stoffwechseldepot" function of cytosomes. There is no reason to call into question the specificity of the reaction products localized on the cytosomes as both kinds of them are insoluble in lipoids (NACHLAS and co-workers 1957, BURSTONE 1959). With regards to the negative results obtained after benzidine reaction according to DE ROBERTIS and GRASSO, the presence of peroxidases can be excluded.

The cytosomal localization of respiratory enzymes clearly shows that beside the mitochondria the cytosomes participate in the oxidative metabolic processes. The carotenoids may play an important role in these processes according to their well-known electron transporting properties (PULLMAN and PULLMAN 1963). The unusual localization of CO and SDH, known in general as mitochondrial ferments, as well the special structure of the mitochondria observed here refers to the possibility that in Molluscs a cell metabolism differing from that of vertebrates should be taken into account.

A relationship between the cytosomes and lysosomes is suggested by the ultrastructure of the cytosomes, by the acid phosphatase activity observed in them (MEEK and LANE 1964, BARANYI 1966) and by the PF-positivity found in certain lysosomes (STUTINSKY and co-workers 1963). Data of BARANYI (1966) demonstrating that in the nerve cells of *Anodonta cygnea* the acid phosphatase activity is completely absent during winter, indicate that cytosomes still cannot be identified without further considerations with lysosomes as this latter is known in general to have a constant acid phosphatase activity. The interpretation of NOLTE and co-workers (1965) that cytosomes may perform a function of lysosomes in a certain stage of their development — still are not in their whole lysosomes — seems to be acceptable.

Summary

Author investigated on all the three paired ganglia of *Anodonta cygnea* L. the properties of cytosomes in the usual way as well as after freeze-drying in paraffine-embedded material and on cryostat sections. The applied methods were: "neurosecretory" stainings, histochemical reactions to detect respiratory enzymes and electron-microscopic investigations.

The electron-microscopic structure of lipochrome pigment-containing granules is identical with the structure of cytosomes in Gastropods reported by NOLTE and co-workers (1965). The paraldehyde-fuchsin-positive material of the cytosomes corresponds to the carotenoid-containing lipochrome pigments. This pigment is in general alcohol-soluble — in summer, autumn and winter it can be dissolved from the cells completely within a short period of time (30 min) and in this case be obtained paraldehyde-fuchsin positivity in material exposed to alcohol treatment only for a short time or not at all. In spring the alcohol solubility of the pigment decreases and it cannot be dissolved from the nerve cells even after a longer (20 hours) period. In these cases be found in the cells paraldehyde-fuchsin positivity in materials exposed to longer alcohol treatment, too.

Histochemically the cytochrome oxidase and succinate-dehydrogenase activities are localized besides mitochondria also in the cytosomes. This emphasizes the important role of cytosomes in cell metabolism. Tubular mitochondria of special structure are present besides the cytosomes.

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HISZTOLÓGIAI, HISZTOKÉMIAI ÉS ELEKTRONMIKROSZKÓPOS VIZSGÁLATOK AZ ANODONTA CYGNEA L. (MOLLUSCA, LAMELLIBRANCHIATA) IDEGSEJTJEINEK CYTOSOMÁIN

Zs.-Nagy Imre

Összefoglalás

Az *Anodonta cygnea* mindhárom ganglionpárján vizsgálta szerző a cytosomák tulajdonságait szokásos módon, valamint liofilizálás után paraffinba ágyazott, továbbá kryostátos anyagon a „neuroszekréciós” festések, a légzőfermentek kimutatására alkalmas hisztokémiai reakciók és elektronmikroszkóp segítségével.

A lipochrom pigmentet tartalmazó szemcsék elektronmikroszkópos szerkezete a NOLTE és mtsai (1965) által Gastropodákban leírt cytosomák szerkezetével azonos. A cytosomák paraldehydfuchsin-pozitív anyaga a karotinoidokat tartalmazó lipochrom pigmentnek felel meg. E pigment általában alkohololdékony, nyáron, ősszel és télen már rövid idő alatt (30 perc) teljesen kioldható alkohollal a sejtekből, s ilyenkor alkoholhatásnak csak rövid ideig vagy egyáltalán ki nem tett anyagon kapunk PF-pozitivitást. Tavasszal a pigment alkohololdékonytsága csökken, hosszabb idő alatt (20 óra) sem oldódik ki teljesen az idegsejtekből. Ilyenkor marad a sejtekben PF-pozitivitás hosszabb alkoholhatásnak kitett anyagban is.

A cytochromoxydase és a succino-dehydrogenase aktivitása hisztokémiailag a mitochondriumok mellett a cytosomákra is lokalizálódik. Ez hangsúlyozza a cytosomák sejttanyagcserében játszott szerepének fontosságát. A cytosomák mellett sajátos szerkezetű tubuláris mitochondriumokat találunk.

ГИСТОЛОГИЧЕСКИЕ, ГИСТОХИМИЧЕСКИЕ И ЭЛЕКТРОННО-МИКРОСКОПИЧЕСКИЕ ИССЛЕДОВАНИЯ В ЦИТОСОМАХ НЕРВНЫХ КЛЕТОК БЕЗЗУБКИ

Имре Ж.-Надь

Были изучены свойства цитосом во всех трех парах ганглиев беззубки при помощи «нейросекреторных окрашиваний» обычным образом и после лioфилизации в залитом парафине материале а также в криостатных срезах и при применении гистохимических методов, употребляемых для выявления дыхательных ферментов и наконец электронно-микроскопически.

Электронно-микроскопическая структура зерн, содержащих липохромные пигменты, такая же, как эта была описана для цитосом в брюхоногих моллюсках (NOLTE et al, 1965). Паральдегидфуксин-положительное вещество цитосом соответствует липохромному пигменту, содержащему каротиноиды. Этот пигмент обычно растворяется в спирте,

летом, осенью и зимой уже после кратковременного воздействия спирта (30 мин.) полностью вымывается из клеток и в это время ПФ-положительность обнаруживается только в тех клетках, которые предварительно не обрабатывались спиртом или воздействие его было слишком короткое. Весной растворимость пигмента в спирте понижается и даже после длительной обработки (20 часов) не вымывается полностью из клеток. В этом периоде года ПФ-положительность клеток сохраняется и после длительной обработки спиртом.

Активность цитохромоксидазы и сукцинодегидрогеназы кроме митохондрии выявляется и в цитосомах. Это подчеркивает важную роль цитосом в обмене веществ клеток. В окружности цитосом обнаруживаются тубулярные митохондрии с характерной структурой.

PHARMACOLOGICAL INVESTIGATIONS ON THE ISOLATED PENIAL APPARATUS OF FRESH-WATER SNAIL *LYMNAEA STAGNALIS* L.

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Only few investigations are known concerning the pharmacology of the penial apparatus of Gastropoda. It was pointed out by KOSHTOYANTS (1936) that the genital apparatus of *Helix pomatia* L. behaves differently from the other organs of the vertebrates. It was established by JAEGER (1962, 1963) in course of his examinations on the penis retractor muscle of *Strophocheilos oblongus* that acetylcholine (ACh) and 5-hydroxytryptamine (5-HT) produced antagonistic response of the preparation with respect to rhythm induction. As suggested by GODDARD (1962) only adrenaline is effective on the penial apparatus of *Helix aspersa* and ACh and histamine are ineffective at concentrations used. The response of the isolated penial complex of *Lymnaea stagnalis* on the application of various agents has been investigated recently by DUNCAN (1964). He observed that in the majority of cases 5-HT produced relaxation inducing frequent rhythmic activity, while the application of ACh resulted in an increase of frequency and decrease in amplitude of spontaneous activity. The aim of the present investigations is partly to examine the contradictory data on the effect of ACh and 5-HT and partly to obtain new data on the mechanism of the effect of these agents on penis preparations.

Method

The specimens of *Lymnaea stagnalis* L. used in these investigations were collected partly from Lake Balaton, partly from pond "Külső tó" at Tihany and were kept for several weeks in aquaria filled with Lake Balaton water before experimental use.

The penial preparation was made as follows: the shell of the animal was removed and the penial complex (penis, penis sheath, praeputium, flagellum) was exposed by cutting up the body wall. The penis retractor muscle and the nerves running to the preparation were cut through. Following this, the preparation was lifted out together with a small portion of the body wall, it was ligated at the end of the body wall and at the flagellum and hung up in a bath of 20 ml in volume. Physiological solution was prepared according to CARRIKER (1946). The activity of the preparation was registered by a light lever on a kymograph at a 10 : 1 lever ratio. After operation the preparations were left to

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stand for half an hour. The agents investigated were added to the bath with an injection syringe. The concentrations given are final concentrations expressed in g/ml. Air-flow was led through the bath producing a rapid mixing of the agents with the bath fluid.

The agents used were: 5-hydroxytryptamine creatinine sulphate (5-HT), acetylcholine chloride (ACh), methysergide (UML-491), 2-bromo-lysergic acid diethylamide (BOL-148), benzoquinonium chloride (mytolon), dibenamine, atropine sulphate, cocaine, morphine, d-tubocurarine chloride, and eserine.

The experiments were performed at room temperature (20–22 °C) in March, April and May.

Results

When the contraction subsequent to preparation ceased the preparation displayed, in the majority of cases, spontaneous rhythmic activity. This rhythmic activity consisted of small phasic contractions and of occasionally occurring interpolated large tonic contractions (*Fig. 1*).

The effect of 5-hydroxytryptamine

The penial complex responded to 5-HT with contraction and with a subsequent rhythmic activity of increased amplitude and frequency (*Fig. 2*), whereas on preparations in the resting period activity was induced. Depending on concentration two-phase effect was produced by 5-HT. It resulted in a small relaxation near threshold concentration (5×10^{-9} g/ml). At 10^{-8} – 10^{-5} g/ml concentrations or above 5-HT never produced relaxation, the response produced was always tonic contraction and its duration increased at higher concentrations. If the preparation was subject only for a short period to the effect of 5-HT then after repeated washings it responded again to the same or to

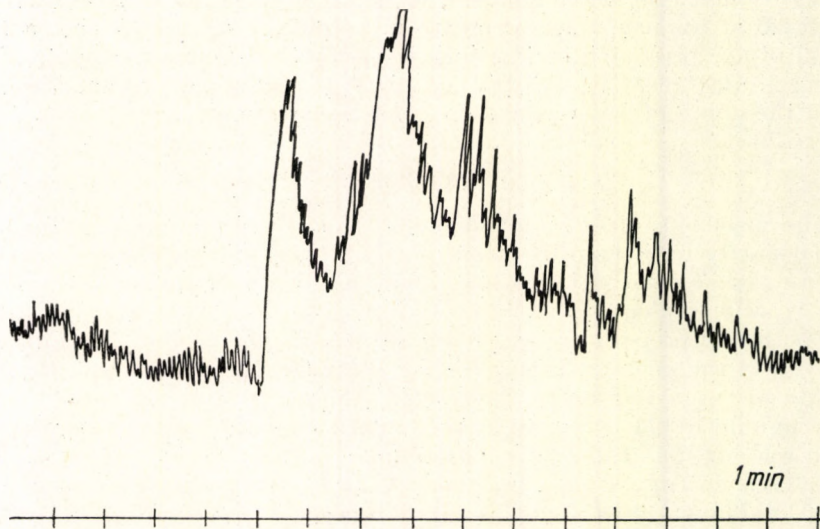


Fig. 1. Spontaneous rhythmic activity of isolated penis complex

1. ábra. Az izolált penis komplex spontán ritmikus aktivitása

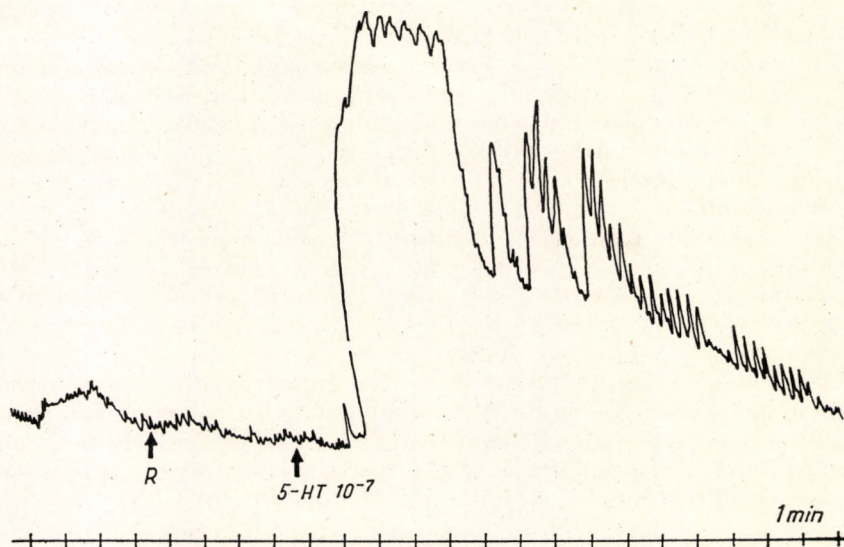


Fig. 2. Effect of 10^{-7} g/ml 5-HT on the isolated penis preparation of *Lymnaea*
 2. ábra. 5-HT hatása *Lymnaea* izolált penis preparátumán 10^{-7} g/ml koncentrációban

higher concentrations of 5-HT. On the applications of high concentrations, however, tachyphylaxy was produced. For instance if 10^{-5} g/ml solution of 5-HT was left on the preparation for a longer period (1–2 hours) the original level of tonus from the initial contraction was restored without washing, the preparation, however, did not respond again to lower concentrations of 5-HT.

Effect of agents influencing the effect of 5-HT

The effect of serotonin was influenced by 5-HT and ACh-antagonists and narcotics.

BOL-148 applied by itself did not affect the activity of the penial apparatus. After pretreatment as long as 10–15 mins, 10^{-5} – 10^{-6} g/ml concentrations of this agent completely inhibited the effect produced by 5×10^{-7} g/ml 5-HT (Fig. 3). After repeated washings the preparation turned sensitive

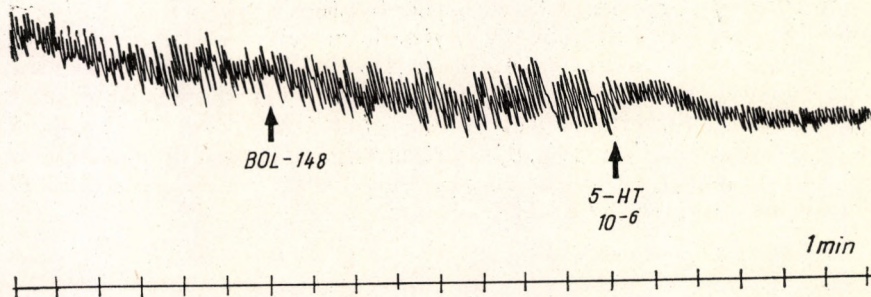


Fig. 3. Effect of 10^{-6} g/ml 5-HT on penis preparation pretreated with BOL-148 for half an hour

3. ábra. 10^{-6} g/ml 5-HT hatása a félórásig BOL-148-cal előkezelt penis preparátumon

again to 5-HT, and responded with contraction as usual. UML-491 produced a similar effect to BOL-148.

Dibenamine was also found to block the effect of 5-HT with the difference that it produced a more lasting contraction than 5-HT, and after about 25 mins the preparation treated with dibenamine became restored also to the original level of tonus. After pretreatment with 10^{-6} g/ml concentration of this agent the application of 10^{-6} g/ml 5-HT produced only small increase in tonus, it induced, however, a considerable rhythmic activity.

Atropine in 10^{-6} g/ml concentration strongly increased both frequency and amplitude of the rhythmic activity or if there was no rhythmic activity before induced tonic activity. This agent inhibited strongly, even after 5 mins of pretreatment, the effect of 10^{-6} g/ml 5-HT solution which otherwise produced contraction (Fig. 4). In some cases, however, an insignificant contracting effect persisted and was followed by an immediate and considerable relaxation. Subsequent to washing the original activity of the preparation was restored but upon applying 5-HT repeatedly it did not produce the usual effect, but increased only the amplitude of the spontaneous activity. Atropine produced lasting effect.

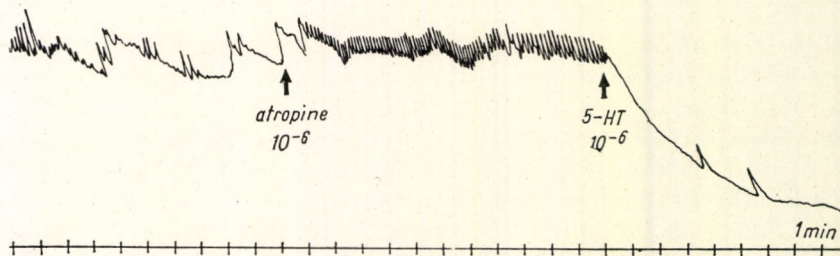


Fig. 4. Effect of 10^{-6} g/ml 5-HT on penis preparation pretreated with atropine (10^{-6} g/ml)
4. ábra. 10^{-6} g/ml 5-HT hatása atropinnal (10^{-6} g/ml) előkezelt penis preparátumon

Morphine at 10^{-5} – 10^{-3} g/ml concentrations affected the penis preparations by itself and produced contraction of tonic character. After restoration to the original level of tonus the preparation responded after pretreatment with 10^{-5} g/ml morphine, to the application of 10^{-6} g/ml 5-HT either with unchanged or with slightly decreased contraction. Applying this agent, however, in 10^{-3} g/ml concentration the contracting effect of 10^{-6} g/ml 5-HT completely ceased and a frequent rhythmic activity was induced (Fig. 5).

d-Tubocurarine and cocaine were ineffective in 10^{-5} g/ml concentration, when applied, however, in 10^{-3} g/ml concentration these agents inhibited completely the contracting effect of 10^{-6} g/ml 5-HT; after their application 5-HT produced relaxation (Fig. 6). Further on, 5-HT when applied subsequent to the application of d-tubocurarine produced rhythmic activity of increased amplitude and frequency (Fig. 7).

The effect of acetylcholine

The threshold concentration of this agent was about 10^{-10} g/ml. This and higher concentrations up to 10^{-5} g/ml produced alike contraction of the penial preparation. For a period rhythmic activity also ceased, it was however restituted by itself.

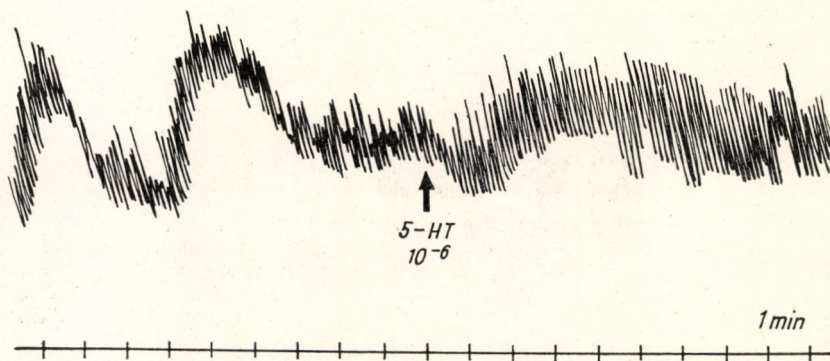


Fig. 5. Effect of 10^{-6} g/ml 5-HT after 20 mins pretreated with morphine (10^{-3} g/ml)

5. ábra. 10^{-6} g/ml 5-HT hatása morfinnal való (10^{-3} g/ml) 20 perces előkezelés után

Effect of agents influencing the effect of ACh

Mytolon solution at 10^{-6} – 10^{-5} g/ml concentrations, which by themselves proved to be strongly stimulatory on the preparation, did not inhibit practically after 1 hour application the effect of 10^{-6} g/ml ACh and 5-HT. After a half an hour pretreatment with higher concentrations (10^{-4} – 10^{-3} g/ml) of mytolon the stimulatory effect of ACh decreased only slightly. On the other hand, 10^{-6} g/ml concentration of atropine completely inhibited the contracting effect of ACh of same concentration (Fig. 8). Rhythmic activity of very high frequency which was induced by atropine, however, ceased on the next application of ACh, it was, however, restored by itself also without washing within about 10 mins.

d-Tubocurarine, cocaine and morphine applied in 10^{-5} g/ml concentration did not inhibit the contracting effect of ACh (10^{-7} – 10^{-6} g/ml), and d-tubocurarine even potentiated at the concentration applied the stimulatory effect of ACh. Rising the concentration of these agents further (10^{-4} – 10^{-3} g/ml) the contraction-producing effect of ACh decreased, but was not completely blocked.

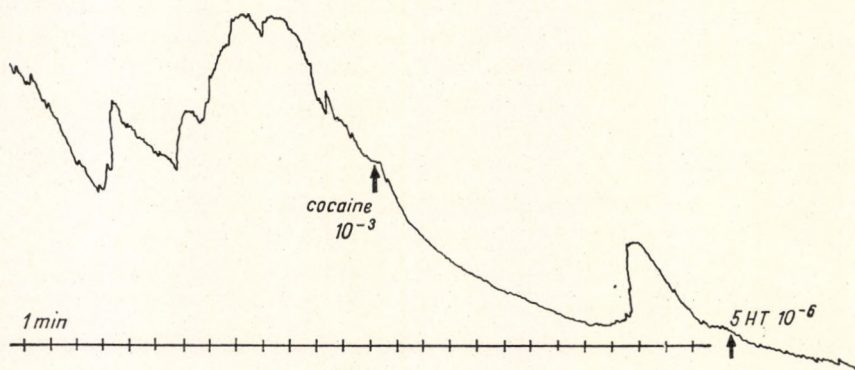


Fig. 6. Effect of 10^{-6} g/ml 5-HT on preparation pretreated with cocaine (10^{-3} g/ml)

6. ábra. 10^{-6} g/ml 5-HT hatása kokainnal (10^{-3} g/ml) előkezelt penis preparátumon

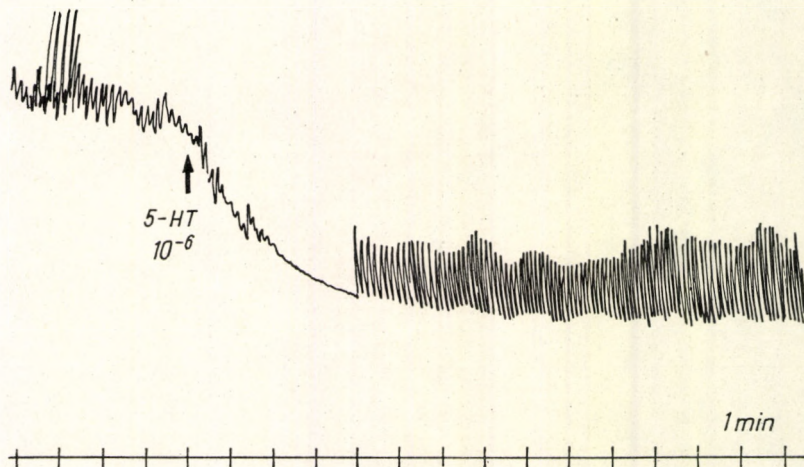


Fig. 7. Effect of 10^{-6} g/ml 5-HT on the application (15 mins) of d-tubocurarine (10^{-3} g/ml)

7. ábra. 10^{-6} g/ml 5-HT hatása d-tubocurarin (10^{-3} g/ml) (15 perc) adása után

Eserine (10^{-4} g/ml) increased strongly the tonus of the preparation. Which was restituted only after a longer interval, whilst a rhythmic activity of greater frequency and higher amplitude was induced as compared to the original. The contraction produced after subsequent application of ACh was similar to the reaction of untreated preparation, rhythmic activity, however, was completely inhibited.

Discussion

The rhythmic activity of the penial apparatus of *Helix aspersa* results from its unbroken contact with the central nervous system (GODDARD 1962). In opposition to this it was observed in conformity with previous observation by DUNCAN (1964) that in case of *Lymnaea stagnalis* the penial apparatus can produce spontaneous rhythmic activity also independently from the nervous system. As observed by us, the normal rhythmic activity consists of small phasic contractions and of occasional, interpolated great tonic contractions with superimposed phasic ones.

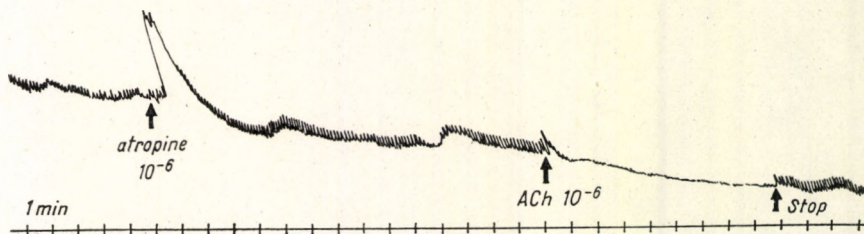


Fig. 8. Effect of 10^{-6} g/ml acetylcholine on penis preparation pretreated with atropine (10^{-6} g/ml)

8. ábra. 10^{-6} g/ml acetylcholin hatása atropinnal (10^{-6} g/ml) előkezelt penis preparátumon

The fact that the penial apparatus is richly supplied with nerves (ELO 1938, GODDARD 1962) renders the study of the effect of drugs more complicated, namely, not only the effect produced on the smooth muscle but that on the neurons must be also considered.

Concerning the effect of 5-HT only relaxation and a rhythmic activity of increased amplitude and frequency was observed by DUNCAN (1964) on the penial apparatus of *Lymnaea*. It was shown, however, by our experiments that 5-HT produced a two-phase effect. At low concentrations (5×10^{-9} g/ml) 5-HT produced weak relaxation, whereas at higher ones always a tonic contraction. Similar results were obtained previously by JAEGER (1963) applying 5-HT on the penis retractor muscle of *Strophocheilos oblongus*, when up to 10^{-8} g/ml concentration relaxation and at higher concentrations an increase of tonus was observed, further by GREENBERG and JEGLA (1963) on the rectum of *Mercenaria mercenaria* and by PHILLIS (1966) on the rectum of *Tapes wallingi*.

It was suggested by GREENBERG and JEGLA (1963) that 5-HT is effective on two sites on the isolated rectum of *Mercenaria*:

- (a) it produces ACh release on cholinergic neurons,
- (b) affects smooth muscles directly.

Using different inhibitors, it became evident, that in case of the preparation used by us in these studies both the neurons and the muscle itself are to be considered. In these studies the contracting effect produced by 5-HT was completely blocked by BOL-148, UML-491 and dibenamine and this was not accompanied by relaxation. The effect of 5-HT on the penial apparatus could also be effectively blocked by ACh antagonists, in that case, however, the application of 5-HT was always followed by a considerable relaxation. The two different types of blocking effect are presumably separated on the basis whether the agents eliminated the direct effect of 5-HT on the muscle or its neurotropic effect (GREENBERG and JEGLA 1963; PHILLIS 1966).

Out of the ACh antagonists investigated (atropine, d-tubocurarine, mytolon) atropine proved to be most effective as regards inhibition of the effect produced by 5-HT. This observation is in contradistinction to data obtained by GREENBERG and JEGLA (1963) on the rectum of *Mercenaria* in which case, namely, the increase of tonus produced by 5-HT was potentiated by atropine, and to those obtained by GRYGLEWSKI and SUPNIEWSKI (1963) according to which atropine did not influence the 5-HT sensitivity of the isolated stomach of *Helix*. d-Tubocurarine was at 1000 times greater concentration as effective as atropine, while mytolon was completely ineffective. Comparing data obtained with those on the inhibitory effect on ACh, it is seen that in this case atropine is the most effective antagonist produced complete inhibition of ACh effect. The contraction induced by ACh was only slightly diminished by d-tubocurarine and especially by mytolon. It was found previously that atropine is an ACh-inhibitor on the isolated stomach (GRYGLEWSKI and SUPNIEWSKI 1963) and intestine (MINKER and KOLTAI 1961) of *Helix*. The penial apparatus of *Lymnaea* behaves differently in this respect, from the genital apparatus of *Helix pomatia*, for in case of the latter the effect of ACh was not inhibited by atropine but by nicotine (KOSHTOVANTS 1936). It is known from studies on the rectum of *Mercenaria* (GREENBERG and JEGLA 1963) that atropine is more effective ACh antagonist than mytolon. Moreover, mytolon blocked on the rectum of *Tapes* only the inhibitory component of the ACh effect, whereby the excitatory component of ACh effect prevailed (PHILLIS 1966). In opposition

to this d-tubocurarine was the most effective ACh antagonist on the rectum of *Tapes*, it inhibited both synaptic and "non-synaptic" ACh receptors, while atropine had only small antagonistic effect (PHILLIS 1966). The same observation was made on the retractor muscle of isolated penis preparations of *Strophocheilos* (JAEGER 1962).

It is worth to note that eserine which normally potentiated the effect of ACh did not produce in the course of these investigations observable alterations.

From among the investigated agents only atropine induced at the concentrations used rhythmic activity of greater amplitude and frequency as compared to the control. This might be explained by the stimulatory effect of atropine on motor activity as observed also in case of preparations of other invertebrates (BARKER, BUEDING and TIMMS 1966).

Besides atropine other agents like morphine and cocaine which as observed by GADDUM and PICARELLI (1957) blocked the M-receptors on the ileum of guinea pig, produced also complete block of 5-HT effect and decreased the contracting effect of ACh on the penial apparatus of *Lymnaea*. It is suggested by GREENBERG and JEGLA (1963) that morphine inhibits the travel of nerve conduction produced by 5-HT, and possibly inhibits the ACh-release from cholinerg nerve endings. In view of the fact that 5-HT contracts the longitudinal muscles of penial preparations and that this effect is inhibitable by the above agents, it is thought probable that the contracting effect of 5-HT asserts itself by the excitation of cholinerg nerve fibers.

The fact that the penial apparatus of *Lymnaea* and the rectum of *Mercuria* (GREENBERG and JEGLA 1963) and *Tapes* (PHILLIS 1966) respond similarly to the investigated chemical agents suggests that the preparations in question have similar pharmacological behaviour. The observation that in the case of the penial apparatus of *Lymnaea* the order of effectiveness of 5-HT-antagonists differed from that of preparations of other molluscs suggests the specificity of the preparation used. In view of the fact that ACh-antagonists which blocked in course of our experiments the contracting effect of 5-HT antagonized the effect of ACh, too, it is thought probable, as suggested by GREENBERG and JEGLA (1963), that this effect produced by 5-HT might be realized by way of ACh release. The relaxing effect produced by 5-HT, however, may assert itself only after the elimination of the above contracting effect of this agent.

Summary

The mechanism of the effect of 5-HT and ACh was examined on the isolated penial apparatus of a fresh-water snail, *Lymnaea stagnalis* L. The preparation responded with tonic contraction to the application of both 5-hydroxytryptamine and acetylcholine. On these two agents atropine proved to be the most effective antagonist. The blocking effect of BOL-148, UML-491, dibenamine, cocaine, d-tubocurarine, mytolon and morphine was studied on the effect produced by 5-HT and ACh.

The results emphasize besides the specificity of the preparation used the similarity between the isolated penial apparatus of *Lymnaea* and other molluscan preparations with regards to their pharmacological behaviour.

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FARMAKOLÓGIAI VIZSGÁLATOK EGY ÉDESvíZI CSIGA,
LYMNAEA STAGNALIS L. IZOLÁLT PENIS PREPARÁTUMÁN

Pécsi Tibor, H. Kuziemski és S.-Rózsa Katalin

Összefoglalás

A *Lymnaea stagnalis* édesvízi csiga izolált ivari apparátusán vizsgálták az 5-HT és ACh hatásmechanizmusát. A preparátum mind az 5-hydroxytryptaminra, mind az acetylcholinra tónusos kontrakcióval válaszolt. Mindkét vegyület leghatásosabb antagonistájának az atropin bizonyult. Az 5-HT, illetve az ACh hatás blokkolása céljából a BOL-148, UML-491, dibenamin, kokain, d-tubocurarin, mytolon és a morfin hatását vizsgáltuk. Az eredmények a preparátum specifikumának hangsúlyozása mellett a *Lymnaea* izolált ivari apparátusának más molluszká preparátumokhoz való hasonlóságát sugallják a farmakológiai viselkedést illetően.

ФАРМАКОЛОГИЧЕСКИЕ ИССЛЕДОВАНИЯ НА ИЗОЛИРОВАННОМ
ПОЛОВОМ АППАРАТЕ БОЛОТНОГО ПРУДОВИКА

Тибор Печи, Генрик Куземский и Каталин Ш.-Рож

На изолированном половом аппарате болотного прудовика был изучен механизм действия серотонина и ацетилхолина. Препарат давал тонические сокращения и на серотонин и на ацетилхолин. Атропин оказался самым эффективным антагонистом обоих веществ. С целью блокирования действия серотонина и ацетилхолина были применены БОЛ-148, УМЛ-491, дибенамин, кокаин, тубокурарин, митолон и морфий. Результаты показали, что изолированный половой аппарат болотного прудовика ведет себя подобно другим препаратам моллюсков.

BIOLOGICALLY ACTIVE COMPOUNDS IN THE GLOCHIDIA OF *ANODONTA CYGNEA* L. I. IDENTIFICATION OF TRYPTAMINE AND SOME AMINO ACIDS BY PAPER CHROMATOGRAPHY

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Examinations conducted on agents functioning as either local hormones or transmitters in the stimulatory processes occurring in the early state of the ontogeny of Mollusca are incomplete. It was suggested that 5-HT and tryptamine may, due to their motor increasing effect, be of importance on the veliger larvae of marine gastropods (KOSHTOYANTS, BUZNIKOV and MANUKHIN 1961) and on the glochidia of *Anodonta* (LÁBOS, SALÁNKI and S.-RÓZSA 1964), respectively.

In this present paper we shall report on the chemical analysis conducted by us on active compounds extracted from the glochidia of *Anodonta* and also data obtained by biological testing will be presented.

Method

The glochidia of *Anodonta cygnea* L. were used as test objects. The larvae were obtained from the gill of the mother.

Extraction

The glochidia taken from the gill of full-grown specimens of *Anodonta* were put into Lake Balaton water. The mucous binding substance was removed by repeated washing. 20 g of the washed glochidia was homogenized in 20 ml 50% ice-cold acetone under constant cooling and was placed for 30 mins into a refrigerator at +5° C. Thereafter the homogenized sample was centrifuged for 30 mins at 3500 r.p.m. and the supernatant was evaporated under reduced pressure and taken up in 10% isopropanol solution (1—2 ml). This solution was used for analysis by paper chromatography. In case of biological testing the extract was taken up in snail Ringer solution (MENG 1958) or in Lake Balaton water. Evaporation and development was performed in nitrogen saturated atmosphere.

Chromatographic analysis

The ascending, one-dimensional paper chromatography was employed on Whatman No 1 paper. The following solvents were used: butanol-acetic acid-water (4 : 1 : 5), isopropanol-ammonia-water (8 : 1 : 1), 8% NaCl solution.

Development in NaCl lasted for 1 hour, in the other two solvents for 10–18 hours.

After chromatographic separation the chromatograms were dried and the spots were made visible either with 0.2% ninhydrin (SMITH 1960) at 105° C, or with Erlich- reagent (CURSON and LEEDS 1955), at room temperature. The spots visualized with ninhydrin were viewed under ultraviolet light were both 5-HT and tryptamine appeared as greenish fluorescing spots (ROD-NIGHT 1959).

Biological testing

Biological testing was performed on glochidia and on the isolated heart preparations of *Helix pomatia* L. In case of glochidia, testing was made as described previously in course of studies on the effect of other agents (LÁBOS, SALÁNKI and S.-RÓZSA 1964), the isolation of *Helix* heart was made as described previously (S.-RÓZSA and GRAUL 1964).

The extract obtained from the glochidia was tested, without chromatographic analysis, in various dilutions in Ringer solution adapted for snail and in Lake Balaton water.

For examining heat stability of the biologically active agents aliquots were taken and kept in a water bath for 15 mins at 100 °C.

The following agents were used as controls and applied dissolved in 10% isopropanol solution: tryptamine (Fluka), 5-hydroxytryptamine creatinin-sulphate (Fluka) and various amino acids.

The experiments were carried out in spring months (March, April) within one season.

Results

1. Chromatographic analysis

On the chromatograms several ninhydrin positive spots were discernible. One of them exhibited greenish fluorescence under ultraviolet light. In the following this spot was identified by running it dissolved in various solvents together with control tryptamine. Upon evidence of data obtained by us the spot revealed by fluorescence may be taken for tryptamine. 5-hydroxytryptamine exhibiting a similar fluorescence cannot be considered because of its Rf value.

It is noteworthy that in case of short term (1–3 hours) development of freshly prepared extracts a fluorescent spot was revealed on every occasion at

Table 1

Presents RF values of one substance of the extract and of control tryptamine in case of different solvents

Solvent	Rf value	
	glochidium extract	tryptamine
Isopropanol-ammonia-water (8 : 1 : 1)	0.71	0.71
Butanol-acetic acid-water (4 : 1 : 5)	0.75	0.76
NaCl 8%	0.54	0.57

the same height with control tryptamine, in case of long-term development, however, (16—18 hours) a nonfluorescent positive ninhydrin spot was observed in the place of tryptamine.

Similarly, on every occasion, a non-fluorescent spot that stained pinkish-purple with Ehrlich-reagent was seen at the same distance with control 5-HT ($R_f = 0.40$). This spot cannot be considered identical with 5-HT, for it does not exhibit fluorescence under ultraviolet light, not even if short term development technique was applied.

Development in NaCl, when it did not last beyond 1 hour, produced colour reactions indicative of indolalkylamine decomposition products.

- | | |
|----------------|--------------|
| 1. bluish-grey | $R_f = 0.75$ |
| 2. blue | $R_f = 0.41$ |
| 3. yellow | $R_f = 0.65$ |

Out of them the 1st and 3rd fades quickly and the stability of the 2nd lasts longer. These facts suggest that in the glochidia an important role is played by indolalkylamine metabolism.

In the course of tryptamine-determinations the single amino acids were, as expected, best resolved in the solvent: butanol—acetic acid—water. In the followings the single amino acids were run as controls together with the separated and eluted spots. In this way five different amino acids were identified. Phenylalanine was identified on ninhydrin pretreated paper and with 1% NaHCO_3 treatment after which the colour reaction of other amino acids disappeared and only that of phenylalanine remained. Tyrosine was detected with Ehrlich-reagent and the other amino acids with ninhydrin. The R_f values of these amino acids are summarized in *Table 2*.

Table 2
Identification of amino acids in
butanol : acetic : acid : water (4 : 1 : 5) mixture

Spot of glochidium extract	R_f	Amino acid	R_f
1	0.15	tyrosine	0.14
2	0.20	valine	0.20
3	0.36	tryptophan	0.36
4	0.39	leucine	0.38
5	0.50	phenylalanine	0.51

The other five compounds having high R_f values (0.59—0.80—0.92—0.96—0.98) could not be identified with amino acids. It cannot be excluded that there are in the extract peptides which are separable and detectable on paper with identical methods (WELSH and FRONTALI 1966, JAEGER 1966).

2. Biological testing

5, 10, 20 and 30fold dilutions of the extract produced alike stimulation on isolated *Helix* heart preparations. Subsequently, the effect of 1 : 10 dilution was studied. The increase of amplitude and frequency produced

is similar to the activity increasing effect of biologically active amines. Initial sharp rise which is characteristic of the effect of 5-HT was never observed (Fig. 1).

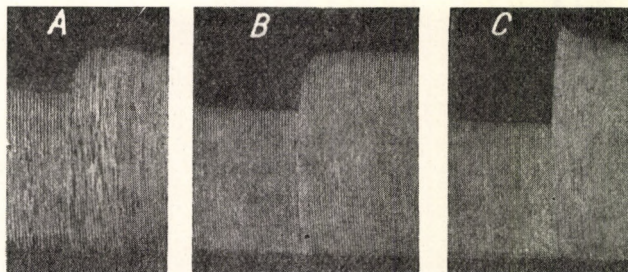


Fig. 1. Biological testing conducted on the isolated heart preparation of *Helix*
A — tryptamine (10^{-5} M), *B* — extract of glochidium (diluted to 1 : 10), *C* — 5-hydroxytryptamine (10^{-6} M)

1. ábra. Biológiai tesztelés izolált *Helix* szíven.

A — triptamin (10^{-5} M), *B* — glochidium extraktum $10\times$ -es hígításban
C — 5-hidroxytryptamine (10^{-5} M)

If the extract was applied dissolved in 5 ml Lake Balaton water the glochidia responded with an initial increase of activity, within 10–15 mins, however, this phenomenon ceased (Fig. 2*A*) and 80–90% of the animals was closed by this time. In case the extract was used after dilution the sharp initial increase of activity was missing and a gradual increase of activity was observed which lasted for more than 20 mins (Fig. 2*B*). This activity increase was different from that produced by tryptamine (Fig. 2*D*), namely, its level was the same in the first 10 mins and in the interval between 10–20th mins. Greater dilutions produced similar effect.

Heat treatment of the extract of glochidia increased the effectiveness of the active compounds in them. Thus on *Helix* heart the activity increasing effect of the extract increased by 20–40% after boiling, and in the case of glochidia, too, a characteristic, more than 20 min long activity was produced. This effect is more pronounced when using a 1 : 5 dilution (Fig. 2*C*). On the other hand the ratio of closures in the boiled extract decreases by 20–45%. A greater ratio of closure was not produced even if the boiled extract was applied for more than 20 mins.

Discussion

In the freshly collected acetone extracts of glochidia tryptamine was demonstrable. From among biologically active agents tryptamine is the most effective in producing an increase in the rhythmic activity of glochidia (LÁBOS, SALÁNKI and S.-RÓZSA 1964). After detection with ninhydrin the component present in the extract exhibited greenish fluorescence under ultraviolet lamp and stained purple with Ehrlich reagent and was located at the same level with tryptamine. 5-HT was not demonstrable in the extract.

Tyrosine, valine, tryptophan, leucine and phenylalanine were also identified in the acetone extract by parallel development with amino acids. The

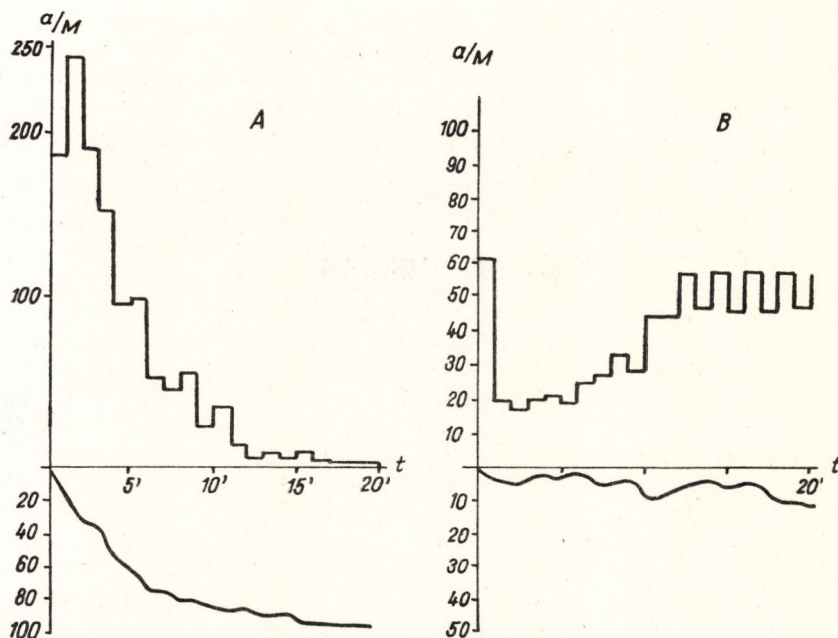
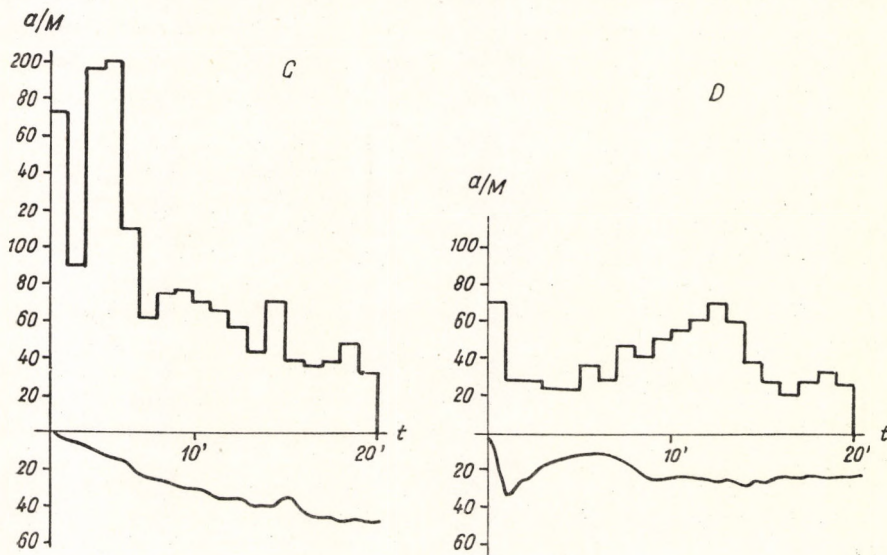


Fig. 2. Biological testing on glochidia. *Abscissa*: time in minutes. *Ordinate*: number of contractions per minutes. The lower curve expresses the ratio of closed in percentage of glochidia. A — glochidium extract diluted to 1 : 5, B — glochidium extract diluted to 1 : 10, C — 5 fold diluted glochidium extract after boiling for 10 minutes, D — 100 μ g/ml tryptamine

2. ábra. Biológiai tesztelés glochidiumokon. *Abszcissa*: idő percekben, *ordináta*: a kontrakciók percenkénti száma. Az alsó görbe a bezárt glochidiumok arányát adja %-ban. A — glochidium extraktum 5-ös hígításban, B — glochidium extraktum 10-es hígításban, C — 5-ös hígítású glochidium extraktum 10 perces forralás után, D — 100 μ g/ml triptamin



other five components were not identified for lack of control. In the case of the nonidentified factors the investigations have to be extended for peptides which are applied as stimulatory factors on molluscs (JAEGER 1966, WELSH and FRONTALI 1966). It is not out of question that besides biologically active amines peptides, too, are involved in the stimulatory effects produced on glochidia.

Data obtained by biological testing show that in the acetone extract of glochidia stimulatory factors are predominating. Not even highly concentrated extract produced inhibition on *Helix* heart. The concentrated extract produced on the glochidia also considerable tonic effect. The increase of rhythmic activity produced is similar to that produced by ions (initial effect), and by tryptamine (an effect lasting for more than 10 mins). On heat treatment the stimulation produced by the extract both on *Helix* heart and on the rhythmic activity of glochidia increased. At the same time, however, its effect on closures of glochidia decreased. This implies that the factor which produces tonic effects is not heat stable and changes on the effect of heating. The observation, however, that the effect produced by the stimulatory factor increases upon heat treatment suggests that a portion of it may be present in the extract also in bounded form which is activated on the effect of heating. It might be also inferred, as an explanation to this phenomenon, that due to the decreased tonic effect, there are more glochidia in the condition of producing rhythmic activity.

The presence of tryptamine in the extract of glochidia supports our previous supposition that this agent might be considered as a local hormone in these larvae (LÁBOS, SALÁNKI and S.-RÓZSA 1964). It has to be emphasized that three amino acids: tyrosine, phenylalanine and tryptophan that are the precursors of important, biologically active amines were also detected by us. The presence of tyrosine and phenylalanine emphasizes again the role played by the catecholamines to which we attributed previously an inhibitory function (LÁBOS 1966). It is also imaginable that depending on changes in the receptor structures and enzyme systems different agents may take the main role in mediation in the different states of ontogeny. This might explain in the case of *Anodonta* the difference of mediation observed among full-grown specimens and in specimens in different states of ontogeny.

Summary

1. Tryptamine is detectable in the acetone extract of glochidia by paper chromatography. This serves as a new evidence for the suggestion that this agent functions as a local hormone in these larvae.

2. From among the amino acids tyrosine, valine, tryptophan, leucine and phenylalanine were identified in the extract of glochidia by paper chromatography.

3. It was established by biological testing that the activity of some stimulatory factors in the extract of the glochidium increases on the effect of heat. The factor producing tonic contraction is heat-sensitive and its activity decreases on heat-treatment.

4. It is assumed that in the different states of ontogeny different biologically active amines are functioning as transmitters in the case of *Anodonta* species.

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BIOLÓGIAILAG AKTÍV ANYAGOK ANODONTA CYGNEA GLOCHIDIUMAIBAN I. TRIPTAMIN ÉS NÉHÁNY AMINÓSAV PAPÍRKROMATOGRÁFIÁS IDENTIFIKÁLÁSA

S.-Rózsa Katalin és Lábos Elemér

1. Glochidiumok acetonos extraktumában papírkromatográfiásan kimutatható triptamin, amely újabb érv ezen ágens lokális hormon szerepére nézve ezen lárvákon.
2. Aminósavak közül a tirozint, valint, triptofánt, leucint és fenilalanint identifikálták papírkromatográfiásan, glochidiumok extraktumából.
3. Biológiai tesztelés eredményeként megállapítást nyert, hogy a glochidium-extraktum bizonyos serkentő anyagainak aktivitása hő hatására növekszik. A tónusos zárast létrehozó faktor hőérzékeny, aktivitása hőkezeléssel csökken.
4. Feltételezik, hogy a fejlődés különböző szakaszaiban más-más biológiailag aktív amin tölt be transzmitter szerepet *Anodonta*-kon.

БИОЛОГИЧЕСКИ АКТИВНЫЕ ВЕЩЕСТВА В ГЛОХИДИЯХ БЕЗЗУБКИ I. ИДЕНТИФИКАЦИЯ ТРИПТАМИНА И НЕКОТОРЫХ ДРУГИХ АМИНОКИСЛОТ ПОСРЕДСТВОМ БУМАЖНОЙ ХРОМАТОГРАФИИ

Каталин Ш.-Рожа и Элемер Лабощ

1. — Триптами́н был выявлен в ацетоновых экстрактах глохидиев беззубки при помощи бумажной хроматографии. Наличие этого агента подчеркивает его значение как локального гормона в глохидиях.
2. — Помимо триптамину были идентифицированы следующие аминокислоты: тирозин, валин, триптофан, леуцин и фенилаланин.
3. — В результате биологического тестирования (на сердце виноградной улитки и глохидиях) было установлено, что активность стимулирующего вещества экстракта глохидиев увеличивается при нагревании, а фактор, вызывающий тоническое закрытие глохидиев, является термолабильным, его активность при нагревании снижается.
4. — Предполагается, что на разных стадиях развития беззубки разные биологически активные амины выступают в качестве медиаторного вещества.

COMPARATIVE STUDIES ON THE EFFECT PRODUCED BY BIOLOGICALLY ACTIVE AGENTS ON THE ISOLATED HEARTS OF *HELIX POMATIA* L. AND *ANODONTA CYGNEA* L.

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It is known that the heart of molluscs responds specifically to a series of biologically active agents. The type of the effect produced by the same agent on various representatives of Mollusca may often be different. Thus, for instance, the catecholamines are recorded to have inhibitory, stimulatory and mixed effects as well (PROSSER 1940, WELSH 1953, KRIJGSMAN and DIVARIS 1955, GREENBERG 1960, JAEGER 1965). Adrenaline was inhibitory or without effect on the hearts of *Helix* and *Anodonta* (JULLIEN and RIPPLINGER 1936, ERSPAMER and GHIRETTI 1951, FÄNGE 1955).

5-hydroxytryptamine was recorded (WELSH 1957, KERKUT and COTTELL 1963, LOVELAND 1963, S.-RÓZSA and GRAUL 1964) to be stimulatory on various representatives of the Mollusca. Data concerning other biologically active amines are either contradictory or insufficient (PILGRIM 1954, GREENBERG 1960).

A review of the effects produced by acetylcholine on the molluscan hearts was given by GREENBERG (1965). The effect of this agent on different species is fairly varying it may be both inhibitory and stimulatory. In the majority of cases it may function as an inhibitory transmitter.

Previous data proved that the type of the effect produced by these agents on the hearts of different mollusc species are not comparable, for in many instances, the same species may respond differently depending on its habitat.

In view of this, it was considered, therefore, necessary to examine in detail the effect produced by these biologically active amines and amino acids on the hearts of *Helix* and *Anodonta*, since these animals were used for many years by us, as widely distributed species in Hungary, for purposes of biological testing because of the suitability of their size for physiological and pharmacological examinations.

Methods

The investigations were conducted on the isolated hearts of *Helix pomatia* L. and *Anodonta cygnea* L. Isolated snail heart preparations were made of unhibernating specimens. Before experimental use the fresh-water mussels were kept in an aquarium filled with Lake Balaton water.

Isolated snail heart preparation

The shell of the animal was removed, the visceral sac was opened along the helix and the heart exposed. Following this the pericardium was removed and a thin cannula was introduced into the auricle and ligated above the boundary of the auriculoventricle. Another ligation was made on the aorta and subsequent to this the heart was suspended by the cannula on a frame and cardiac action was registered on a kymograph. The level of the solution was kept constant in the cannula during the experiment.

In case of snail heart MENG's (1958) solution was used as a biological one and the agents investigated were also dissolved in the same.

Isolated mussel heart preparation

The valve on the dorsal side of the animal was removed and the heart was exposed by cutting open both the mantle and the pericardium. The two aortas and the left auricle were ligated and a cannula was introduced into the right side auriculoventricular opening. The ventricle was excised and suspended by the cannula on a frame and fastened by the binding at the left auricle to a light lever and cardiac action was registered on a kymograph.

To set isolated mussel's heart in action the physiological solution recommended by MARCZYNSKI (1959) was used.

The experiments were performed in spring months at room temperature (20–22 °C).

In the course of these experiments the following agents were used: acetylcholine, dopamine, adrenaline, noradrenaline, 5-hydroxytryptamine, 5-methoxytryptamine, tryptamine, tryptophan, L-tyrosine, tyramine, glutamine, γ -aminobutyric-acid (GABA), histamine, histidine, α -methyl-DOPA, DOPA, DL-phenylalanine, DL-serine, benzoquinonium chloride (mytolon) and 2-bromo-d-lysergic acid diethylamide (BOL).

Results

1. The effect of biologically active amines and amino acids

Acetylcholine (ACh) proved to be inhibitory on both the hearts of *Anodonta* and *Helix*. The heart of *Helix* was more sensitive to acetylcholine, at 10^{-9} M concentration and above the agent produced complete arrest of cardiac action. In case of lower concentrations this inhibition was eliminable after repeated washing out of the agent, at 10^{-3} M concentration, however, the inhibition was irreversible.

The threshold concentration of acetylcholine (10^{-6} M) for the heart of *Anodonta* produced a slight decrease of amplitude. Contrary to findings obtained by us previously (NISTRATOVA and PÉCSI 1966) the increase in concentration produced diastolic arrest. At 10^{-5} M and 10^{-4} M concentrations diastolic arrest lasted for 20 seconds and 1.5 mins, respectively, whereas in case of 10^{-3} M concentration for 4,5 mins. In these cases, however, the heart is delivered from inhibition by itself after a longer—shorter period and starts pulsating spontaneously. At high concentrations of ACh the amplitude of cardiac action decreased subsequent to the recovery of the heart from inhibition. ACh at 10^{-2} M concentration arrested cardiac action and the heart was

not delivered from this arrest of itself even after passing of 13 mins, and its activity was restored only by repeated washings with Ringer solution.

Acetylcholine solutions near the threshold were not stimulatory either on *Helix* or *Anodonta* hearts. It happened also that the irregular cardiac action of *Anodonta* registered before ACh treatment became regular after treatment in case the agent was removed by washings, and in some instances the amplitude increased, too. In the case of *Helix* heart no stimulation was noted following washing out.

The effect of catecholamines on *Helix* and *Anodonta* hearts is of opposite direction. On *Helix* heart, namely, dopamine (DA), adrenaline (A) and noradrenaline (NA) produced stimulatory effect, but on the heart of *Anodonta* these agents proved to be inhibitory.

Dopamine solutions at 10^{-9} M and higher concentrations produce positive inotropic and chronotropic effects on snail heart. At higher concentrations up to 10^{-3} M this agent is stimulatory. Its effect might be discontinued by repeated washings.

Helix heart responded with an increase of amplitude to 10^{-9} M and higher concentrations of adrenaline and noradrenaline. The degree of the increase of amplitude varied between 20–40% and was not dependent on concentration, but might much rather be depending on the individuum. The effect produced by adrenaline and noradrenaline might also be discontinued by repeated washings, and following this, the heart starts to respond again to these amines. In case of *Helix* heart no difference in effect between adrenaline and noradrenaline was observed. Both agents were stimulatory. In case of dopamine, however, not only an increase of amplitude was observable as compared with these agents, but that of frequency was observed, too.

The sensibility threshold of dopamine on the heart of *Anodonta* was about 10^{-7} M. This and 10^{-6} M concentrations of this drug produced an about 20% decrease of amplitude. To higher concentrations up to 10^{-4} M the heart responded with a sharp increase of tonicity. On the effect of concentration increase the inhibitory effect increased. After cessation of treatment with dopamine cardiac action is restored by itself and after some minutes the original ground level and amplitude characterized the pulsation of the heart. Following inhibition cardiac action was more regular and of a much greater amplitude than after application of either adrenaline or noradrenaline. Dopamine washed out easily and the heart responded again to further applications of dopamine, the reaction produced, however, was less intensive. On repeated application of this concentration the heart became adapted to dopamine and responded either with a very small decrease of amplitude only or did not respond at all. Following washing out of 10^{-4} M dopamine solution, the 10^{-5} M solution of this agent was practically without effect.

The threshold concentration of adrenaline on the heart of *Anodonta* proved to be 10^{-6} – 5×10^{-6} M. At 5×10^{-5} M concentration a short systolic arrest took place, and after increasing the concentration further (10^{-4} – 10^{-3} M) a sharp rise in tonicity was registrable and the heart was arrested in systole and after the lapse of some time cardiac action recovered itself without washing out the drug (Fig. 1a). The reaction observed resembles strikingly that observed previously in the case of ACh (NISTRATOVA and PÉCSI 1966).

It is to be noted that in one single instance an increase of amplitude as compared to the control was observed after spontaneous restitution from in-

hibition caused by 10^{-4} M adrenaline solution (positive inotropic after-effect).

The effect produced by noradrenaline was similar to that of adrenaline and dopamine. In case of the heart of *Anodonta*, however, a 10–50 times greater concentration of the drug was necessary for producing the same effect.

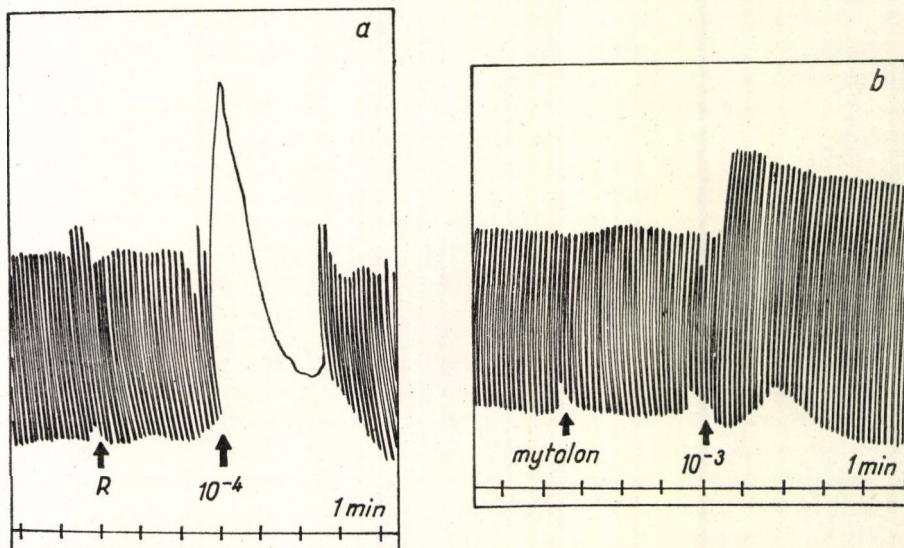


Fig. 1. — Effect of 10^{-4} M adrenaline on the isolated heart of *Anodonta* before (a) and b—after pretreatment with mytalon (10^{-3} M)

1. ábra. — Adrenalin hatása izolált *Anodonta* szíven 10^{-4} M koncentrációban (a) és b—ugyanaz 10^{-3} M mytalon előkezelés után

5-hydroxytryptamine (5-HT) was stimulatory on both *Helix* and *Anodonta* hearts. In case of both experimental objects the threshold concentration was the same (10^{-10} – 5×10^{-10} M) and this produced positive inotropic and chronotropic effects. At 5×10^{-9} M and 5×10^{-8} M concentrations the increase of amplitude registered was 20% and 60%, respectively. The maximum stimulatory effect produced by 5-HT on *Helix* heart was not higher than 90%, whereas on *Anodonta* an increase of amplitude by more than 200% could often be observed depending on the initial amplitude. In agreement with data obtained previously by us neither *Helix* heart (S.-RÓZSA and GRAUL 1964) nor *Anodonta* heart (PÉCSI 1965) was arrested by high concentrations, and a slight increase in tonicity was observable, at most, when applying 10^{-3} – 10^{-2} M concentrations.

Stimulatory effects produced on *Helix* heart by high concentrations (10^{-4} – 10^{-3} M) of catecholamines and 5-HT are easily distinguishable on basis of the type of stimulation. The effect produced by 5-HT is characterized by an initial sharp increase of amplitude which is followed by a more stabile increase of amplitude. This initial effect is lacking from the stimulatory effect produced by catecholamines.

5-methoxytryptamine (5-MT) solutions of 10^{-10} M concentration and above produced on *Helix* heart positive inotropic and chronotropic effects but the amplitude never increased by more than 20%. This stimulation chang-

ed into inhibition at 10^{-6} M concentration and above, and the effect was easily discontinued by washing even at fairly high concentration (10^{-3} M). The effect produced by this agent on *Helix* heart is clearly discernible from that produced by 5-HT on basis of the characteristic two phases of its.

The threshold concentration of 5-methoxytryptamine on the heart of *Anodonta* was 10^{-9} – 5×10^{-9} M. At this concentration both the amplitude and frequency of cardiac activity considerably increased. The effect produced by this drug on *Anodonta* heart is similar to that produced by 5-HT, namely, this drug does not inhibit cardiac action even at high concentrations. At 10^{-6} M concentration and above an increase in tonicity was produced. In case of this animal, too, the produced effect was easily washed out.

Tryptamine (TA) was stimulatory on both objects. At 10^{-10} M and higher concentrations it increased both amplitude and frequency of cardiac activity, in case of *Helix* heart. The effect of this drug resembles the reactions produced by 5-HT, but it is more easily discontinued by washings and the increase of amplitude is also smaller (Table 1). In the majority of cases inhibitory effect was observed by repeated application of high concentrations (10^{-3} M).

On the heart of *Anodonta* tryptamine is less effectual than 5-HT. The threshold concentration of this drug varied between 5×10^{-8} – 10^{-7} M. Car-

Table 1. — 1. Táblázat

Type of effect, threshold concentration and maximum effect produced by biologically active amines and amino acids on isolated heart preparations of *Helix* and *Anodonta*

Biológiailag aktív aminok és aminosavak hatástípusa, küszöbkonzentrációja és maximális effektusa izolált *Helix* és *Anodonta* szíven

Agent	On heart of <i>Helix</i>			On heart of <i>Anodonta</i>		
	<i>Helix</i> szíven			<i>Anodonta</i> szíven		
	type of effect	threshold in M	per cent of maximum effect	type of effect	threshold in M	per cent of maximum effect
Anyag	Hatás típus	Küszöb-konzentráció M-ben	Maximális effektus %-ban	Hatás típus	Küszöb-konzentráció M-ben	Maximális effektus %-ban
Acetylcholine	inhibition	10^{-9}	100	inhibition	10^{-6}	100
Dopamine	stimulation	10^{-9}	40	inhibition	10^{-7}	100
Adrenaline	stimulation	10^{-9}	40	inhibition	10^{-6}	100
Noradrenaline	stimulation	10^{-9}	40	inhibition	10^{-6}	100
5-hydroxytryptamine	stimulation	10^{-10}	90	stimulation	10^{-10}	100
5-methoxytryptamine	stimulation	10^{-10}	20	stimulation	10^{-9}	100
	inhibition	10^{-6}	20			
Tryptamine	stimulation	10^{-10}	30	stimulation	10^{-8}	100
Tryptophan	stimulation	10^{-9}	15	ineffectual	—	—
Tyramine	stimulation	10^{-9}	10	stimulation	10^{-8}	100
	inhibition	10^{-4}	50			
Glutamine	stimulation	10^{-9}	10	ineffectual	—	—
GABA	stimulation	10^{-9}	10	ineffectual	—	—
Histamine	stimulation	10^{-7}	8	ineffectual	—	—

diac action was not arrested even on the application of high concentrations (10^{-5} — 10^{-4} M) of this drug, but responded with an increase of tonicity. Arrhythm was produced occasionally by tryptamine. This was never observed when using 5-HT. The effect produced by tryptamine is more easily discontinued by washing out than the effect produced by 5-HT.

Tryptophan (TRP) solutions at 10^{-9} M and higher concentrations produced a weak stimulation (10—15%) in case of *Helix* heart. Stimulation did not increase upon rising the concentration and ended, too, without washing out of the agent. Tryptophan proved to be ineffective on the heart of *Anodonta*.

The stimulatory effect produced on *Helix* heart by 10^{-9} — 10^{-5} M concentrations of tyramine (TIR) was insignificant (5—10%), at higher concentrations (10^{-4} — 10^{-3} M) this agent produced an about 50% inhibition. The effect of this drug is easily washed out and very often ceases by itself.

On the heart of *Anodonta* 10^{-8} M and higher concentrations of tyramine had positive inotropic and chronotropic effect. An increase in tonicity was observable also at concentrations beyond 10^{-5} M. The drug did not produce inhibition even at higher concentrations. The stimulatory effect may surpass even more than 100%.

Helix heart responds with a weak (10%) stimulation to low concentrations (10^{-9} — 10^{-6} M) of glutamine (GLA). At higher concentrations (10^{-4} M) this drug is inhibitory or without effect. On the heart of *Anodonta* it is ineffective at every concentration.

GABA produced on *Helix* heart a nonspecific, small (10%) stimulation at 10^{-9} M and higher concentrations and was ineffective on *Anodonta* heart.

Histamine (HA) solutions at 10^{-7} M and above produced small stimulation (5—8%) in case of *Helix* heart, and were ineffective on *Anodonta* heart.

Histidine, tyrosine, α -methyl-DOPA, DL-phenylalanine and DL-serine proved to be ineffective on both *Anodonta* and *Helix* hearts.

Table I. summarizes data on the type of effect, on sensitivity threshold and on the degree of effectiveness of biologically active agents investigated.

2. Influencing of the effects of biologically active amines by ACh and 5-HT antagonists

In the following we shall discuss the examinations performed on the mechanism of effect of agents that proved to be previously effective on both test objects and which interfere in neurohumoral regulation. Thus at first we attempted to obtain data on the susceptibility of the effects of acetylcholine, catecholamines, 5-hydroxytryptamine, tryptamine and tyramine to ACh and 5-HT antagonist, with the aim of discriminating the possible place of effect.

Pretreatment with mytolon and BOL was made at 10^{-5} — 10^{-4} M and 10^{-4} M concentrations, respectively. These concentrations did not produce in themselves noteworthy effects either on *Helix* or on *Anodonta* hearts. A 30 mins pretreatment with 10^{-5} M mytolon solution resulted in a complete elimination of the inhibition produced by 10^{-8} M and 10^{-7} M acetylcholine solutions. The same pretreatment with mytolon, likewise, eliminates the stimulation caused by dopamine (10^{-7} M), adrenaline (10^{-7} M) and noradrenaline (10^{-7} M). The effect of these two latter agents may turn inhibitory on the heart of *Helix* pretreated with mytolon, and in particular following pretreatment of long duration (1—1.5 hour).

Table 2. — 2. Táblázat

Influence of mytolon and BOL on the effect produced by biologically active amines on the hearts of *Helix* and *Anodonta*

Mytolon és BOL hatása *Helix* és *Anodonta* szíven biológiailag aktív aminok effektusára

Agent	On heart of <i>Helix</i>		
	<i>Helix</i> szíven		
Anyag	normal effect	after mytolon	after BOL
	normál hatás	mytolon után	BOL után
ACh	inhibition	elimination	unchanged
Dopamine	stimulation	elimination	partial elimination
Adrenaline	stimulation	elimination or inhibition	partial elimination
Noradrenaline	stimulation	elimination or inhibition	partial elimination
5-HT	stimulation	unchanged	elimination
Tryptamine	stimulation	unchanged	elimination
Tyramine	inhibition	unchanged	stimulation is eliminated

Agent	On heart of <i>Anodonta</i>		
	<i>Anodonta</i> szíven		
Anyag	normal effect	after mytolon	after BOL
	normál hatás	mytolon után	BOL után
ACh	inhibition	elimination	unchanged or partial elimination
Dopamine	inhibition	elimination	elimination or stimulation
Adrenaline	inhibition	elimination or stimulation	elimination or stimulation
Noradrenaline	inhibition	elimination	elimination
5-HT	stimulation	unchanged	elimination
Tryptamine	stimulation	—	—
Tyramine	stimulation	elimination	elimination

Preincubation of *Helix* heart with mytolon, even if it lasted as long as 1.5–2 hours, did not influence the stimulatory effect of 5-HT, tryptamine and tyramine.

A pretreatment of 10–20 mins of *Anodonta* heart with mytolon (10^{-4} M) eliminated the inhibition produced by ACh, dopamine, noradrenaline and adrenaline. The inhibitory effect produced by 10^{-4} – 10^{-3} M adrenaline solutions turned into definite stimulatory effect (*Fig. 1b*). The positive inotropic and chronotropic effect produced by adrenaline after mytolon treatment was long-lasting without washing.

Mytolon did not influence the stimulatory effect produced by 5-HT on *Anodonta* heart, whereas it completely ceased the stimulatory effect of tyramine.

On *Helix* heart preincubated with BOL (10^{-4} M) a complete cessation of the stimulatory effect produced by 5-HT, tryptamine and tyramine solutions (10^{-6} M) occurred 20 mins following application. BOL decreased the stim-

ulatory effect of dopamine, adrenaline and noradrenaline (10^{-6} M) by approx. 50–60%, it did not affect, however, the inhibitory effect of ACh (10^{-8} M).

BOL (10^{-4} M) eliminated in case of *Anodonta* heart, too, the stimulatory effect caused by 5-HT and tyramine and also the inhibitory effect produced by dopamine, adrenaline and noradrenaline. Following pretreatment with BOL dopamine and adrenaline became slightly stimulatory.

BOL did not eliminate the effect produced by ACh on the heart of *Anodonta*, in some instances, however, decreased the degree of the effect produced.

To learn when the stimulatory effect produced by 5-HT and that obtained following mytolon treatment on the application of adrenaline is realized by the participation of the same receptors, we examined the effect produced by these two agents on the heart of *Anodonta* after pretreatment with mytolon and BOL. The effect of 5-HT remained invariably stimulatory also after pretreatment with mytolon, this effect could be stopped, however, completely by BOL. The effect of adrenaline, however, which was normally inhibitory turned strongly stimulatory following pretreatment with mytolon, but this stimulation was not influenced by BOL.

Table 2. summarizes the susceptibility of the investigated agents to various antagonists.

Discussion

The effect produced on *Helix* heart by the various amines investigated manifested itself, in general, in the increase or decrease of amplitude and frequency. Differences existed primarily not in the threshold concentrations, which was, in general, 10^{-10} – 10^{-9} M in case of most agents but in the maximum effects produced. From among the amines only histamine had a higher sensitivity threshold (10^{-7} M). The sensitivity threshold of amines on the heart of *Anodonta* was, with the exception of 5-HT, higher by 2–3 order of magnitude than on *Helix* heart.

From among the factors examined only ACh was inhibitory on *Helix* heart at every concentration. ACh was found to be stimulatory on some Gastropoda, thus on the isolated heart of *Strophocheilos* (JAEGER 1961). The stimulatory effect of low concentrations of ACh was registered by CORDA (1955) on the heart of *Helix aspersa*, whereas the observations of JULLIEN et al. (1954) showed, as it was confirmed by our own findings, that on *Helix pomatia* ACh was never stimulatory whatever concentration it was used in. Concerning the lamellibranchs in the majority of cases ACh had a two-phase effect, it was partly stimulatory, partly inhibitory, depending on concentration (GREENBERG 1965). In our case the heart of *Anodonta* responded to ACh concentrations by 3 times greater order than *Helix* heart. ACh was found, however, in this case, too, definitely inhibitory at every concentration. In this respect a difference exist between the heart of *Anodonta cygnea* and the hearts of *Anodonta cataracta* and *Anodonta grandis*, namely, in the case of these two latter species ACh produced a two-phase reaction (inhibition and stimulation) (GREENBERG 1965). Data concerning other lamellibranchs are most varying and the comparison of theirs seems to be of no use (GREENBERG, 1965).

With respect to catecholamines *Helix* and *Anodonta* hearts behave differently. A positive inotropic and chronotropic effect was produced on *Helix* heart by 10^{-9} M and higher concentration, whereas, *Anodonta* heart responded in all instances with inhibition to all catecholamines examined by us.

The degree of the inhibition may, depending on concentration, range from a decrease of amplitude up to a complete arrest. In this respect, our data on the effect of adrenaline confirm those obtained by FÄNGE (1955).

Dopamine was found to have a two-phase effect on *Tapes* heart (CHONG and PHILLIS, 1965) and on *Mercenaria* heart (SPIRITES and JACOBOWITZ, 1966). This two-phase effect was not demonstrable by us on the heart of *Anodonta*. The degree and form of stimulation produced by each catecholamine applied on *Helix* heart was the same. It was not demonstrable, however, that stimulation was dependent on concentration. This finding of ours may be of some interest, for the catecholamines were regarded previously as either ineffective (ERSPAMER and GHIRETTI 1951) or inhibitory (OSTLUND 1954) factors on *Helix* heart.

Though several authors were (DAHL et al. 1966, PHILLIS, 1966) of the opinion that from among the catecholamines a special role is attributable to dopamine in the mediation of molluscs, in course of analysing the effect of adrenaline, noradrenaline and dopamine no data were obtained by us which would support the above suggestion. The effects produced by the three catecholamines did not differ considerably as regards the threshold concentration or the maximum effect produced.

Out of the amines investigated 5-hydroxytryptamine was the only that produced at the same threshold concentration (10^{-10} M) stimulation on both experimental objects. The only difference was that the maximum effect on *Anodonta* heart was greater (Table 1). Contrary to data obtained by YOSHIMURA and KURIAKI (1957) and to those obtained by GREENBERG (1960) 5-HT did not produce inhibition even at very high concentrations. The type of the effect produced resembles that described by HILL (1958) and KUZIEWSKI (1962).

5-methoxytryptamine, tryptamine and tyramine have, too, produced stimulatory effect on both *Helix* and *Anodonta* heart. Threshold concentration on *Helix* heart was lower in case of these agents, too. Higher concentrations of both 5-methoxytryptamine and tyramine, however, were inhibitory on this object.

The effect of tryptophan, glutamine, GABA and histamine is stimulatory on *Helix* heart but does not produce, even at high concentrations a more than 5–15% increase of amplitude (Table 1).

The order of the stimulatory agents on basis of the maximum effect produced is

on the heart of *Helix*: 5-HT > DA · A · NA > TA > 5-MT > TR >

TIR, GABA > GLA > HA,

on the heart of *Anodonta*: 5-HT > 5-MT > TA, TIR.

Much fewer amines produce stimulatory effect on *Anodonta* heart, than on *Helix* heart, and glutamine and histamine may be regarded as completely ineffectual, though 10^{-5} M glutamine solution was found stimulatory on *Tapes* heart (PHILLIS, 1966). GABA was ineffectual on *Tapes* heart, too. According to PHILLIS (1966) and PILGRIM (1954) histamine in high concentrations is unspecific agent on the hearts of other molluscs, too.

None of the amino acids investigated influenced cardiac action of the heart of *Anodonta*, and only tryptophan and GABA produced but negligible, nonspecific increase of amplitude on *Helix* heart.

Summing up, it may be concluded that amines can be taken for physiologically effective agents, and even the precursors of the effective amines, i.e. phenylalanine are insignificant in producing physiological effect. *Helix* heart is more sensitive to the agents investigated than *Anodonta* heart, consequently, it is more suitable for purposes of pharmacological investigations and biological testing. In view of the fact that in case of every agent but ACh stimulatory effects dominated, it is emphasized that in the realization of this effect identical mechanisms are involved, which produce on the effect of the various agents activity increases of different degree in the muscles. The uniformizing of responses to this degree is by all means indicative of the identity of the ground-mechanism.

On the other hand, the observation that the effect of catecholamines manifests itself in physiological effects of opposite direction on *Helix* and *Anodonta* hearts suggests that there is a great possibility for individual differences in case of different representatives. This may be elucidated only by detailed investigation of the properties of the receptors. It is not considered probable that in case of the two objects the catecholamines are interacting with different receptors, and it is thought much more possible that alterations taking place in other factors (receptor configuration, pattern of loading) are determining the different physiological effects. In case of some molluscs the accessibility of receptors may also influence the type of the response produced (JAEGER 1966). The fact that in some instances a stimulatory effect was observed on *Anodonta* heart following washing out of the agent indicates that the stimulatory effect of catecholamines is masked.

Data obtained with antagonist show that the effect produced by ACh takes place in case of *Helix* and *Anodonta* hearts in the same way as described previously on molluscs, namely, it was eliminated by mytolon, and not eliminated by BOL, or it was only slightly influenced by it (WELSH and TAUB 1951, WELSH and SLOCOMBE 1952, LUDUENA and BROWN 1952, CHONG and PHILLIS 1965). On the basis of our data it is inferred that the acetylcholine-receptors in these representatives of molluscs, too, are very similar.

Mytolon which inhibited the ACh receptors in molluscs eliminated also in both cases the effect of catecholamines. This agent decreases or discontinues the effect of dopamine, adrenaline and noradrenaline even if the effect produced is stimulatory on *Helix* heart, or inhibitory on the heart of *Anodonta* (Table 2). Responses of opposite sign are produced in the majority of cases by catecholamines in hearts treated with mytolon, and accordingly, inhibition is produced on *Helix* heart and stimulation on the heart of *Anodonta*.

A reversion of response takes place in case of *Anodonta* heart on the application of adrenaline and in that of *Helix* heart on the application of adrenaline and noradrenaline. These facts suggest that the effect produced by catecholamine might be related to structures that are inhibitable by mytolon, they do not imply, however, that the effect takes place exclusively on these receptors. This latter statement is supported by the fact that BOL also influenced the effect of catecholamines, when, namely, this agent completely or partially eliminates it. BOL influenced the effect of catecholamines on *Helix* heart in a much less extent and never eliminated it completely. These facts

allow the supposition that there may exist another place of reaction for catecholamines the nature of which, however, needs further investigations.

The effect produced on *Helix* heart by 5-HT, tryptamine, and tyramine, and that produced by 5-HT on the heart of *Anodonta* were not influenced by mytolon. The effect of tryptamine on *Anodonta* heart is, however, inhibited by this agent. This involves, that the effect of 5-HT and tryptamine takes place on separate receptors and is completely eliminable by BOL in case of our two test objects. We have no exact knowledge as yet of the mechanism by which the effect of tyramine is realized on molluscs. In case of the vertebrates it is assumably connected to α -receptors (FARMER 1966).

It may be said on the basis of data obtained that the places of reaction suggested for ACh and 5-HT are isolated from each other, and the structure of the receptors of the other agents necessitates further studies.

Summary

1. Examining the effect of various amino acids and amines on the isolated hearts of *Helix* and *Anodonta* it was established that only amines are involved in the production of physiological effects. It was observed that the sensitivity of *Helix* heart on the agents tested was greater by 2–3 orders.

2. ACh produced on both *Helix* (10^{-9} M) and *Anodonta* (10^{-6} M) hearts negative inotropic and chronotropic effects.

3. Catecholamines (dopamine, noradrenaline, adrenaline) produced stimulation on *Helix* heart, and inhibition on the heart of *Anodonta*.

4. 5-HT produced on both objects stimulatory effect at the same threshold concentration (10^{-10} M) and inhibitory effect was not produceable even on the application of high concentrations.

5. Besides 5-HT other agents as tryptamine, 5-methoxytryptamine and tyramine were also stimulatory factors, the two latter, however, were inhibitory on *Helix* heart when applied at high concentrations. Tryptophan, glutamine, GABA and histamine produced an increase of amplitude on *Helix* heart, and were ineffectual on the heart of *Anodonta*.

6. The effect of ACh was inhibited on both objects by mytolon, and the effect of catecholamines was eliminated or was changed into the opposite effect by this agent. Mytolon does not influence the effect produced by 5-HT and tryptamine. It inhibits the effect of tyramine on the heart of *Anodonta*, but does not inhibit it on the heart of *Helix*.

7. BOL ceased the effect produced on the heart of *Anodonta* by the amines investigated except for ACh. On *Helix* heart it also did not influence the response produced by ACh, but eliminated the stimulatory effect of 5-HT, tryptamine and tyramine, and decreased to a small extent the effect of catecholamines.

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BIOLÓGIAILAG AKTÍV ANYAGOK HATÁSÁNAK ÖSSZEHASONLÍTÓ VIZSGÁLATA *HELI*X POMATIA L. ÉS ANODONTA CYGNEA L. IZOLÁLT SZÍVÉN

S.-Rózsa Katalin és Pécsi Tibor

Összefoglalás

1. Aminósavak és aminok hatásának vizsgálata alapján izolált *Helix* és *Anodonta* szíven megállapítást nyert, hogy fiziológiai effektus létrehozásában elsősorban az aminok vesznek részt. A *Helix* szív két-három nagyságrenddel érzékenyebb a tesztelt ágensekre.
2. Az ACh mind *Helix* ($1 \cdot 10^{-9}$ M), mind *Anodonta* ($1 \cdot 10^{-6}$ M) szíven negatív inotrop és kronotrop effektust vált ki.
3. Catecholaminok (dopamin, noradrenalin, adrenalin) *Helix* szíven serkentést, *Anodonta* szíven pedig gátlást hoznak létre.
4. Az 5-HT mindkét objektumon azonos küszöbkoncentrációban ($1 \cdot 10^{-10}$ M) hoz létre serkentő hatást, s gátló effektus nagy koncentrációk applikálásával sem vált-ható ki.
5. Az 5-HT-n kívül a triptamin, 5-methoxytriptamin és tiramin ugyancsak stimuláló faktorok, de a két utóbbi nagy koncentrációban *Helix* szíven gátol. A triptofán, glutamin, GABA és hisztamin *Helix* szíven amplitudónövekedést hoznak létre, *Anodonta* szíven hatástalanok.
6. Mytolon blokkolja az ACh hatást mindkét objektumon, ezenkívül kivédi vagy ellenkező előjelűvé változtatja a catecholaminok hatását. Nem befolyásolja az 5-HT és a triptamin hatást. A tiramin effektust blokkolja *Anodonta* szíven, de *Helix* szíven nem.
7. BOL *Anodonta* szíven az ACh kivételével valamennyi vizsgált amin hatását teljesen kivédi, *Helix* szíven nem befolyásolja az ACh hatást, de kivédi az 5-HT, triptamin serkentő hatását, míg a catecholaminok hatását kis mértékben csökkenti.

СПРАВНИТЕЛЬНЫЙ АНАЛИЗ ДЕЙСТВИЯ НЕКОТОРЫХ БИОЛОГИЧЕСКИ АКТИВНЫХ ВЕЩЕСТВ НА ИЗОЛИРОВАННОМ СЕРДЦЕ ВИНОГРАДНОЙ УЛИТКИ И БЕЗЗУБКИ

Каталин Ш.-Рожа и Тибор Печи

1. — В ходе исследования эффекта аминов и аминокислот на изолированном сердце виноградной улитки и беззубки было установлено, что амины являются более активными. Сердце виноградной улитки на 2—3 порядка чувствительнее сердца беззубки к изученным агентам.
2. — Ацетилхолин вызывает отрицательный инотропный и хронотропный эффект на сердце у виноградной улитки (1.10^{-9} M) и беззубки (1.10^{-6} M).
3. — Катехоламины (допамин, норадреналин, адреналин) оказывает усиливающее действие на сердце виноградной улитки, а на сердце беззубки — тормозящее.
4. — Серотонин вызывает стимуляцию на обоих объектах в одинаковых пороговых концентрациях (1.10^{-10} M) и в больших концентрациях тоже никогда не вызывает торможение.
5. — Помимо серотонина стимуляторный эффект оказывают триптамин, 5-метокситриптамин и тирамин, но из них последних два в больших концентрациях вызывают торможение на сердце виноградной улитки. Триптофан, глутамин, ГАБА и гистамин вызывают увеличение амплитуды на сердце виноградной улитки, а на сердце беззубки они неэффективны.

6. — Митолон снимает эффект ацетилхолина на обоих сердцах и предотвращает действие катехоламинов или же превращает его в противоположный знак. Митолон не влияет на эффект серотонина и триптамина, но блокирует действие тирамина на сердце беззубки но не на сердце виноградной улитки.

7. — БОЛ на сердце беззубки за исключением ацетилхолина снимает эффект всех изученных агентов, а на сердце виноградной улитки блокирует эффект серотонина, триптамина и тирамина, но не влияет на эффект ацетилхолина и снижает незначительно действие катехоламинов.

RNA IN THE GANGLIA OF MOLLUSCA IN NORMAL CONDITIONS AND FOLLOWING NERVE DAMAGE (A HISTOCHEMICAL STUDY)

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The nucleic acid content of nerve cells, its changes, and the closely related protein synthesis serving as a basis in cell function and regeneration have been subjected to detailed investigations (HYDEN 1947, 1960, 1962, BRODSKY 1966). Histological and histochemical examinations presented data first of all on the role of the nucleus and nucleolus, on the ratio of the dimensions among various parts of the cell, further on, the character and the time-sequence of alterations taking place in course of function (VOGT and VOGT 1946, EDSTRÖM and EICHNER 1958, HYDEN 1959, PEVZNER 1964).

Attention was called to the special reaction of neurocytes by COHEN and JACKLET (1965) in course of their studies on the protein synthesis of the nerve cells in *Periplaneta americana*. They found that in case of axon-damages an RNA ring appeared in perinuclear localization in the regenerating nerve cell within 12 hours, and it became most marked on the 3—4th day. This phenomenon seems suitable to identify the cell body of the damaged fiber.

The nerves of the mussels are built up of unmyelinated fibers. Due to this the usual myelin-degeneration methods cannot be adopted to identify the nervous paths belonging to the single cell groups. The retrograde sign of regeneration, however, in case it does appear same as in the insects, might be of some help in localizing the neurocytes of axons passing in the different nerves.

The objective of the study presented here is primarily to elucidate the conditions related to the content and accumulation of nucleic acid in the nerve cells, because in connection with this we have no knowledge of systematic studies performed on Pelecypoda. Further, we wanted to establish, in general, whether the perinuclear RNA ring described above in *Periplaneta*, or some other signs of regeneration appear in the nervous system following intersection of the axons.

Material and method

The experiments were conducted on the cerebral, visceral and pedal ganglia of 14—16 cm long specimens of *Anodonta cygnea* L. Following excision from the animals the ganglia were fixed in Zenker solution for 3 hours. Oriented embedding of the various ganglia and attached small portion of tissue into celloidine-paraffine followed, and 8 μ sections were prepared.

Staining was made with methyl green-pyronine y (KURNICK 1955) and malachite green-pyronine y (PMAg) (BAKER and WILLIAMS 1965). Ribonuclease digestion (PEARSE 1961) was made to examine the RNA specificity of pyronine-staining.

Staining with the methyl green-pyronine y mixture proposed by KURNICK (1955) proved too pale, and, therefore, the stains were used differently from the original description, in the following ratio:

2 per cent pyronine y (GT, Gurr, England)	15.0 ml
2 per cent methyl green (NAD)	5.0 ml
Distilled water	20.0 ml

The PMAg staining method was applied with good result also without modification. This method was adopted later in the course of examinations, because the malachite green mixture can be preserved for a longer period without buffering.

The cleaning of the diluted solutions of the stains with CHCl_3 was made until no further changes were observable in the colour of the extracting chloroform. Evaporation of the purified stains followed and solutions of suitable concentrations were prepared again.

Stained sections were dehydrated with isobutyl alcohol, because, as observed, pyronine was more intensively dissolved by *n*-butyl alcohol than it was desired.

In digestion studies ribonuclease prepared of ox pancreas according to the method of BRACHET was used (GOMORI 1953).

In the course of light microscope evaluation of the sections comparative computations were made on basis of measurements with ocular-micrometer concerning the sizes of nuclei and nucleoli in cells that stained intensively or less intensively with pyronine.

Measurements on the length and width of nerve cells were made and on their basis cells of nearly equal sizes were selected. The cubic content of nuclei was calculated on basis of length and width measurements. In case the ratio of longitudinal and cross diameters of the nuclei was 1 : 1.2 the Fischer-Inke equation was used

$$V = \frac{\pi}{6} (LB)^{3/2}$$

(L = longer diameter, B = shorter diameter).

In case of nuclei that are more divergent from spherical shape computation was made according to PUFF's equation (PALKOVITS 1962);

$$V = \frac{8 \pi F^2}{3L}$$

(F = surface, L = longer diameter.) Limit of error about 3 per cent.

In one group of molluscs the right side nervus pallialis posterior maior, in another groups the right branch of the cerebrovisceral connective (CVC) was intersected. Following operation the animals were slaughtered daily in 10–14 subsequent days and their cerebral, visceral and pedal ganglia were stained with PMAg and examined.

Results

All three pairs of ganglia of the central nervous system of *A. cygnea* exhibited a similar picture following staining with PMAg. The protrusions of the nerve and glia cells stained well with malachite green, whereas the cytoplasm, nucleus and the nuclei of the glia cells stained more palish. The nucleolus stained deeper with pyronine y, and the cytoplasm in the majority of the nerve cells and glia cells stained lighter with pyronine y.

The cytoplasm of some nerve cells in the cerebral and pedal ganglia stained intensively with pyronine y which was localized to a rough granular substance. Cells like these will be referred to later on as "pyroninophilous" cells. The whole cell volume is filled, in general, with these bright red granules (*Fig. 1*). The nuclei of the pyroninophilous cells are small in comparison to



Fig. 1. "Pyroninophilous nerve cell" in the cerebral ganglion $\times 960$

1. ábra. „Pyroninofil idegsejt" a ggl cerebraleban (960 $\times$)

those of other cells, and their shape is longitudinal. The nucleus is, in general, of central localization, but may also rather frequently be observable near the boundary of the cell. In most nuclei invaginations were observable. The nucleolus that stains with malachite green is extraordinarily small as compared to those of non-pyroninophilous cells and are, on occasion, scarcely visible even under immersion lens. The differences in volume between the nuclei of pyroninophilous nerve cells and of those of nerve cells of same dimension and staining normally are presented in *Table 1*.

The data show that the volume of the nuclei in pyroninophilous nerve cells are one third of that of the nuclei in nerve cells of similar size and staining less intensively with pyronine y.

Pyroninophilous nerve cells were observable chiefly in the cerebral and pedal ganglia. They numbered one or two in the sections but very often occurred only in the 4–5th subsequent sections each.

Nerve cells in which not the whole cytoplasm but only one or two bounded sections stain intensively with pyronine y are more seldom found. The area

Table 1

Volume of nuclei in pyroninophilous nerve cells and in normally stained ones

Pyroninofil és nem pyroninofil sejtek magvainak köbtartalma

	Number of cells	Size of nerve cells (μ)		Volume of nucleus (μ^3)
		length	width	
Pyroninophilous nerve cell	40	28.3 ± 3.8	21.0 ± 2.8	144 ± 48
Non-pyroninophilous nerve cell	40	28.2 ± 4.1	21.0 ± 2.0	560 ± 74

that stains intensively with pyronine y is most often localized near the origin of the axon or in the immediate neighbourhood of the nucleus. In case of partial pyroninophilia the nucleus is often of excentric localization. Nerve cells like these differ from the pyroninophilous cells in that their nuclei are, in general, round, their size is equal to that of nuclei in non-pyroninophilous cells and invaginations are not observable in them. Their nucleoli, same as those of non-pyroninophilous cells, are of 1—3 μ diameter, and stain intensively with pyronine y. These cells conform, however, to pyroninophilous cells in that the pyroninophilous area or areas are granular. The majority of such cells occurs, too, in the pedal and cerebral ganglia, and are to be found only seldom in the visceral ganglia.

The PMaG staining method is widely used for demonstrating RNA, but the specificity of pyroninophilia has to be established with other methods. The most suitable procedure serving this purpose is the digestion with ribonuclease. As we have no knowledge of similar studies performed on the nervous system of freshwater mussel, it was necessary to examine the relationship between pyroninophilia and RNA. For this purpose every second section of the series made of the same ganglion was incubated in ribonuclease and was stained with PMaG parallel with non-incubated sections. On basis of data obtained it was possible to establish the identity of the pyroninophilous substance with RNA, because the ribonuclease treated cells did not exhibit pyroninophilia.

Following the intersection of the pallial nerve and CVc the histological picture of the central nervous system is similar, in general, to the above ones, but besides this, special phenomena were also observable.

The first noteworthy phenomenon was that after 2—3 days following the intersection of the right n. pallialis or of the CVc a fine granular, homogeneously looking, ring-shaped zone staining intensively with pyronine, a so called "perinuclear ring" appeared around the nucleus of some cells in the visceral ganglion. This zone is best noticeable on the 3rd, 4th days, but is still observable also on the 7th and 8th days (*Fig. 2*). The perinuclear ring is most marked in large sized and assumably motor cells. In nerve cells of small sizes the area that stained intensively with pyronine and surrounds the nucleus fills nearly the whole cytoplasm and therefore it is difficult to decide whether it is a perinuclear ring or perhaps the cytoplasm is stained slightly deeper than average. The nuclei of cells possessing a perinuclear ring are centrally localized. Their shape is elongated and no invaginations were observable in them. Their nucleoli which stain intensively with pyronine y are large (about 3—4 μ diameter). The cubic content of nuclei of nerve cells with perinuclear ring and of non-

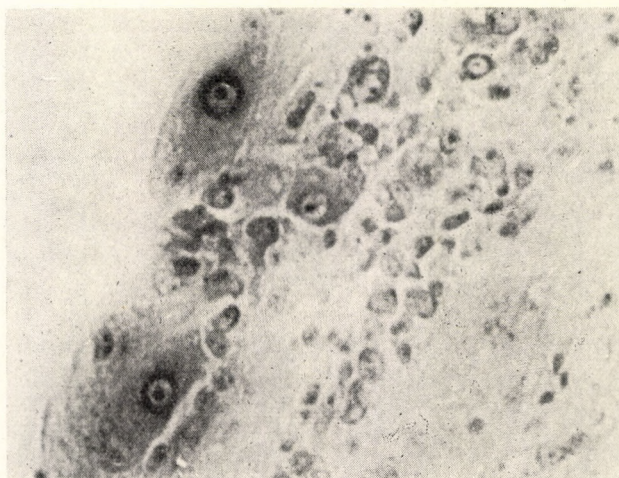


Fig. 2. Cells with perinuclear ring in the cerebral ganglion on the 3rd day following the intersection of CVc ($\times 960$)

2. ábra. Perinuclearis gyűrűs sejtek CVc átmetszése után a 3. napon fixált ggl. visceralesban ($960 \times$)

pyroninophil cells were calculated inside the same preparate. The values obtained are presented in *Table 2*.

According to the estimations the size of nucleoli in cells that possess a perinuclear ring is about three times as great as that of nucleoli in the control cells, whereas no difference in the volume of nuclei was observed.

In cerebral and pedal ganglia a typical perinuclear ring was not observable after the intersection of either n. pallialis or of CVc. The number of pyroninophilous perinuclear cells are few in the visceral ganglion, too, and they are dispersed. They may occur near the origin of chief nerve branches, in the nucleus posterior and in other areas of the cortex alike.

After digestion with ribonuclease the pyroninophilous perinuclear ring disappears which indicates RNA.

The other noteworthy phenomenon observed was that in ganglia fixed on the 7th day following intersection of either pallial nerve or of CVc the glia cells stained deeper with pyronine y. The bright red colour of the glia cells surrounding the large sized nerve cells is most conspicuous (*Fig. 3*). Granulation is not noticeable under light microscope. Other glia cells are of deep

Table 2

	Number of cells	Size of nerve cells (μ)		Volume of nucleus (μ^3)
		length	width	
Nerve cells with perinuclear ring	20	33.4 ± 2.6	17.7 ± 2.1	596 ± 112
Non-pyroninophilous nerve cells	20	31.9 ± 2.8	18.3 ± 1.9	588 ± 77

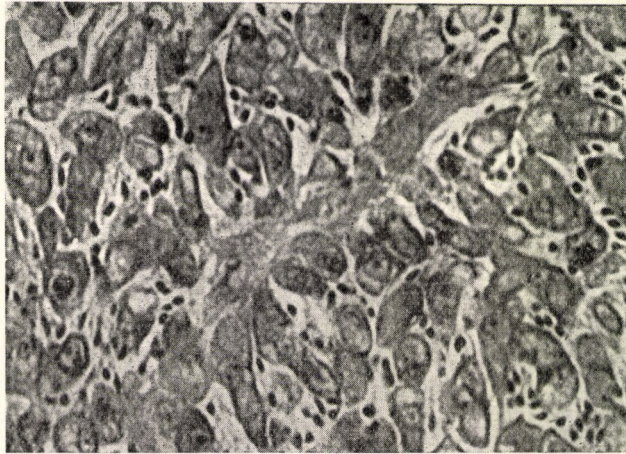


Fig. 3. Intensive pyroninophilic of lamellar glia on the 7th day following intersection of the nerves ($\times 960$)

3. ábra. Lemezes glia intenzív pyroninofiliája idegátmetzés utáni 7. napon (960 $\times$)

red colour and are granulated. In numerous glia cells granules which stained with malachite green were also observable. Glia cells staining intensively with pyronine y were observed in every three pair of ganglia.

The third characteristic feature observed was that on the 9th day following intersection of CVc glia fibers staining intensively with pyronine appeared in the visceral ganglion. This was not demonstrable either in cerebral or pedal ganglia. The majority of these fibres pass in the direction of the intersected CVc and leaves there the ganglion, and they are to be found at the origin of every chief nerve branch. Several fibers which stain with pyronine pass to the nerve cells of the cortex. After a more careful examination of the serial sections, it appeared, that the nerve cells of the cortex and chiefly those which are vacuolized are surrounded by the majority of pyroninophilous fibers. In other instances the pyroninophilous fiber terminates near the nerve cell in little club-shaped formations.

Parallel with the pyronine staining of the glia morphological alterations also occur in some nerve cells. On the 6—7th day following the intersection of pallial nerve one or two vacuoles appear in the cytoplasm of some nerve cells. The number of nerve cells containing vacuoles increases on the 8th—9th day and on the 10th day they may even amount to 50% of the total number of nerve cells. The vacuoles in some cells fill the whole cytoplasm and in such case the nucleus is shifted to the axon-hill or to the boundary of the cells. After the intersection of CVc the vacuoles appear sooner and in the glia examined on the 6th day vacuolized cells were predominating. Signs of desintegration appeared in about 3% of nerve cells on the 9th—10th day.

The size of the nuclei and nucleoli has changed parallel with the degree of vacuolization of nerve cells. At the beginning of vacuolization the nucleus is somewhat greater than in nerve cells of similar sizes without vacuolization. The size of nucleoli is above average and the nucleoli stain intensively with pyronine. The nuclei of nerve cells which contain large vacuoles are smaller,

they are elongated, and invaginations were also observable in them. In such nerve cells the nucleolus is smaller and stains less intensively with pyronine.

The average size of nuclei of vacuolized nerve cells does not differ from that of nuclei in the control nerve cells. It is to be noted, however, that in the size of nuclei great differences exist among vacuolized cells. Whereas in intact animals the quadratic deviation of the average volume of the nuclei ($570 \mu^3$) was ± 75 , the standard deviation of the average volume of nuclei ($530 \mu^3$) of vacuolized cells of similar size was ± 212 .

It is to be noted, finally, that the animals were alive for fourteen days following intersection of the right nervus pallialis posterior maior, whereas, after the intersection of the CVC only for maximum 10 days.

Discussion

Digestion studies with ribonuclease show that in that class of Mollusca which is examined in this study pyronine is specific to RNA and is, therefore, suitable for investigating the ribonucleic acid content and its alterations in nerve cells.

The cells of the ganglia of *Anodonta* contain, similar to other animals, different quantities of RNA. The cytoplasm and the nucleus of nerve cells stain, in general, similar to glia cells only weakly, in opposition to the nucleolus which stains mostly intensively. This staining is homogeneous which is indicative of the presence of finely distributed RNA. On another occasion, however, some regions of the cytoplasm and often the whole cytoplasm itself is extraordinarily rich in RNA which is present in the form of rough granules. Cells not containing RNA granules, and the partially or completely pyroninophilous cells are most obviously not characteristic of the type of the cells, but as it is known from literature (HYDEN 1960, BRODSKY 1966), of the rate of protein synthesis and might be related to the functional condition of cells. Parallel with changes in the periodic activity of freshwater mussel quantitative changes were demonstrable in the Nissl-substance (SALÁNKI, ZS.-NAGY and H.-VAS 1965) and in the nucleic acid content (ZS.-NAGY, BRODSKY and SALÁNKI 1966), the differences demonstrated in this study might also be connected with this.

In certain cells following intersection of the nerves the rich RNA content is different, it is not rough granular, and is localized in fine granular arrangement around the nucleus. This pattern might be related to the special condition of the cell, i.e. to regeneration.

It is probable that the rough granular RNA which may be localized in the cytoplasm of only partially pyroninophilous cells also at a greater distance from the nucleus is of different origin and is attached to different cell constituents than the fine granular, perinuclear RNA. In course of examining the changes in Nissl-substance both excessively granulated and homogeneously stained nerve cells were observable in the ganglia of *Anodonta cygnea* (SALÁNKI, ZS.-NAGY and H. VAS 1965). It is assumed that these two different structures might be identical to the so-called "compact" and "loose ergastoplasm" described previously in course of electronmicroscopic studies (DE ROBERTIS 1954), and might be explained likewise by the different origin of RNA.

The size of nuclei in pyroninophilous and non-pyroninophilous cells and in pyroninophilous cells with a perinuclear ring varied considerably. It is

known that at the beginning of increased synthesis the RNA content of the cells begins to increase in the nucleolus and that there is a correlation between nucleolar size and the RNA content of the cell (BERTRAM and BARR 1949, BRACHET 1955, EDSTRÖM and EICHNER 1958, STOWELL 1963). According to biochemical data chiefly transfer-RNA is to be found in the nucleolus (SIRLIN 1961, SIRLIN, KATO and JONES 1961) and thus the size of the nucleolus is indicative of the degree of protein synthesis. For this reason the difference in size observed among nucleoli of cells of equal sizes might be taken for the sign of the intensity of actual RNA and of related protein synthesis, respectively. The smallest nucleoli were observed in cells in which the cytoplasm was filled with RNA and it is assumed that in such cells transfer RNA production is most probably interrupted. In most cells the nucleoli are of medium size and this might perhaps be indicative of average protein synthesis.

The cells with pyroninophilous ring have extremely large nucleoli which is indicating very intensive RNA production and protein metabolism. This latter phenomenon is completely justified if the pyroninophilous ring is considered the sign of regeneration and also conforms to the data of VOGT and VOGT (1946) who observed in connection with "retrograde degeneration" the increase of nucleolus and the accumulation of the Nissl-substance.

In pyroninophilous cells not only the nucleolus is small but the nucleus, too, and on the nucleus invaginations are observable. This observation does not conform to the general opinion that the size of both nucleus and nucleolus is directly proportional to the RNA content of the cytoplasm, and can be explained so that in these cells the RNA-metabolism of both nucleus and nucleolus is restricted considerably due to the excessively great accumulation of nucleic acid and protein.

Cells with perinuclear RNA ring similar to those described by COHEN and JACKLET (1965) in the nervous system of *Periplaneta* were demonstrable in the visceral ganglia following the intersection of the nerves. The nuclei of these cells do not differ from the average but the size of the nucleoli is 3 times greater than average. It is undoubted that this might be related to increased protein synthesis and regeneration, respectively. At the same time two other phenomena were also observable following the intersection of nerves. On the 7th day the glia nuclei arranged around some nerve cells exhibited an intensive staining, and on the 9th day the glia protrusions that usually did not stain with pyronine turned pyroninophilous. It is known, that RNA was demonstrable also in glia cells and that its quantity is dependent on functional effects (HYDEN 1959, PEVZNER 1964). The glia has an important role in the food-supply of nerve cells and is, perhaps, important also in other respects, therefore, this phenomenon might be regarded as a sign of increased functioning. It cannot be neglected, however, that following the intersection of nerves and especially a week from intersection vacuolization is observed in some cells as a sign of degeneration. This cannot be explained by the alterations of the size of nuclei and nucleoli. Signs of degeneration were observed in other cells too, and it is not excluded that the pyroninophilia observed in glia cells, and on the protrusions might perhaps be related to degeneration and not to regeneration.

In the examinations presented in this paper, cells with perinuclear ring were observed only in the visceral ganglia following the intersection of either CVc or of pallial nerve. It is not clear why cells like these do not occur also in the cerebral ganglion, since the cell body of one part of fibers which pass in

the CVc are obviously inside the cerebral ganglion. An explanation to this might perhaps be found in the fact that in the large motor cells the perinuclear ring is most conspicuous and that the fibers of the motor cells of cerebral ganglia do not pass towards the visceral ganglion. Only studies in which the motor nerves will be intersected might give answer to these questions.

Summing up, it may be said that following axon damages a perinuclear pyroninophilous ring appears also in certain cells of Mollusca, and it is thought that this observation might be of use in localization studies. Further investigations are needed to elucidate the origin of pyroninophilia occurring in the glial cells and on the protrusions and to establish the relationship between their pyroninophilia and degeneration or regeneration.

It is not unlikely that the alterations observed in the glia are indicating the interrupted regenerative processes and the beginning of degeneration of deeply damaged nerve cells.

Summary

Applying malachite green pyronine staining on the ganglia of *Anodonta cygnea* the following observations were made:

1. Under normal conditions the cytoplasm of the nerve cells contains various amounts of RNA. In certain cells the cytoplasm is completely filled with RNA which is localized on rough granules ("pyroninophilous cells").
2. Both nuclei and nucleoli of the "pyroninophilous cells" are significantly smaller than those of non-pyroninophilous cells of similar size.
3. Following the intersection of nerves a fine granular perinuclear RNA appears in some cells. The nucleoli of these cells are about 3 times as great as those of control cells.
4. On the 7th day following nerve damages some groups of cells in the glia contain numerous RNA and on the 9th day RNA is demonstrable also in the protrusions of glia. At that time strong vacuolization is observable in some cells.

The perinuclear RNA ring is a regeneration phenomenon, and might be useful in localization studies. It is questionable, however, whether the strong increase of RNA content in the glia and vacuolization are related to regeneration or to degeneration processes of the nerve cells.

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RNS HISZTOKÉMIAI VIZSGÁLATA MOLLUSCA GANGLIONBAN NORMÁL VISZONYOK KÖZÖTT ÉS IDEGKÁROSODÁS UTÁN

Salánki János és Gubicza András

Összefoglalás

Malachitzöld-pyronin festés alkalmazásával *Anodonta cygnea* ganglionjában azt találtuk, hogy

1. Normál körülmények között az idegsejtek cytoplazmája különböző mennyiségben tartalmaz RNS-t. Vannak sejtek, melyek cytoplazmáját durva szemcsékre lokalizálódva teljesen kitölti („pyroninofil sejtek”).
2. A „pyroninofil sejtek” magja és nucleolusa szignifikánsan kisebb, mint a hasonló méretű, nem pyroninofil sejteké.
3. Idegátmetés után egyes sejtekben finomszemcsés perinuclearis RNS-gyűrű jelenik meg. E sejtek nucleolusa hasonló méretű kontroll sejt nucleolusánál kb. $3 \times$ nagyobb.
4. Idegkárosodást követő 7. napon a glia egyes sejtcsoportjai sok RNS-t tartalmaznak, a 9. napon RNS glianyúlványokban is kimutatható. Ebben az időben egyes sejtekben erős vakuolizáció észlelhető.

A perinuclearis RNS-gyűrű regenerációs jelenség, és lokalizációs vizsgálatokra alkalmas lehet. Kérdéses, hogy a glia RNS tartalmának feltűnő megszaporodása és a vakuolizáció is a regenerációval vagy pedig egyes sejtek degenerációjával függ-e össze.

ГИСТОХИМИЧЕСКОЕ ИССЛЕДОВАНИЕ РНК В ГАНГЛИЯХ МОЛЛЮСКОВ ПРИ НОРМАЛЬНЫХ УСЛОВИЯХ И ПОСЛЕ НАРУШЕНИЯ НЕРВА

Янош Шаланки и Андраш Губица

При применении пиронина малахитовой зелени в ганглиях беззубки было обнаружено, что

1. — В нормальных условиях цитоплазма нервных клеток содержит разное количество РНК. Обнаруживаются такие клетки, цитоплазма которых полностью наполнена грубыми зернами («пиронинофильные клетки»).

2. — Ядро и ядрышко пиронинофильных клеток сигнификантно меньше чем в непиронинофильных клетках.

3. — После перерезки нерва в определенных клетках появляется околоядерное кольцо РНК, состоящее из мелких зерен. Ядрышко этих клеток в 3 раза больше, чем в нормальных клетках.

4. — Через 7 дней после перерезки нерва в отдельных клетках глии обнаруживается высокое содержание РНК, а через 9 дней уже и в отростках глии. В это время характерна и вакуолизация.

Околоядерное кольцо РНК является регенеративным явлением, и можно применять для локализации. Останется невыясненным вопрос о том, что наблюдаемое увеличение РНК в глии и вакуолизация регенерацией связаны ли или являются результатом дегенерации отдельных клеток.

FILTRATION AND O_2 CONSUMPTION RELATED TO THE PERIODIC ACTIVITY OF FRESHWATER MUSSEL (*ANODONTA CYGNEA* L.)

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It is characteristic for the physiology of bivalves to maintain through the activity of the cilia in their gills a constant water flow. They take up the necessary oxygen from the streaming water and filter the food, too. At the same time, they also filter the suspended materials of not food character and sediment them. Filtration is in this sense very important with regards to the animals' growth and reproduction as well from the viewpoint of water purification. It is understandable that investigations were performed in greater part on marine species (GALTSTOFF's monograph 1964) but considering water purification and O_2 consumption experiments were extended also on freshwater species (HARANGHY 1936, KOCH and HERS 1943, HARANGHY and BALÁZS 1963).

Research was chiefly concentrated on the water quantity pumped by individual animals, on the degree of water purification and O_2 consumption, these all depend on external factors (temperature, O_2 supply, ebb and tide, daily rhythm of illumination, quantity and quality of food resp.) on the size and age of animals. As the passage of water is effected by the activity of cilia, conclusions are in general drawn directly from this activity and no or hardly no attention is paid how the filtration itself and O_2 consumption are related to the specific behaviour reactions of the animal. Already GALTSTOFF (1964) pointed out this insufficiency in the interpretations.

Previous investigations (LOOSANOFF 1939, BARNES 1955) emphasized that the activity of certain mussel species, leastways under special laboratory conditions, can be interpreted, for a relatively short time, as continuous (from 2—3 hours till 15—20 hours). Namely, the close muscles get from time to time, for a period of some hours, into a certain degree of tonic contraction and the valves close tightly. Thus the animal is more or less separated from the surrounding water and with respect to its valve movement it is in complete rest.

The alterations of activity with rest periods, the so-called frequency of periodic activity is a function of several factors as well in *Anodonta* as in many marine species (KOSHTOYANTS and SALÁNKI 1958, SALÁNKI 1962, 1965, 1966), among them in nature supposedly oxygen supply is one of the most important.

Valve movement, backgrounded by the action of close muscles, may play in two aspects a role in filtration. Partly the rhythmic valve movement

including the quick closure and opening of the valves may cause an increased water passage, partly for the time of the rest period when the valves are tightly closed for hours supposedly there is no water passing through the gills and correspondingly also filtration activity stops. It is thus obvious that the effect of a certain factor influencing filtration activity (temperature, pollution) cannot be interpreted as affecting only the activity of cilia but it can be an essentially important factor related to the behaviour reaction in mussel, that is it can be understood as a regulation achieved through the rhythmic and periodic activity.

Our purpose was to elucidate how the filtration and O_2 consumption of mussels depending on periodic activity are shaped and to control the hypothesis whether the periodic activity and its changes consequent to different factors are important clues in interpreting the oxygen consumption and filtration activity of mussels or not.

Material and methods

Experiments were performed on the freshwater mussel *Anodonta cygnea* L. The animals were chosen to be in general of 14–16 cm in length thus assuring — as they came from the same biotope — that no difference in age existed among the individuals. They were sampled from an artificial water basin, but were kept prior to the experiments for some weeks in streaming Lake Balaton water. During the experiments they were placed separate by in 3–5 l standing lake water. Filtration activity and O_2 consumption were measured in separate series.

Measurement of filtration activity

An indirect method was chosen for this purpose as we wanted to obtain data on the water purification and not on the quantity of the pumped water. The method of COLE and HEPPEL (1953) was used agreeing in principle with other similar methods so far as it takes as basis of measurement the filtration time of the slowly sedimented suspended particles. In this case the suspended material was a neutral red stain. Solved in water above pH 7 the bigger part of this stain is present in the form of fine crystals and can be dissolved only after acidification: in this state it can be well measured photometrically. The advantage of the method is the slow self-sedimentation, facilitating continuous, reliable measurements for 24 hours. On the other hand, it is disadvantageous that the stain partly gets soluble to small extent already at pH 7 thus it is not convenient for obtaining absolute values. In our experiments, however, we wanted to compare the samples taken out one after the other from the same vessel and for this purpose the method was adequate. Parallel with the samples also the spontaneous sedimentation was measured. A solution of 20 mg/l of neutral red was used and for each measurement 10–10 ccm water was taken in two parallels from a standard level of the vessel. After acidification with 2 drops 3×N hydrochloric acid the transmission was measured at 546 mμ wave length with Uvifot photometer. In the figures transmission values are directly demonstrated.

These experiments were carried out at 21–23 °C room temperature.

Measurement of O₂ consumption

At the beginning of the experiment the 5 l water where the animal was placed was separated from the oxygen of the air by a paraffine oil layer. Earlier data reported that under such conditions the mussel lives on undamaged, only its activity changes after the decrease in O₂ tension (SALÁNKI 1965). The water samples were taken up under nitrogen, O₂ content was measured with MAUCHA'S (1947) half-micro method using in each case 10 ccm water. This means in the case of 20 samples 200—250 ccm of volume, i.e. 4—5% of the total quantity and thus insignificant. In the figures we have given the quantity of O₂ in the water at the time of sampling in mg/l values. Experiments were carried out at 24—25 °C room temperature.

Recording of activity

The activity of the mussel was recorded by an earlier described mussel actograph (SALÁNKI and BALLA 1964). The animal's one shell is fixed, the other one is connected to a mechanical recorder; the movement of the valves can be put on record continuously, eventually even for days, on a slowly rotating (17 mm/h) registrating paper. Thus, at any time the open or the closed state of the valves can be read. With the help of a register the beginning, resp. the end, of the periodic activity produces a warning signal.

Influencing of activity

When it was necessary, the activity of the animal was experimentally altered during the investigations. To increase the frequency of periodic activity CdCl₂ solution was added. Previous experiments showed that the frequency of the periodic activity in *Anodonta cygnea* L. can be increased with 5—10 mg/l CdCl₂ significantly (SALÁNKI 1960) resulting in changing activity to rest within relatively short periods (from 2 to 4 hours). This was of importance as in this case the alteration of activity and rest period could be reproduced several times during 24 hours, thus facilitating significantly the comparison and evaluation of filtration activity, resp. O₂ consumption, between the two types of behaviour.

Other interferences

In special cases the shells of the animals were partially removed or we interfered in other ways for definite purposes. These interferences are reported in detail in the "Results".

Results

a) Filtration activity

Intact animals were placed in vessels containing 3 l water and their activity was recorded. The animals were fixed in the actograph 1—2 days previous to the filtration experiments. Consequently, water was circulating for some hours in the vessels. When the rhythm got regular the circulation was closed. Then water was replaced with a 20 mg/l solution of neutral red. The stain was dissolved in filtered Lake Balaton water. From this on at the beginning, resp. at the end, of active periods we took water samples at the level of the mussel's sypho to determine the concentration of the still suspended stain.

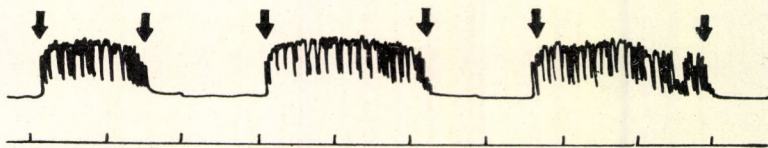


Fig. 1. Actogram of a mussel in periodic activity. Arrows show the taking of water samples; time signal: hours

1. ábra. Aktogramm periodikus aktivitással működő kagylóról. Nyilak a víz mintavételét jelölik, időjelzés óránként

Fig. 1 is an actogram, the arrows indicate the time when the sampling took place. (The beginning and the end of activity is in natural compliance with the beginning and with the end of rest period.) We found that the extraction of neutral red was significantly quicker in the vessels where the animals were kept as the spontaneous sedimentation in the controls where there were no animals. This difference is to be attributed to the filtration activity of the mussel.

Comparing the results obtained from the sample series we found that the rate of the filtration of neutral red is quicker at the beginning, then the curve slowly flattens out. Further on an interesting and clean-cut correlation can be drawn concerning the relation between periodic activity and rate of filtration

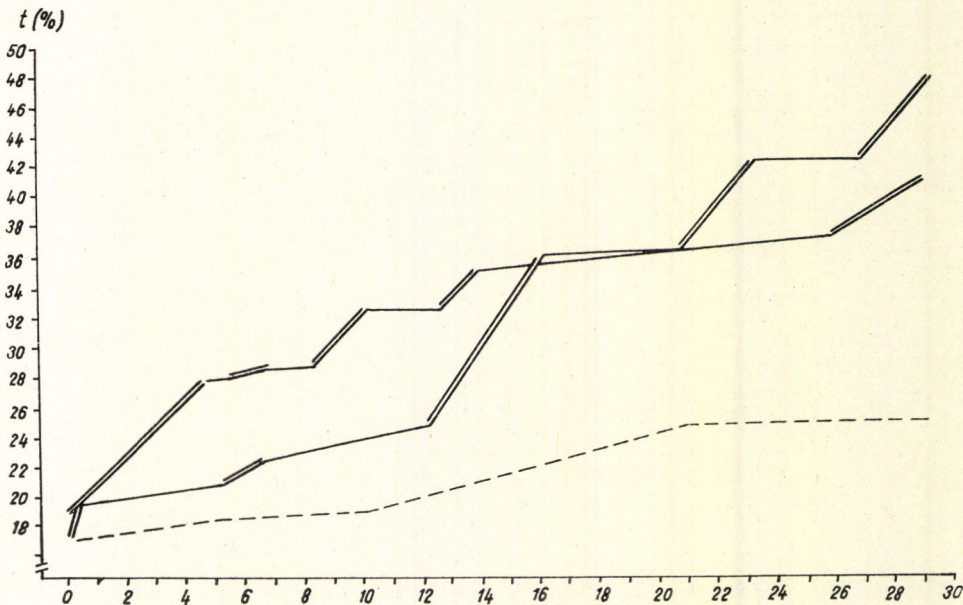


Fig. 2. Relation between periodicity and filtration in intact mussel

Indications: — active (open) phase, --- closed (rest) phase, spontaneous sedimentation Ordinate: transmission. Abscissa: time (hour)

2. ábra. A periodicitás és filtráló tevékenység összefüggése intakt kagylók esetén
Jelzések: — aktív (nyitott) szakasz; --- zárt (nyugalmi) szakasz; spontán szedimentáció. Ordináta: transzmisszió. Abszcissa: idő (óra)

(*Fig. 2*). If the shells of the animal are open and operate rhythmically the decrease of the suspended material is consistently significant. If they are closed, the filtration is stopped, the decrease does not surpass that one expected in the course of spontaneous sedimentation. However, it occurred in certain cases that during the "rest" period a decrease was observed that could not be explained with spontaneous sedimentation. But it might be connected to the fact that sometimes despite the closed state of the shells a small opening exists around the sypho and the weak current may cause some filtration, too. These observations can be yet not treated on the hand of our experiments as common phenomena. In cases reported in *Fig. 2* such phenomenon did not occur.

By applying suspended neutral red to measure filtration activity it is rather problematic that the animal does not only filter and sediment the stain from the water, but it is to a certain degree absorbed by the mussel's tissues, as they get coloured. The rate of absorption is obviously the most intensive at the hours when the animals were put into the solution and may be the quick decrease, found at the beginning of the experiment, could be ascribed to it, too. In order to partly eliminate this factor separate experiment-series were performed.

Mussels were placed into rather great quantity (50 l) of 20 mg/l neutral red solution for 72 hours, by this means diminishing, resp. exhausting, their absorptive possibilities. Then they were placed into the actograph and the measurements of the filtration activity was started under conditions as before.

It was found that the sedimentation ascribed to the animal does not differ from that performed by intact animals. This means that the quantity of the suspended stain extracted from the water was not influenced by the fact that the animal previously already absorbed neutral red. It is assumed that absorption takes place from the dissolved stain, but the filtration from the stain present in suspension, and that this latter, unsolved part, forms the bulk of the stain in the water.

Unforeseen result of these experiment series was that the mussels previously saturated with stain showed activity lasting for a longer time than usual (*Fig. 3*). With regards to these facts we introduced (independent from the activity) the taking of the samples per 2 hours to get a picture on the alterations occurring in filtration. As it is shown in *Fig. 4* certain fluctuations occur in the course of filtration also here, which could be connected to the rhythmicity of shell movement, resp. to the activity, of cilia.

These observations point to the fact that neutral red is not an indifferent material from the viewpoint of physiology and behaviour of mussel either, thus emphasizing the necessary precaution in applying this method for purposes of quantitative analyses.



50 min.

Fig. 3. Mussel activity after saturation with neutral red

3. ábra. Kagyló aktivitása neutrálrvörössel való telítés után

From experiments on animals previously saturated with neutral red, we did not obtain an answer for the question how far under these conditions the sedimentation is related to the active, resp. rest periods. Therefore, experiments were performed when under similar conditions the frequency of periodic activity was increased experimentally. For this purpose we used CdCl_2 as its effect in this relation is already known (SALÁNKI 1960).

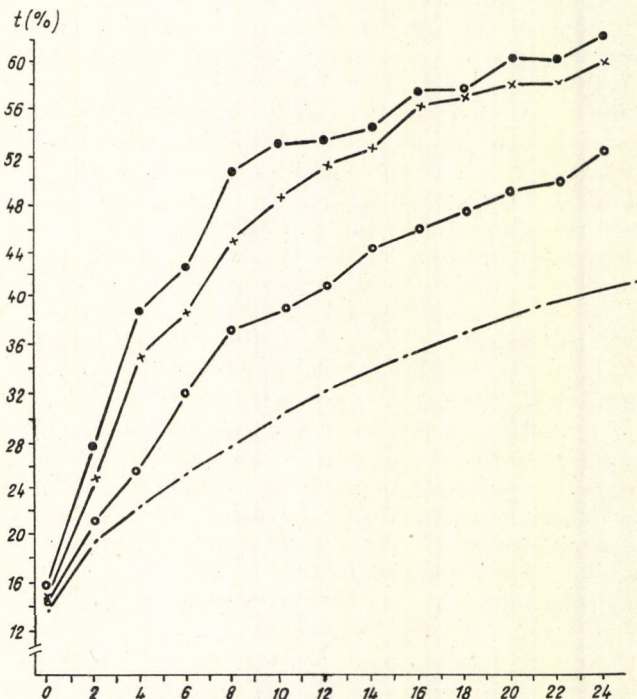


Fig. 4. Filtration of mussels kept previously for 72 hours in NR at lasting activity.
 Indications: ● No. 1 experiment; × No. 2 experiment; ○ No. 3 experiment
 Ordinate: transmission. Abscissa: time (hour)

4. ábra. Előzőleg 72 órán keresztül NR-ben tartott kagylók filtrációs tevékenysége állandó aktivitás mellett. Jelzések: ● 1. sz. kísérlet; × 2. sz. kísérlet; ○ 3. sz. kísérlet
 Ordináta: transzmisszió. Abszcissza: idő (óra)

The measurement of the filtration activity of mussels kept for 72 hours in stain solution was carried out in the presence of 10 mg/l CdCl_2 . In this medium instead of lasting activity the alteration of short active and rest periods can be observed. The value obtained with photometry showed in the samples taken at the beginning and at the end of active periods that the purification of water from neutral red follows the same gradualness as found in intact animals: during the active period the amount of the suspended material decreases intensively while during the rest period (closed valves) the filtration stopped (Fig. 5).

b) Periodicity in oxygen consumption

After previous recording of the activity for some days the water surface was covered with a paraffine layer and from this time onwards samples were taken at the beginning, resp. the end, of each active period for oxygen determinations. The decrease of O_2 constant was neglected under $0.5 \text{ mg/l } O_2$ values in general. We found that the oxygen consumption related to the time unit is fivefold higher during an active period than at rest. With regards to mean values the oxygen consumption numbers in active state: 0.175 mg/g

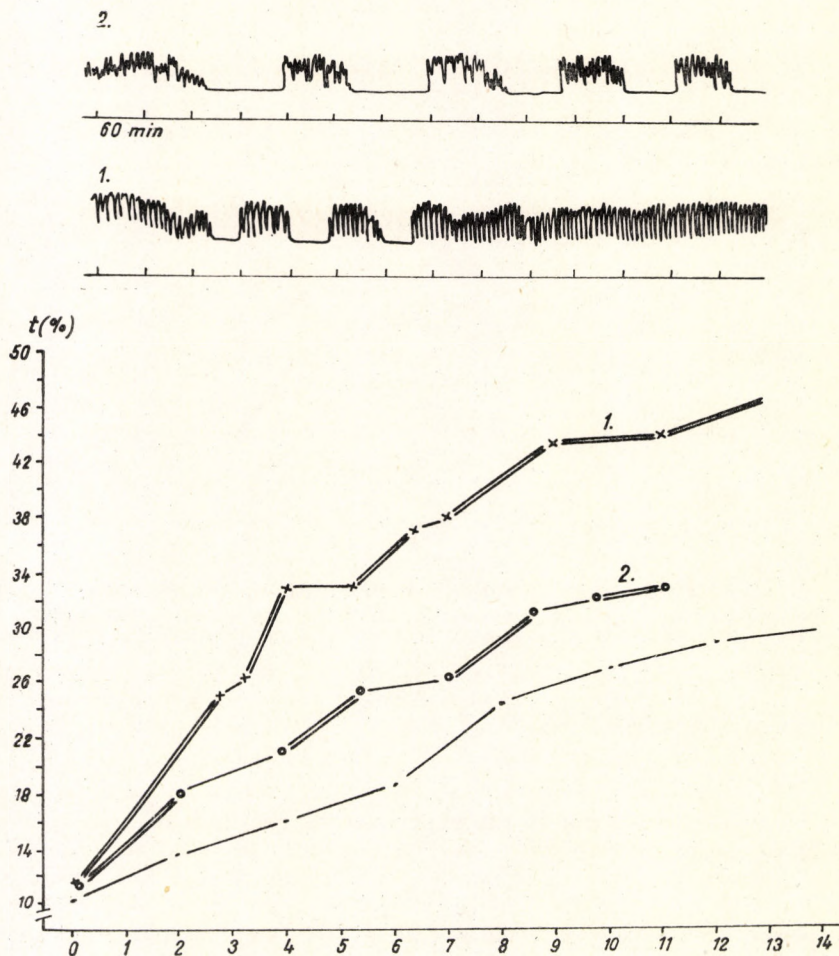


Fig. 5. Activity and filtration of mussel saturated with NR after 10 mg/l CdCl_2 . Indications: 1 = No. 1 experiment; 2 = No. 2 experiment; — active (open) phase; — rest (closed) phase; - - - spontaneous sedimentation. Ordinate: transmission. Abscissa: time (hour)

5. ábra. NR-rel telített kagylók aktivitása és filtrációja 10 mg/l CdCl_2 után. Jelzések: 1 = 1. sz. kísérlet; 2 = 2. sz. kísérlet; — aktív (nyitott) szakasz; — nyugalmi (zárt) szakasz; - - - spontán szedimentáció. Ordináta: transzmisszió, Abszcissa: idő (óra)

dry material/hour, while in the rest period it is 0.036 mg/g dry weight/hour. In *Fig. 6* the course of one of the experiments (values of activity and oxygen consumption) is presented.

Experiments concerning the extraction of oxygen from the water showed similar results to those obtained by investigating the filtration of suspended material. In this case, however, we cannot be sure whether the uptake of oxygen from the water indicates also the time course of oxygen consumption by the animal. It might be supposed that during the rest periods the oxygen consumption is covered from inner sources; if so, this process naturally does not affect

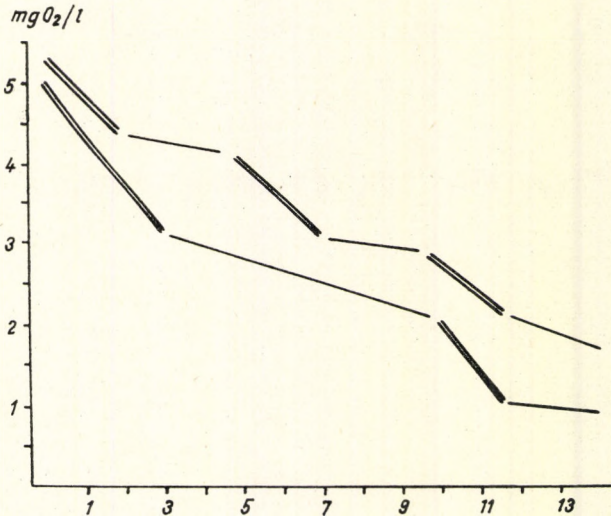


Fig. 6. Relation between periodic activity and O₂ consumption. *Abscissa:* time (hour). Note: the animal was kept in 5 l water, therefore the consumption value given in the figure is the 1/5 of the actual consumption. — active period; — rest period;

6. ábra. Periodikus aktivitás és az O₂-fogyasztás összefüggése. *Abszcissa:* idő (óra). Megjegyzés: az állat 5 l vízben volt elhelyezve, az ábrán leolvasható fogyasztás tehát a tényleges fogyasztás 1/5-e. — aktív szakasz; — nyugalmi szakasz

the O₂ tension of the water in the experimental vessel. However, in the next active state beside the *de facto* oxygen consumption also the "depo" gets restored, causing an increase in oxygen uptake higher than the actually used up amount. In this case the fluctuation in oxygen content of water parallel to the periodic activity is only illusory, or at least smaller than what the measurements show.

To clear this contradiction we removed the caudal part of the mussel's shell around the sypho up to the posterior adductor, without damaging it. At the same time 2—2 pea-sized holes were bored at the middle of the shells. In this way the water could circulate even in the rest period when the shells were closed. We recorded the activity of mussel kept in with paraffine layer covered water and at given times water samples were taken for oxygen determinations.

It was conspicuous that the treated animals contrary to practice showed activity lasting for days and the adductor muscles did not get into the state of lasting tonic contraction. Also an increase in the frequency of rhythmic activity could be observed. Therefore we measured the O_2 content of the water in every 2 hours regularly. No significant fluctuation could be however detected (Fig. 7). In the first 14 hours the average value of the O_2 consumption was

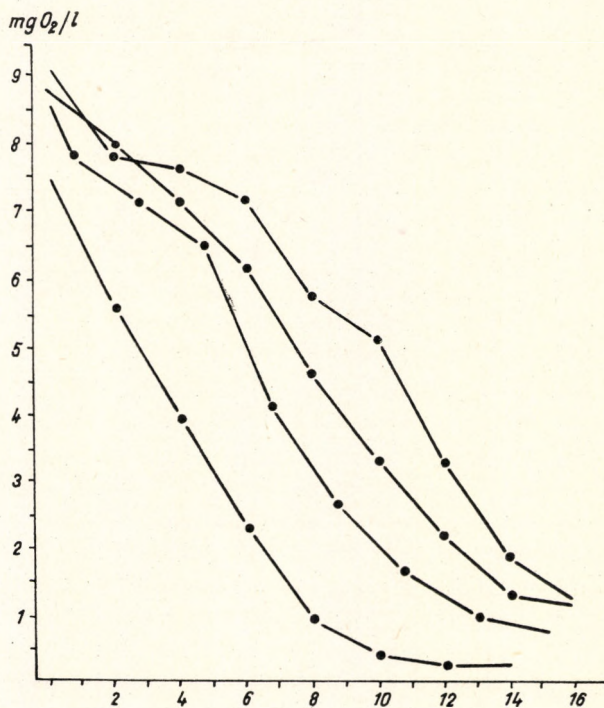


Fig. 7. O_2 consumption after the removal of shell around the sypho. Abscissa: time (hour)
(See "Note" for Fig. 6)

7. ábra. O_2 -fogyasztás a kagylóhéj szifo körüli részének eltávolítása után.
Abszcissa: idő (óra). (Megjegyzés, mint 6. ábra.)

0.269 mg O_2 /g dry material/hour, when the oxygen content of the water decreased to 1–2 mg.

To investigate the oxygen consumption of the treated mussels during the active and rest periods again the already introduced method was used, i.e. $CdCl_2$ was added to the water in which the animals were kept. It resulted in an alteration of short active and rest phases. Determining the oxygen content of the samples taken at times of the interchanges we found that the O_2 consumption is essentially higher in the active period than at rest. The difference is even higher than in intact animals; in the presence of 2.5 mg $CdCl_2$ it is elevenfold, in the case of 5 mg $CdCl_2$ it is even fifteenfold. The oxygen consumption calculated for 1 g dry material was: for 2.5 mg $CdCl_2$ /l in active period 0.467 mg/hour, at rest 0.031 mg/hour; for 5 mg $CdCl_2$ /l 0.717 mg/hour

in active period and 0.065 mg/hour at rest. The gradualness of oxygen consumption corresponding to the periodic activity demonstrated in *Fig. 8* is also striking.

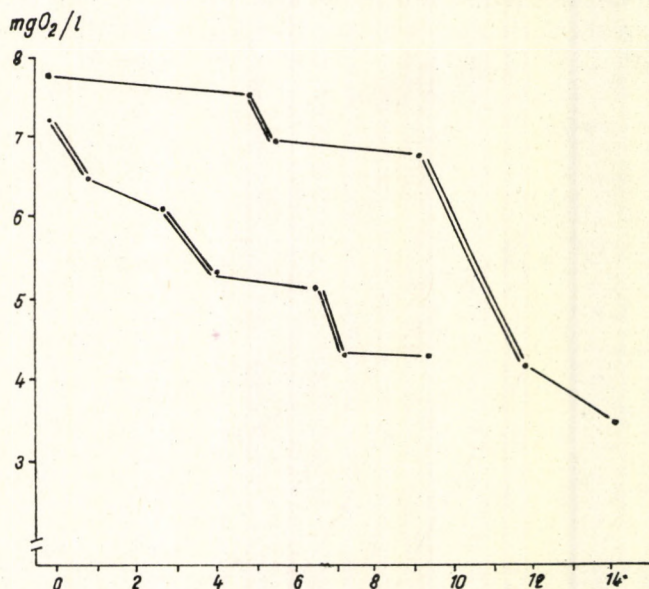


Fig. 8. O₂ consumption during periodic activity provoked by CdCl₂ in case of removal of shell around the sypho. (See "Note" for *Fig. 6*)

8. ábra. O₂-fogyasztás CdCl₂-dal provokált periodikus aktivitás alatt, a szifo körüli héjrész eltávolítása esetén. (Megjegyzés: mint a 6. ábrán.)

The wet weight of animals (without shells) used in the experiments was in general 70–80 g. Consequently, the oxygen consumption of an untreated total animal was in open state 2.57 mg/hour, in closed state 0.55 mg/hour.

Discussion

In general, three interpretations are concluded from the results obtained by investigating the filtration and sedimentation activity as well O₂ consumption of mussels:

- (a) role of mussels in water purification,
- (b) nutrition of mussels,
- (c) rate of ciliary activity in mussels.

On hand of laboratory measurements sometimes far leading calculations were made and publications appeared on the sedimentation activity of mussels, expressed in metric centners and related to yearly cycles (VERWEY 1952, ITO and IMAI 1955). Other authors interpret the decrease of filtration activity of mussels following different effects in advance as the influencing of ciliary activity (HARANGHY 1957), as it gets realized actually through the activity of cilia.

Our experiments clearly demonstrate the justifiable claim of GALTISOFF (1964) that shell movement should be considered when investigating the filtration of mussels. This reasoning is in near contact with the knowledge of the animal's specific behaviour manifested in the periodicity of activity. Our results show that there is a great difference in the purification of water from the suspended material and in oxygen uptake, consequently, in the amount of the pumped water during the active and the rest periods. It cannot be stated that if the shells are closed through the tonic contraction of the close muscles, the filtration activity completely stops, — this is not true especially for the filtration of oxygen. These observations are in contradiction with data reported by NEWELL and NORTHCROFT (1965). However, it is obvious that the values obtained during active periods cannot be transferred not only on yearly cycles but even on a one-day period by means of simple multiplication, as because of the periodicity in activity there occur also phases when the activity is interrupted or is insignificant. It cannot be discussed that the results of measurements, carried out for longer time (days) but omitting the parallel registration of activity can be deceiving and could serve as interpretation of broadly scattered values (e.g. HAVEN and MORALES-ALAMO 1966).

In general, investigations pay attention to the animal's size, temperature, the time of sexual cycles and to the fact that within a certain limit of size the animal filtrates the bigger particles quicker than the smaller ones. Besides these considerations our experiments showed that as important factor also the animal's periodic activity should be taken into account. To its proper estimation only the method of parallel registration of activity can be suitable. The periodicity of activity is valiant not only for *A. cygnea*, but is a known phenomenon also in several marine molluscs (LOOSANOFF 1939, SALÁNKI 1966).

The difference of activity in the different phases of periodic activity points also to the problem that the inhibiting effect on the filtration activity of a certain factor cannot be simply interpreted as an effect appearing at the general level of ciliary activity. It is plausible that either the fluctuation of temperature or the pollution of water produce an effect through the regulation of periodic activity similar to the experimentally used CdCl_2 , influencing the occurrence and time scale of rest periods. The periodically appearing closure of shells leads also in that case to the decrease of water purification if the ciliary activity is, during the active periods, otherwise normal or even slightly increasing. In our opinion when investigating the ciliary activity in intact animal the simultaneous registration of shell activity is indispensable.

In our experiments the pre-treatment with neutral red as well the removal of the shell around the syphos resulted in the absence of the rest period. The effect of neutral red in this aspect is the more remarkable as in previous investigations with other agents only decrease in the activity was reported, when rest periods appeared more frequently (KOSHTOYANTS and SALÁNKI 1958, SALÁNKI 1960, 1955). BARNES (1965) by increasing the O_2 supply, CO_2 tension and giving more food could not demonstrate any significant increase in activity. The increasing activity observed when the sypho was liberated from the shell is similar to the effect obtained in the case of denerved sypho (SALÁNKI 1961).

As rest periods are appearing in greater frequency when the O_2 content of the water decreases (SALÁNKI 1965) it can be supposed that by removing the shells in the very same water body the oxygen supply of the syphos is better. Its effect through the receptors results in an increase of activity. In any case

these observations refer to the important role of syphos in activity regulation. But in both cases consequent to CdCl_2 the animals reacted as the intact ones did, showing that both pre-treatment with neutral red and liberation of the syphos do not damage essentially the regulatory mechanism.

The parallel decrease of the water's oxygen level with the periodicity of activity puts the question whether the increased oxygen uptake during the active, and the decreasing one in rest period are, or are not connected with the mussel's actual energy requirement. It is obvious that during the active period the muscle work itself causes a significant O_2 consumption, the heart function is also more intensive (PÉCSI and SALÁNKI 1964) indicating an increased metabolism. On the other hand, it is commonly known that also under strictly hypoxic conditions lively active periods can be observed in *Anodonta cygnea*, emphasizing the relative low level of oxygen required for activity. Therefore, it is assumed that a certain amount of the oxygen taken up during the active period is stored and consumed during the rest period; during the latter the energy supply takes place in this interpretation not only from anaerobic processes. It is possible that this oxygen storage plays directly or indirectly a role in the regulation of the duration of the rest period or at least in modifying it.

Summary

The relations between the mussel's water purification and oxygen consumption related to the animals' characteristic activity rhythm were investigated. It was found:

1. The filtration measured with indirect method occurs during the active period, when the shells are rhythmically active;
2. The oxygen consumption during the active period is 5–10fold higher than in the rest period when the shells are closed;
3. The neutral red method for filtration, developed by COLE and HEPPER (1953) is not suitable to obtain quantitative values;
4. Saturation with neutral red as well the removing of shell around the sypho increase the activity of the animals.

The fact that the mussel's activity is not continuous but lasting intervals caused by different factors interrupt the open state, make the results of experiments questionable where no simultaneous activity registration were performed. These data seem the less acceptable the more they are related to results obtained on single individuals and from short lasting measurements in respect the whole year-sedimentation of the total mussel population in the biotops.

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FILTRÁCIÓ ÉS O₂-FOGYASZTÁS ÖSSZEFÜGGÉSE A PERIODIKUS AKTIVITÁSSAL TÁVI KAGYLÓNÁL

Salánki János és Lukacsovics Ferenc

Összefoglalás

Vizsgálták kagyló víztisztító működésének és oxigénfogyasztásának összefüggését az állat jellegzetes aktivitási ritmusával. Megállapítást nyert:

1. Az indirekt módszerrel mért filtráció lényegében az aktív periódus alatt zajlik le, amikor a héjak ritmikus aktivitást mutatnak;
2. az oxigénfogyasztás aktív periódus alatt 5—10-szer nagyobb, mint nyugalmi periódusban, amikor is a héjak szorosan zárt állapotban vannak;
3. a filtrációmérésre használt, COLE és HEPPER (1953) által ajánlott neutrálvörös módszer nem alkalmas kvantitatív értékek nyerésére;
4. neutrálvörössel való feltöltés, valamint a szífo körüli kagylóhéj-rész eltávolítása az állatok aktivitását fokozta.

Az a tény, hogy a kagylók aktivitása nem folyamatos, hanem a héjak nyitvatartásában sok tényezőtől befolyásoltan tartós megszakítások vannak, vitathatóvá teszi a filtrációra és oxigénfogyasztásra vonatkozó azon vizsgálatok adatait, ahol egyidejű aktivitásregisztrálást nem alkalmaztak. Különösen kétségesé teszi azon számítások realitását, melyekben egyes egyedeken rövid ideig történt mérésből, egy-egy biotóp összkagylóinak egész évi szedimentációjára vonnak le következtetéseket.

ВЗАИМОДЕЙСТВИЕ ФИЛЬТРАЦИИ И ПОТРЕБЛЕНИЯ КИСЛОРОДА С ПЕРИОДИЧЕСКОЙ АКТИВНОСТЬЮ БЕЗЗУБКИ

Янош Шаланки и Ференц Лукачович

Было изучено взаимоотношение фильтрационной активности и потребления кислорода с характерным ритмом активности животного. Было установлено:

1. — Фильтрация, измеренная косвенным методом, фактически происходит только при активном периоде животного, когда створки раковин обладают ритмической активностью.

2. — Потребление кислорода в активной фазе в 5—10 раз выше чем в периоде покоя, когда створки раковины находятся в закрытом состоянии.

3. — Метод нейтралрота для измерения фильтрации, предложенный Коле и Хеппер (1953) не позволяет получить квантитативные данные.

4. — Насыщение нейтралротом и удаление раковины около сифона приводят к увеличению активности животного.

Тот факт, что активность беззубки неплавная, а прерывистая, ставит под сомнение данные, полученные в отношении фильтрации и потребления кислорода без одновременной регистрации активности животного. Особенно сомнительны те данные, на основе которых после кратковременного измерения характеристики отдельных особей приходят к выводу о годовой седиментации беззубок целого биотопа.

COMPARATIVE STUDY ON THE CHOLINESTERASE ACTIVITY OF DIFFERENT TISSUES OF FRESHWATER MUSSEL (*ANODONTA CYGNEA* L.)

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Important role is attributed, in general, to acetylcholine (ACh) in the stimulatory processes of Pelecypoda same as in the case of other molluscs. The role of ACh is considered important primarily in influencing cardiac action (see GREENBERG 1965), but its participation in the regulation of somatic muscles (TWAROG 1960), in the operation of the cilia of the gill (BÜLBRING et al. 1953), and in the mechanism of the central nervous system (HORRIDGE 1961, PUPPI 1963) was also suggested or demonstrated.

Nevertheless, we have only deficient or contradictory data at disposal concerning the presence of cholinesterase (ChE) in the different tissues, on the properties and quantitative relationships of this enzyme and on the elimination of released ACh. In the case of various bivalves a higher degree of ChE activity has been demonstrated so far only in the adductors (VARGA 1959, ZS.-NAGY 1963) with both biochemical and histochemical methods.

A considerable difference in ChE activity was found recently by KALAMKAROVA and KRYUKOVA (1966) between tonic and phasic parts of the adductors. BÜLBRING et al. (1953) demonstrated ChE activity in the gill of *Mytilus*. In course of examinations on heart muscle NISTRATOVA and YUZHANSKAYA (1966) did not find ChE activity in the ventricle, and demonstrated only traces of its in the auricle, and these findings led them to the conclusion that ACh released at cardiac nerve terminations is not decomposed in the heart itself. The above authors did not find ChE activity in the musculature of the intestine either.

ChE activity was not demonstrable by histochemical methods in the central nervous system of freshwater mussel (ZS.-NAGY and SALÁNKI 1965), however, by biochemical methods it was provable (SALÁNKI et al. 1966).

Because, according to the general opinion, the demonstration of specific ChE might be of great importance in the estimation of cholinerg mechanisms the present examinations were made with the objective to decide in the case of *Anodonta cygnea* L 1) if there is ChE present or not in all such tissues in which importance is attributed to ACh by different authors on basis of pharmacological and physiological examinations. These present investigations were not extended to the ganglia because the property of their ChE activity has been examined previously (SALÁNKI et al. 1966); 2) to obtain data on the properties of ChE by applying various substrates and inhibitors; and 3) to obtain comparative data on the ChE activities of tightly connected but differ-

ently functioning parts of organs (the auricle and ventricle of the heart, the "tonic" and "phasic" parts of the adductors) in the hope that these data might, perhaps, be of some help in explaining the functional properties of these parts.

Method

Full-grown specimens of freshwater mussel (*Anodonta cygnea* L.) were used. ChE activity was determined in the two parts of the heart (auricle and ventricle), in the "tonic" and "phasic" parts of the adductors, in the intestine, and further in the gill, mantle and lymph. The experiments were carried out all the whole year round.

The tissues used were excised from specimens freshly taken out from water. The lymph was drained from the pulsating heart taking care that sample-taking should not stop cardiac action. To get hold of sufficient amount of sample for preparing the necessary amount of homogenizate, identical tissues were excised simultaneously from a number of animals. To determine the activity of the "tonic" and "phasic" parts of the adductors samples were excised separately from the anterior and posterior adductors, and were homogenized subsequently.

Homogenizing of samples was made with motor-driven Potter homogenizator for 5 min, under constant cooling and using distilled water. In case of the adductors the wet weight content of the homogenizate was 20 mg/ml and in the case of other tissues approx. 50 mg/ml. The homogenizate was centrifuged for 5 min at 3000—4000 rpm and 1 ml of the supernatant was used as extract, and added to the incubation mixture.

5 ml incubation mixture was used. It contained 1 ml extract, 1 ml substrate-solution, 1 ml 0.2 M trismaleate buffer (pH 8) and 2 ml distilled water. The substrate concentration of the mixture was 5 mM on every occasion. The spontaneous hydrolysis of the substrates was determined in extract-free samples.

When inhibition was examined, 1 ml inhibitor of suitable molarity was pipetted instead of distilled water into the incubation tube. In that case the tube in which spontaneous hydrolysis was measured also contained 1 ml inhibitor. The determinations were conducted at $37 \pm 0.1^\circ\text{C}$.

In case of the adductor and the lymph, incubation time was 1 hour, in case of the other tissues, 3 hours.

Enzyme-activity was measured by the colorimetric method described by HESTRIN (1949). This method is based on the quantitative reactions taking place in basic milieu between ACh and hydroxylamine. The light absorption of the iron-hydroxamate produced after acidification was measured with Beckman GU 2400 spectrophotometer at 430 m μ wave-length. Calibration curves were taken in case of each substrates.

The following substrates were used: acetylcholine bromide (ACh-Br) (de Laire), acetyl- β -methyl-choline bromide (MeCh-Br) (Leight), butyryl thiocholine iodide (BuThCh-J) (Fluka), butyryl choline iodide (BuCh-J) (Fluka), benzoyl-choline chloride (BeCh=Cl) (Leight).

The following agents were applied as inhibitors: eserine-sulphate (B. D. H.) and diisopropyl-fluorophosphate (DFP).

The nitrogen content of the extracts was also determined on every occasion. For this purpose the Kjeldahl technique was used. The ammonia was

released with a strong alkaline and distilled into concentrated boric acid solution and titrated with 0.01 N HCl solution using GROACH's combined indicator. The results of ACh decomposition are expressed in μg substrate/mg N/h units. The comparison of decomposition rates of different substrates was made in ratio of their molecular weight.

Results

A) Heart

After the intersection of the adductors the valves were opened, the heart exposed, the auricle and ventricle excised separately and the lymph was removed from the heart by washing with distilled water. The extract was prepared as described before.

1. ChE activity

The mixture was incubated for 3 hours in the presence of 5 mM ACh-Br substrate. Table 1 illustrates the rate of ACh hydrolysis (μg ACh/mg N/h) (the average of 12 measurements).

Table 1

Comparison of ChE activities in the auricular and ventricular part of *Anodonta* heart. Data indicate the quantity of ACh hydrolyzed during one hour by homogenizate containing one mg N

1. táblázat

Anodonta szív pitvari és kamrai része ChE aktivitásának összehasonlítása. Az adatok 1 mg N tartalmú homogenizátum által 1 óra alatt hidrolizált ACh mennyiségét jelzik μg -okban

Auricle μg ACh/mg N/hour		Ventricle μg ACh/mg N/hour	
1.	358		129
2.	505		95
3.	1 110		301
4.	597		216
5.	542		199
6.	678		199
7.	620		116
8.	367		114
9.	476		104
10.	747		183
11.	378		136
12.	497		142
573			161
(100.0%)			(28.1%)

The measurements show that the extracts prepared from both parts of the heart (ventricle and auricle) have ChE activity. The parallel values and also the averages, show that the ChE activity of the auricle is relatively high and that of the ventricle is considerably lower, less than one-third of the former.

As it is evidenced by *Table 1*, the extracts prepared at different times have rather different ChE activities, the difference in ACh decomposition observed between the two regions of the heart was, however, always marked. The difference of values in case of identical organs is not attributable to the inadequacy of the method but rather to functional and seasonal factors. (Studies concerning this are reported elsewhere.) In the followings we shall present only average values computed from hydrolysis data of minimum five different extracts.

2. Substrate-specificity

In course of these studies besides ACh-Br we also applied the following substrates: MeCh-Br, BuThCh-J and BeCh-Cl. All these agents were used at 5 mM concentration and at an incubation time of 3 hours.

It was observed that these substrates also were more effectively decomposed by the auricle than by the ventricle. The average values are shown in *Table 2*.

Table 2

ChE activities of the heart (auricle and ventricle) in the case of different substrates

2. táblázat

A szív (pitvar és kamra) ChE aktivitása különböző szubsztrátok esetében

	ACh mμM/mg N/hour	MeCh mμM/mg N/hour	BuThCh mμM/mg N/hour	BeCh mμM/mg N/hour
Auricle	2,068.0	1,787.0	852.0	259.0
Ventricle	534.0	125.0	236.0	0

Figure 1 illustrates the rate of substrate decomposition per 1 hour in percentage of ACh decomposition.

It is seen that the decomposition rate of ACh is the highest in case of both auricle and ventricle. If decomposition values of the various substrates are expressed in percentage of ACh decomposition it becomes evident that there is considerable difference between the auricle and ventricle concerning their hydrolysis rates. The hydrolysis rate of ACh and MeCh was approximately the same in the case of the auricle, whereas the ratio of ACh : MeCh hydrolysis rates was 1 : 0.25 in case of the ventricle. It is also worth to mention that while BeCh is hydrolyzed though only to a small extent by the auricle, the same was not observed in the case of the ventricle. In the ratio of BuThCh : ACh-decomposition no difference was observable between auricle and ventricle.

Since the sensitivity of ChE-es to various inhibitors might be of considerable interest in establishing the properties of these enzymes, we have examined the effect produced by eserine and by the organic P-derivative: DFP, both of which are considered the most important ChE inhibitors.

Eserine was used in 10^{-10} – 10^{-5} M concentrations at an incubation time of 3 hours and using 5 mM ACh-Br solution as substrate. In *Fig. 2* inhibition

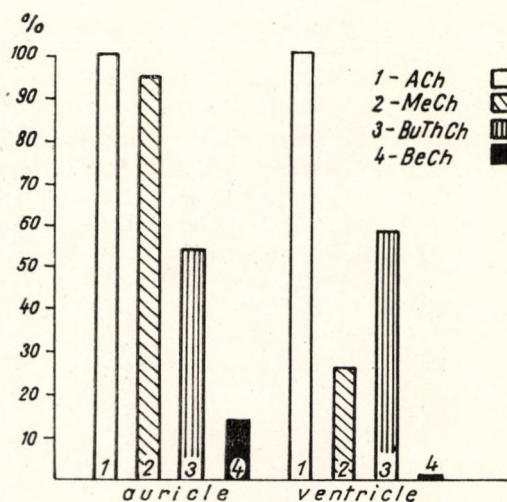


Fig. 1. Relative heart ChE activities in case of different substrates expressed in percentage of ACh-decomposition

1. ábra. A szív (pitvar és kamra) relatív ChE aktivitása különböző szubsztrátok esetében, az ACh-bontás százalékában

values of ChE activity of auricle and ventricle are illustrated in the function of the concentration of the inhibitor. The susceptibility of ChE activity to eserine differed considerably in case of auricle and ventricle. In both cases a nearly 100% inhibition was produced by 10^{-6} M eserine, in the case of the

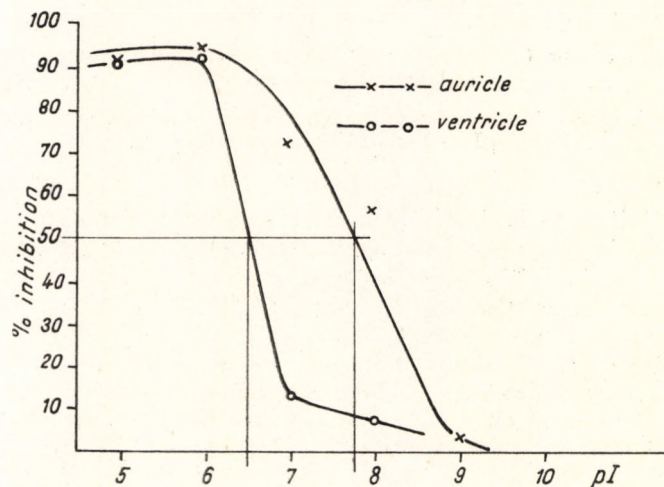


Fig. 2. Inhibition of the ChE activity of the heart (auricle and ventricle) by eserine. pI: — log eserine concentration

2. ábra. A szív (pitvar és kamra) ChE aktivitásának gátlása eserinnel. pI: — log eserín koncentráció

auricle, however, the slope of the inhibition curve became steep at a concentration by two orders lower, than the curve of the ventricle. A 50% inhibition of ChE activity was produced by about 2×10^{-8} M and 4×10^{-7} M concentrations of eserine in case of auricle and ventricle, respectively, i.e. there was an one-order difference between the two values, whereas in case of both auricle and ventricle the concentration at which complete ChE inhibition was produced remained below 10^{-5} M.

The inhibitory effect of DFP on the ChE activity of auricle and ventricle was examined at 10^{-8} – 10^{-3} M concentrations of this agent likewise at an incubation time of 3 hours and at 5 mM ACh-Br substrate concentration. Results are presented in Fig. 3.

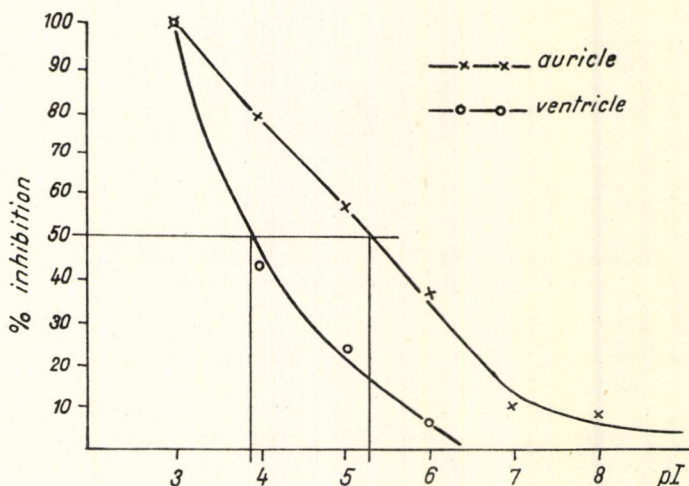


Fig. 3. Inhibition of the ChE activity of heart (auricle and ventricle) by DFP.
pI: — log DFP concentration

3. ábra. A szív (pitvar és kamra) ChE aktivitásának gátlása DFP-vel.
pI — log DFP koncentráció

ChE activity was inhibited at and beyond 10^{-8} M and 10^{-6} M concentrations of DFP in case of auricle and ventricle, respectively. In the case of the auricle 50 per cent inhibition was observed at about 5×10^{-6} M concentration, and in the case of the ventricle at 1.5×10^{-4} M concentration of DFP. ChE activity of both parts of the heart was completely inhibited by 10^{-3} M DFP. Thus, the inhibition produced by this agent resembles that of eserine in relation of the ratio of auricle: ventricle, but in comparison to eserine a by 1–3 order greater concentration of DFP was needed to produce the same inhibition.

B) Adductor muscles

1. ChE activity

In one series of measurements the adductors of one animal were only used. The anterior and posterior adductors were detached from the valves, the white "tonic" and yellowish "phasic" parts were separated and the extracts

prepared of these two, macroscopically and assumably also functionally different parts using the method described previously. Time of incubation was 1 hour. The ChE activity values obtained are presented in *Table 3*.

Table 3

ChE activity of the "phasic" and "tonic" parts of the adductor

3. táblázat

Záróizom „fázisos” és „tónusos” részének ChE aktivitása, $\mu\text{g ACh/mgN/óra}$

Cholinesterase activity $\mu\text{g ACh/mg N/hour}$	
tonic	phasic
3,158	4,174
1,567	2,105
3,296	4,981
1,945	2,669
2,988	4,622
2,832	4,252
2,365	2,680
3,341	5,442
2,525	2,948
2,668 (100.0%)	3,763 (141.0%)

It can be established that the ChE activity values of the adductors vary within wide limits equally as in the case of the heart. It is also seen, that in the two, functionally different parts (phasic and tonic) of the adductors, there is a marked and in every case unidirectional difference in ChE activity. ChE activity rate of the yellowish phasic part is by 40% higher than that of the white tonic part.

2. Substrate specificity

Parallel with ACh-Br the following agents were also applied as substrates: MeCh-Br, BuCh-J and BeCh-Cl. These agents were used at 5 mM final concentration. In *Fig. 4* hydrolysis values at 1 hour incubation time are given in percentage of ACh hydrolysis.

Marked difference in substrate specificity was not observable between the macroscopically different parts of the adductors. Identical substrates are decomposed with equal intensity by the two different parts of adductor. The rate of hydrolysis of the various substrates, however, is different. The rate of MeCh decomposition is the highest, surpassing to some extent that of ACh. The rate of hydrolysis of BuCh is considerably lower and that of BeCh is only minimal.

3. Inhibition by eserine and DFP

Essential difference in susceptibility to eserine was not observable between the phasic and the tonic parts (*Fig. 5*). Inhibition presents itself at a concentration as low as 10^{-11} M, whereas complete inhibition was produced at 10^{-7} M

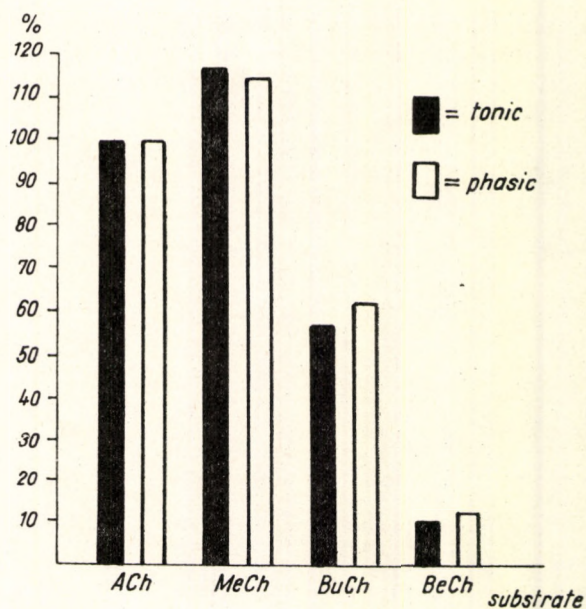


Fig. 4. Relative ChE activities of the adductor ("tonic" and "phasic" parts) in case of different substrates and expressed in percentage of ACh decomposition

4. ábra. Záróizom („tónusos” és „fázisos” rész) relatív ChE aktivitása különböző szubsztátok esetében, az ACh bontás százalékában

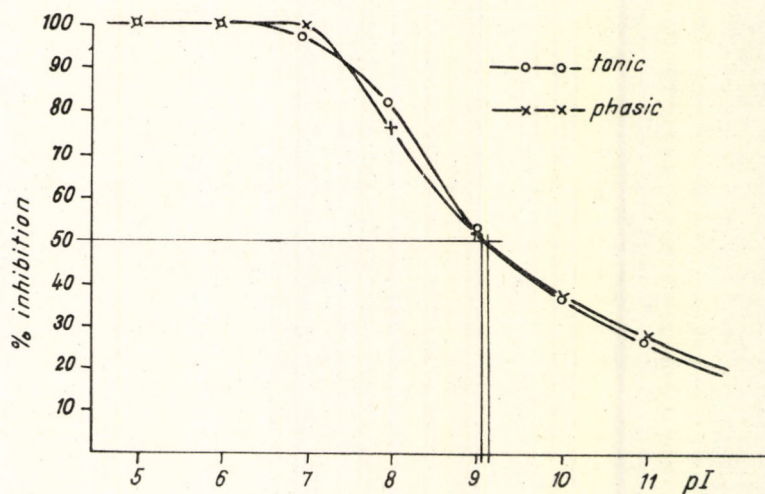


Fig. 5. Inhibition of ChE activity of adductor ("tonic" and "phasic" parts) by eserine

5. ábra. Záróizom („tónusos” és „fázisos” rész) ChE aktivitásának gátlása eserinnel

concentration. At 1 hour incubation time $8-10 \times 10^{-10}$ M eserine produced 50% inhibition in case of both tonic and phasic parts of the adductors.

The inhibitory effect of DFP on ChE (*Fig. 6*) manifested itself at concentrations as low as 10^{-8} M (10–15% inhibition), it did not produce, however, complete inhibition even at 10^{-5} M concentration. Though in the case of DFP the inhibition values of the tonic and phasic parts were nearly the same, they cannot be considered completely identical. The tonic part is slightly more

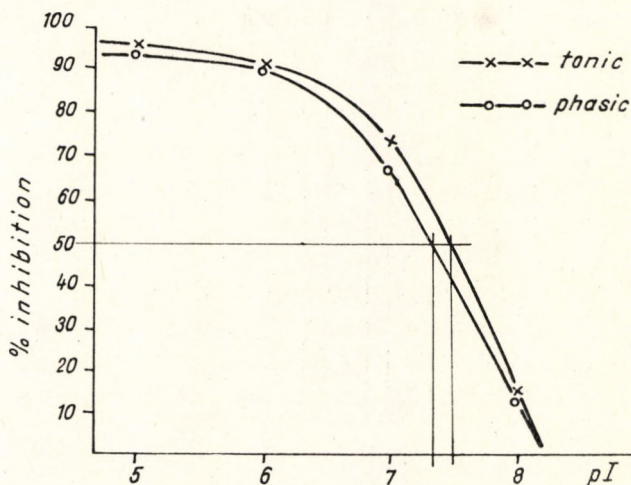


Fig. 6. Inhibition of ChE activity of adductor ("tonic" and "phasic" parts) by DFP
6. ábra. Záróizom („tónusos" és „fázisos" rész) ChE aktivitásának gátlása DFP-vel

inhibited by DFP than the phasic part. 50% inhibition was observed at 3×10^{-8} M and about 5×10^{-8} M concentrations of this agent in the tonic and phasic parts, respectively. This is assumably due to the greater ChE activity of the phasic part. It is worth to note that at higher DFP concentrations inhibition is flattened.

C) *The gill*

The internal lamellae of the gill were used because the external ones are full of developing embryos in certain periods of the year. The lamellae are richly supplied with cilia the activity of which is very susceptible to the influence of cholinergic drugs (BÜLBRING et al. 1953).

1. ChE activity

The ChE activity of the gill was measured at an incubation time of 3 hours using 5 mM ACh-Br substrate as usual. The rate of hydrolysis computed from values of several parallel measurements was $393.0 \mu\text{g ACh/mg N/h}$ in average. When measuring the substrate specificity of that enzyme which is present in the gill and produces the hydrolysis of cholinesters we used experimental conditions identical to that used during our previous measurements.

Besides ACh-Br, we used as substrates 5 mM solutions of MeCh-Br, BuThCh-J and BeCh-Cl, too. The results obtained are illustrated in *Fig. 7*. It is seen that the rate of decomposition of MeCh is relatively high (60% of ACh decomposition), whereas decomposition of BuThCh and BeCh was not observable practically.

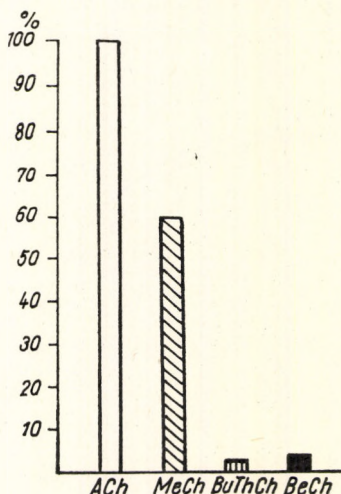


Fig. 7. The relative ChE activities of the gill in case of different substrates, in percentage of ACh decomposition

7. ábra. Kopoltyú relatív ChE aktivitása különböző szubsztrátok esetében, az ACh-bontás százalékában

2. Inhibition by eserine and DFP

Observations on the effect of eserine on ChE activity of the gill show that an about 50% and 90% inhibition was produced at 1.5×10^{-8} M and 10^{-5} M eserine concentrations, respectively (*Fig. 8*).

In case of DFP, 50% inhibition was produced at 10^{-4} M concentration of this agent (*Fig. 8*).

D) Other tissues

(Intestine, mantle, lymph)

It is suggested that the motor activity of that section of the intestine which passes through the heart influences cardiac action, and that due to its special anatomical localization this section might be involved in the regulation of pulsation of the heart. This possibility was examined by some authors (CHONG and PHILLIS 1965) and we thought also worth examining the ChE activity of the intestine.

The rate of ChE activity in that section of the intestines which passes through the heart was 295.0 μg ACh/mg N/h in average. This value lies between activity values of the auricle and ventricle.

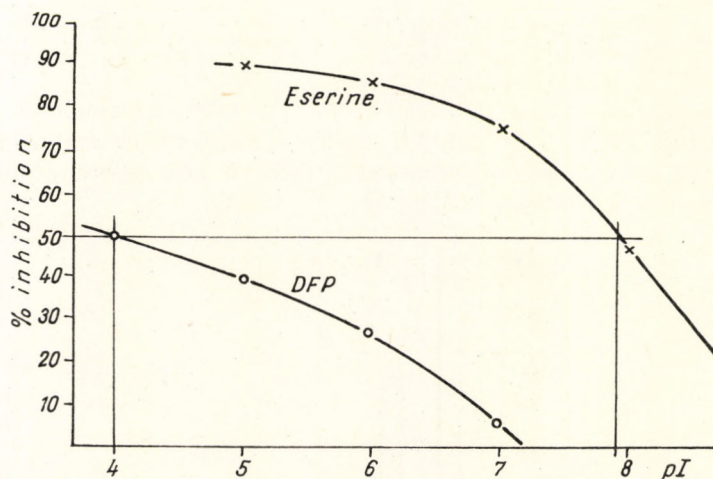


Fig. 8. Inhibition of the ChE activity of the gill by eserine and DFP

8. ábra. Kopoltyú ChE aktivitásának gátlása eserinnel és DFP-vel

When measuring the rate of ChE activity of the extract of the intestine in the presence of eserine solution and at 5 mM ACh-Br substrate concentration the inhibition, produced by 3.0×10^{-8} M eserine, was 50%. When using DFP, 50 per cent inhibition was produced by 2.5×10^{-6} M concentration of this compound (Fig. 9).

In the mantle smooth muscle fibers are localized in sporadic arrangement which differ from the "polymorph"-like structure of the fibers in the

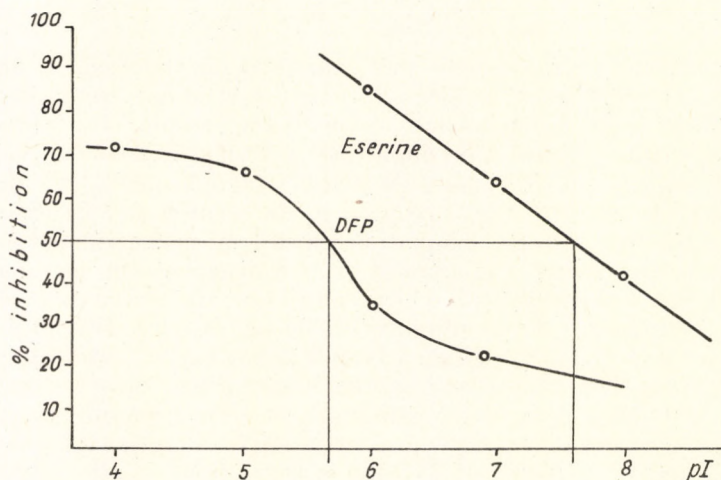


Fig. 9. Inhibition of the ChE activity of the intestines by eserine and DFP

9. ábra. Bél ChE aktivitásának gátlása eserinnel és DFP-vel

adductors (Zs.-NAGY and SALÁNKI 1965). Therefore, we also have examined the ChE activity of the mantle. The rate of ChE activity on basis of ACh-Br decomposition was $445.0 \mu\text{g ACh/mg N/h}$ in average.

Decomposition rates in case of 5 mM concentrations of MeCh-Cl, BuThCh-J and BeCh-Cl at pH 8.0, at 37°C temperature and at an incubation time of 3 hours were, as expressed in ratio of ACh decomposition, 78%, 43% or nought, respectively (Fig. 10).

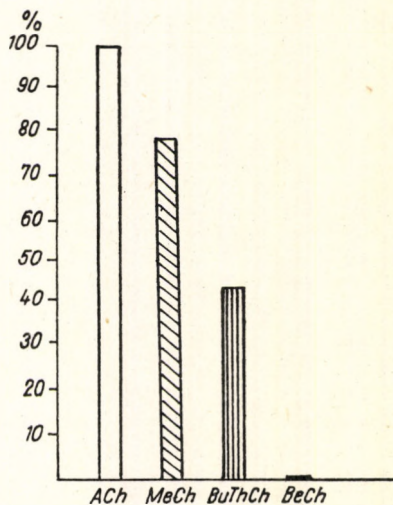


Fig. 10. Relative ChE activity values in percentage of ACh decomposition in case of different substrates

10. ábra. Köpeny relatív ChE aktivitása különböző szubsztrátok esetében, az ACh-bontás százalékában

ChE activity of the lymph was examined on the basis of suggestions (NISTRATOVA 1965) that ACh released in the heart is not decomposed in loco but subsequent to its being washed out with the lymph. This infers that the lymph itself might perhaps have high ChE activity. In view of the very low dry-matter (approx. 0.25%), and N-content (about 0.01%) of the lymph, the rate of ChE activity was computed in different ways. In case of every extract, we pipetted into the incubation tubes 1 ml uncentrifuged and centrifuged lymph, respectively. The amount of ACh hydrolyzed in one hour by that amount of uncentrifuged lymph which contains 1 mg N was $5400 \mu\text{g}$; in case of centrifuged lymph this amounted to $10,800 \mu\text{g}$. ACh hydrolyzed in one hour by 1 g (approx. 1 ml) uncentrifuged lymph ("wet tissue") was $540 \mu\text{g}$.

Comparing these results with ChE activity values of other tissues examined, it is seen that the activity values expressed in term of N are very high. Considering, however, the very low protein-content of the lymph, it is seen that the ChE activity of the total lymph of the animal constitutes only a small portion of the activity of the whole animal.

Examining MeCh-Cl, BuThCh-J and BeCh-Cl decompositions of centrifuged lymph, it was found that the cholinester hydrolyzing enzyme of the

lymph does not produce practically decomposition of the substrates used by us with the exception of ACh. This property of the lymph distinguishes it from tissues of other types.

Discussion

In course of previous examinations (SALÁNKI et al. 1966) ChE activity was demonstrable in the central nervous system of *Anodonta cygnea*, and on basis of the hydrolysis values of the different substrates applied it is inferred that it might be a specific cholinesterase.

The results presented in this paper show that the method used by us is suitable to determine the ChE activity also in almost every tissue examined. In activity rate considerable difference was observed among the different tissues. Activity rate was the lowest in the ventricular part of the heart, and the highest in the phasic region of the adductor. The ratio between the two values was 1 : 23. This ratio is not changed considerably when expressing activities in term of fresh weight (Fig. 11). The results show that both parts of *Anodonta* heart, further the adductors, the gill, that section of the intestine which passes through the heart and the mantle, too, are capable of ACh hydrolysis. These results are in agreement with those obtained by VARGA (1959), ZS.-NAGY (1964) and BÜLBRING (1953) demonstrating ChE activity in the adductor and the gill, respectively. Our results correspond also to data suggesting that the ACh has an important role in the stimulatory processes of the various organs

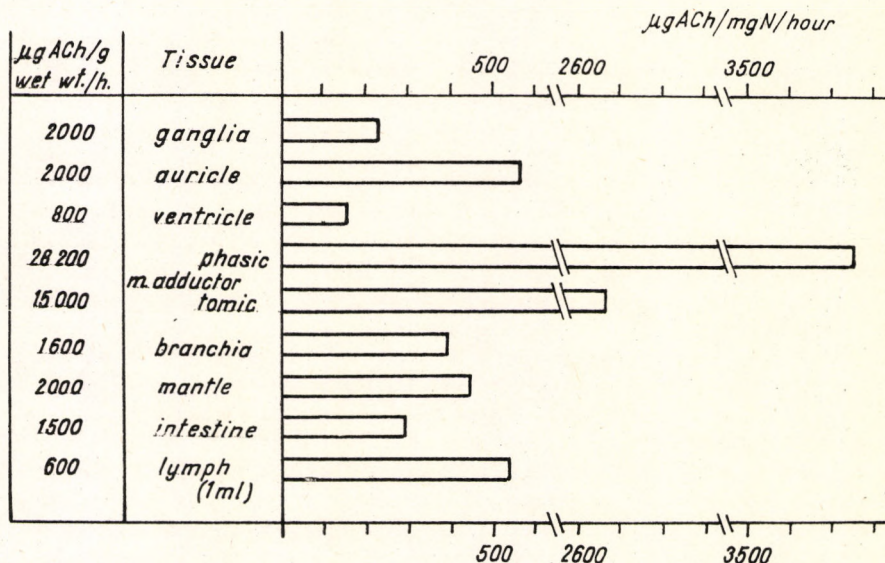


Fig. 11. ChE activities of various tissues of *Anodonta cygnea*. For the sake of comparison the data on ganglia obtained previously with similar methods (SALÁNKI et al. 1966) are also presented

11. ábra. *Anodonta cygnea* különböző szöveteinek ChE aktivitása. A ganglionokra vonatkozó adatokat összehasonlítás céljából korábbi, hasonló módszerrel végzett vizsgálatok alapján (SALÁNKI és mtsai 1966) adjuk meg

of bivalves (PROSSER 1940, BÜLBRING 1953, TWAROG 1960, HORRIDGE 1961, PUPPI 1963, GREENBERG 1965). It was also evidenced by the observations presented here that there is a considerable ChE activity in both regions of the heart, i.e. not only in the auricle but in the ventricle, too, which does not conform to data obtained by NISTRATOVA and YUZHANSKAIA (1966). The observation that there is a well-measurable ChE activity, in that section of intestines which passes through the heart, does not agree either with data of the above authors. The different results obtained are assumably due to the sensitivity of the method used. This assumption is most probable because we measured a rather great activity (more than three times that of the ventricle) in the auricle in opposition to NISTRATOVA and YUZHANSKAIA (1966) who demonstrated it here only in traces.

Examinations on cholinesterase activity of the single tissues showed that from among various substrates used not only ACh but also MeCh was relatively well decomposed and BuThCh (BuCh) decomposition, though of a much less extent, was also observable. Only the tonic and phasic parts of the adductor and the auricle produced BeCh decomposition, the rate of which never amounted to more than 20% of ACh decomposition (*Figs 4 and 1*). It is worth to note that likewise in the two parts of the adductor the observed MeCh decomposition was about 10% higher than that of ACh. In opposition to the general observation that in one and the same species no difference in substrate specificity exists between the different tissues (HEATH 1961), we made besides the above-mentioned property of the adductors and the auricle the observation too, that there is difference in behaviour in case of MeCh decomposition of the ventricle and in the BuThCh-decomposition of the gill. In the two latter instances decomposition rates expressed in percentage of ACh decomposition were considerably lower than in the other tissues. This might be elucidated by further, more detailed examinations. The substrate specificity of the tissues suggest that there is specific ChE-se present in the mussel tissues examined by us, since in case of non-specific ChE (BuChE) a much greater decomposition of BuThCh and considerable BeCh-decomposition would be expected. This suggestion conforms to other data on the substrate specificity obtained by us previously in course of studies on the ChE activity of ganglia (SALÁNKI et al. 1966).

In course of the application of inhibitors it was found that eserine is effectual at much lower concentration than DFP. An as low as 10^{-10} – 10^{-8} M concentration of eserine is sufficient to inhibit the hydrolysis of 5 mM ACh-Br by 50%, whereas DFP only at 10^{-8} – 10^{-4} M concentration produced the same effect (*Figs 2, 3, 5, 6, 8, 9*). At least a two-order difference was observable in case of every organ examined. The great sensitivity of ChE activity to eserine is very remarkable especially in case of the adductors on which DFP proved to be also most effectual. Difference in sensitivity was observed also in case of nearly 100% inhibition. In case of the adductor 10^{-7} M eserine, in case of the heart and the gill only 10^{-6} M of this agent produced complete inhibition (*Figs 5, 2, 8*).

It is worth to compare the ChE activity values of the auricle and ventricle and those of the tonic and phasic parts of the adductors. The ChE activity of the lymph deserves also special interest.

In every case, a considerable, about threefold difference was measured in ChE activity between the auricle and ventricle, when, namely, the activity

rate of the auricle was higher. As regards MeCh decomposition a nearly four times greater value was obtained in case of the auricle than in that of the ventricle, and in case of the former a slight BeCh decomposition was also noted. A considerable difference exists also between auricle and ventricle as regards sensitivity of enzyme activity to inhibitors (*Figs 2, 3*). It is worth noting that in the auricle the sensitivity of ChE to inhibition is lower by two orders as compared to the ventricle. This might be related to differences observed in MeCh- and BeCh-decompositions. It is inferred that there is a considerable difference in the esterase activity between these two functional parts of the heart. It is assumable that the higher ChE activity of the auricle might be connected to its cholinerg mediation.

We have no exact knowledge of the innervation of mussel heart. In all probability heart-nerves are passing to both parts of its, to the auricle and to the ventricle (SUZUKI 1935). It is imaginable that the majority of cholinerg terminations is located in the auricle and the rhythm of the heart is regulated in vivo by their rhythm. Thus, it is suggested, that the high ChE activity of the auricle is related to cholinerg innervation. In the light of these considerations, however, all examinations on the humoral regulation of cardiac action, in the course of which the testing of biologically active agents and the examinations on the effect of pharmacons was made on isolated ventricle only, have to be subjected to criticism. In case of examinations like these the agents have to be tested on the auricle too, for it might be expected as suggested by literary data (CLONG and PHILLIS 1965, AIKAWA and ISHIDA 1966) that auricle and ventricle respond differently to the application of biologically active agents and pharmacons.

Difference in ACh decomposition was observed also between the white "tonic" and yellowish "phasic" parts of the adductors, in case of the "phasic" part, namely, a 40% higher activity value was registered. Concerning the inhibitory effect produced by eserine and DFP no difference was noted between the two parts of the adductors as regards the ratio of decomposition values of other substrates to that of ACh. Difference in ChE activity was found between the two regions of the adductors by KALAMKAROVA and KRYUKOVA (1966), too. In their case the rate of ChE activity of the phasic part was three times higher.

Considerable differences in activity of other enzymes, too, were observed (FORTE 1965) between the two microscopically well-distinguishable regions of the adductors. These observations might explain the functional difference between the two regions. It is assumable that in case of the "phasic" region of the adductor the more quick relaxation that was observed following contraction (ZHUKOV 1956) is due to the higher ChE activity of this region as compared to the "tonic" region. It is to be noted, however, that no detailed examinations were performed heretofore concerning the reaction of the adductors to the direct application of ACh, and no attempts were made to decide whether ACh is released actually during nerve stimulation in case of neuromuscular transmission. The effect of ACh was examined by TWAROG (1960) only on *Mytilus* ABRM and the effect noted was tonic contraction.

In the knowledge of the ChE activity of myosin which has been demonstrated also in case of mussels (KÖVÉR és KOVÁCS 1960) it is also assumable that the ChE-activity differences depend on the different myosin content of the two regions of the adductors. Though the preparation and homogenization

of the extract were made with distilled water, the extract contained some amount of salts due to the dissolution of the physiological salt content of tissues. Considering data obtained by PORRS (1958) the ionic strength of our extracts was about 0.02. Because myosin is not extractable at the ionic strength of our extracts, the above assumption has to be rejected, and the difference observed attributed to the difference between the neural/sarcolemmic ChE activities.

Examinations on the ChE activity of the lymph were made on basis of certain assumptions (NISTRATOVA 1965) that the decomposition of ACh released in the heart does not take place in the heart itself, and it is suggested that this natural inhibitor of the heart might be eliminated as a result of the ChE activity of the lymph. The ChE activity of the lymph was high in relation to its nitrogen content. Due to the low protein content of the lymph, however, the amount of ChE present in the lymph seems to be insufficient to produce decomposition of ACh originating from other tissues. It is worth noting that practically no other substrate than ACh is decomposed by the lymph. It is suggested that the importance of the extraordinarily specific ChE of the lymph is the elimination of the remaining ACh — released in different tissues and getting only partly decomposed into the lymph — before it reaches other acetylcholine receptors. The above suggest that the lymph may act as a specific ACh-barrier between ACh-sensitive structures lying far from one another.

Summary

ChE activity measurements were made in the various organs (heart, adductor, gill, intestine, mantle, lymph) of *Anodonta cygnea* L. by HESTRIN's (1949) biochemical method. It was found that the extracts of all tissues examined are capable of ACh decomposition.

ChE activity was determined during separated measurements also in the auricular and ventricular parts of the heart and in the "phasic" and "tonic" parts of the adductors. It was established that the activity of the auricle and of the phasic part was considerably higher than that of the ventricle and of the tonic part of the adductor, respectively, and it was concluded that this might be of great interest from functional point of view.

The decomposition rates of the various substrates (ACh, BuThCh, MeCh, BeCh) and the sensitivity to both eserine and DFP suggest that the ChE examined by us is specific (AChE) suggesting that there are cholinerg mechanisms present in freshwater mussel.

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KÜLÖNBÖZŐ SZÖVETEK KOLINESZTERÁZE AKTIVITÁSÁNAK ÖSSZEHASONLÍTÓ VIZSGÁLATA TÁVI KAGYLÓN (ANODONTA CYGNEA L.)

Salánki János, Varanka István és Hiripi László

Összefoglalás

Vizsgáltuk *Anodonta cygnea* L. különböző szerveinek, nevezetesen a szív, záróizom, kopolytű, bél, köpeny, lymphá ChE aktivitását HESTRIN (1949)-féle biokémiai módszerrel. Azt találtuk, hogy mindezen szervek homogenizátuma rendelkezik ACh bontó képességgel.

Külön vizsgálat tárgyát képezte a szív pitvari és kamrai részének, valamint a záróizom „fázisos” és „tónusos” részének ChE aktivitása. Megállapítottuk, hogy a pitvar,

ill. a fázisos rész aktivitása jelentősen magasabb, mint a kamráé, ill. a tónusos záróizomrészé, aminek feltehetően funkcionális szempontból is nagy jelentősége van.

Különböző szubsztrátok (ACh, BuThCh, MeCh, BeCh) bontása, ill. eserinnel és DFP-vel való gátolhatóság alapján a vizsgált ChE specifikusnak (AChE) fogható fel, ami a tavi kagylóban kolinerg mechanizmusok jelenlétére utal.

СРАВНИТЕЛЬНОЕ ИССЛЕДОВАНИЕ ХОЛИНЭСТЕРАЗНОЙ АКТИВНОСТИ РАЗНЫХ ТКАНЕЙ БЕЗЗУБКИ

Янош Шаланки, Иштван Варанка и Ласло Хирпи

Была изучена холинэстеразная активность сердца, запирающей мышцы, жабер, кишки, мантии и лимфы биохимическим методом Хестрина (1949). Все перечисленные выше ткани обладают способностью расщеплять ацетилхолин.

Холинэстеразная активность предсердия и желудочка сердца а также фазной и тонической частей запирающей мышцы изучалась отдельно. Было найдено, что холинэстеразная активность предсердия и фазной части запирающей мышцы значительно выше чем желудочка и тонической мышечной части, что имеет, повидимому большое значение и в функциональном отношении.

На основе применения разных субстратов (ACh, BuThCh, MeCh, BeCh) и ингибиторов (Эзерин,ДФП) авторы приходят к выводу, что выявленная холинэстеразная активность является специфической и это подчеркивает важность холинэргических механизмов у беззубок.

INVESTIGATIONS OF PESTICIDE RESIDUES IN FISH AND OTHER AQUATIC ORGANISMS OF LAKE BALATON AND SOME OTHER AQUATIC HABITATS

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In all parts of the world of intense agricultural production, diverse plant protection and insecticide materials have been applied at ever increasing rates during the last 15—20 years. The initially almost limitless use and spreading of the various kinds of pesticides were extremely encouraged by the heavy demands on marketable fruits and vegetables, as well as the recognition that the application of these easily administrable synthetic organic compounds considerably increases the quantity, and enhances the quality of the yield. Measures especially successful in agriculture and forestry had at first eclipsed the already apparent damages, and thus delayed restrictions in the use of pesticides.

Later, however, indications have increasingly multiplied, especially in the United States of America, calling attention, among others, to the fact that the diverse pesticides, transmitted by precipitation or some other means into the surface or subsurface waters, will deleteriously affect their quality and might thus be highly detrimental to life. The first conspicuous effects of this damaging phenomenon manifested themselves in the high-rate mortality of fish (HYNES 1960, TARZWELL 1965a). Subsequent and recent investigations have also shown that a number of invertebrate organisms (worms, crustaceans, various aquatic insect larvae), many of them important sources of fish-food, had also perished. In these days, attention focussed on the study of the indirect effects of the pesticides, prevailing by the means of biological accumulation and transmission through the food-chain (KLEIN 1962, TARZWELL 1965b, KEITH, MOHN and ISE 1965). Instigated by these findings, world-wide projects were framed for the solution of the pesticide problem, and provisions taken endeavouring to delimit within reasonable bounds the application of these toxic agents.

In Hungary, the attention of the research workers was drawn to the problem by the extensive destruction of fish in Lake Balaton in March—June, 1965. According to estimations, the loss of fish amounted to about 50 wagons, of which about 40% was pike-perch (RIMANÓCZY 1966). With respect to the considerable rate of destruction, a host of research workers of a number of institutions initiated investigations for the clarification of its course, causes, and future effects (Fisheries Enterprise of the Balaton, National Fishery Board, National Institute of Public Health, Water Economy Scientific Research

Institute, National Animal Health Research Institute, National Agricultural Quality Inspecting Institute, National Institute for Food and Nourishment Research, Danube Research Station of the Hungarian Academy of Sciences, Biological Research Institute of the Academy of Sciences, etc.).

On the basis of investigations, and excluding other possibilities (parasitic, bacterial, virus infections, radioactive or industrial pollutions, etc.), the probable cause of the fish destruction in Lake Balaton can be ascribed to the effects of pesticides (primarily DDT and its decomposed derivatives) arrived into the lake (V. CIELESZKY and A. DÉNES 1965 in MS.).

Our studies aimed at obtaining information, on the basis of ample materials, on the content of pesticide residues in the more important fish species and other aquatic organisms of Lake Balaton, and to compare them with similar conditions prevailing in other waters. The publication of the research results is deemed worth-while in view of the fact that they submit information on the present situation in a field but slightly studied in Hungary until recently, and thus establish a basis of comparison for future attainments.

Material and methods

1. Collection and preparation of materials

Our research material comprised first (August—November, 1966) the fish and other organisms of Lake Balaton. After the termination of two research series, it was found necessary to analyse samples deriving from other localities, for the sake of comparison. We have thus examined the fish samples of the Danube-reach in Comitát Tolna and two fish ponds in Comitát Somogy (Somogyicsicsó and Mike), as well as the bivalve shells of the stagnant reach of the Danube-branch near Győr and the Old Lake of Tata. Fish were selected immediately after their having been netted, whereas the shell and Crustacean plankton samples were collected prior to the study. The formers were gathered by hand, the latter by a large-mesh No. 6 plankton net.

Investigations extended to ten (in details to four) fish and three mollusc species. The constituent members of the Crustacean plankton had not been separated as to species. The quantitative and qualitative distribution of the organisms studied were as indicated in the Table on p. 119.

Fish were dissected by the usual methods of "kitchen technology". Liver, fats, roe and milt were segregated, in larger fish also blood, spleen, kidney and gall. Smaller fish were worked up, depending on the quantity available, in their entirety, or their inner organs indiscriminately together. Meat was invariably examined. The data of smaller fish found in the stomach of predatory fish were listed separately. Shells were cut in two by a knife, and the entire animal analyzed. Plankton was left spread on a filter paper to facilitate the evaporation of the greater part of water.

Of the organs listed above, those which made it necessary had been minced by a meat-grinder. Frozen tuna fillets, used for negative control, had been prepared similarly.

Of the separated organs (also minced if necessary) 15—20 and 50—60 grams, respectively, were weighed according to the available quantities. The entire amount of gall, spleen, kidney, and blood were worked up. Of the other

Fish	Specimen	Live weight (kg)
<i>Lucioperca lucioperca</i> L. (pike-perch) (+ spawn)	80	68
<i>Esox lucius</i> L. (pike)	50	18
<i>Cyprinus carpio</i> L. (carp) (+ spawn)	120	25
<i>Abramis brama</i> L. (bream) (+ spawn)	150	20
<i>Pelecus cultratus</i> L. (razor-fish) (mainly spawn)	110	4
<i>Aspius aspius</i> L. (balin)	10	6
<i>Amiurus nebulosus</i> LE SUEUR (bullhead pout)	8	1
<i>Carassius carassius</i> L. (crucian-carp)	5	2
<i>Perca fluviatilis</i> L. (perch)	11	9
<i>Ctenopharyngodon idella</i> VALLENCIENNES (Amur)	1	4
Total	545	157
Bivalves		
<i>Anodonta cygnea</i> L. (mussel)	220	30
<i>Unio tumidus zelebori</i> (PAREYSS) ZELEBOR (river mussel)	150	22
<i>Unio pictorum balatonicus</i> KÜSTER (painter's mussel)	300	15
Total	670	67
Other		
Crustacean plankton (filtered)	—	5

materials, ample quantities (200—400 g) were minced and average samples taken. The quantity of the average samples had been determined by previous experiments.

2. Technique

To determine acid- (HCH isomeres, DDT and DDE) and lye-resistant (dieldrin and aldrin) pesticide residues, two parallel samples were taken from all investigated material. The weighed samples were broken, together with some anhydrous sodium sulphate, into powder in a porcelain mortar. The sodium sulphate powder mixture was transferred into an Erlenmayer flask (ground-stoppered), and pur. n-pentane added until it covered the material 2—3 cm high.

Development continued by repeated vigorous shaking for 2 hours, and dissolution by one night. Next day, the n-pentane extraction was filtered through an anhydrous sulphate layer (4—5 cm) placed on glass-wool in a funnel; the material collected in the funnel was also washed out two or three times by 100—150 ml n-pentane. Of the combined extraction, n-pentane was evaporated down to 5—10 ml, without heating, either outdoors or in a chemical box.

The purification of the acid-resistant pesticide residues derived from fats and other accompanying substances was executed through a diatomite column mixed with vitriol. In most cases, there was no need for aceto-nitrile shaking (CIELESZKY and DÉNES 1966).

In the purification of the lye-resistant pesticide residues, the potassium hydroxide saponification of the fats were first done (O'DONNELL 1954, 1955; CUETO 1960, CIELESZKY and DÉNES 1966). Subsequent to the aceto-nitrile shaking, the pesticide residues to be determined received final purification through an activated aluminiumoxyde column (BROCKMANN).

After the chromatographic column-clearing, the substances were condensed and collected in centrifugal tubes, completely evaporated down.

The pesticide residues transferred into the centrifugal tubes were dissolved in 0.1 ml distilled p.a. ethylacetate, and their separation was executed by thin-layer chromatography. Adsorbent: aluminiumoxyde G (after STAHL), developer: pss. n-hexane.

The developing of the chromatograms was made by ABBOTT's (1964) technique.

Evaluation was made semiquantitatively with reference to standards developed along with the substances to be determined.

Since, in our investigations, extremely small quantities of materials (1–10 γ) had to be identified, the technique discussed above was repeatedly controlled. In our experience, the possibility of error is primarily inherent in the course of fluid-to-fluid distributional purifications. Whenever possible, we had therefore abandoned this form of technique. By determining the suitable dimensions of the vitriol-diatomite column, we had been able to assure and maintain the desirable effectivity of purification.

Results and conclusions

The numerical data of the results of investigations are summarized in *Tables 1–6*. Of the demonstrated residual components (α -, β -, γ -, δ -HCH; DDT; DDE, aldrin, dieldrin, and an unknown one), the greatest amounts were shown by DDT and its decomposition products, DDE, γ -HCH and an unknown component. On the basis of its Rf value, this latter somewhat resembles heptachlorine, but its chemical identification could not be made in want of a standard (*Figs. 1, 2*). That fact also speaks against heptachlorine that, as far as we know, this substance is not used in applied technologies in Hungary. The high occurrence of DDT and its decomposing substances seems to be obvious in view of the amount of the pesticide applied (dusted) in the area of the Balaton and its drainage basin. In the Comitats Veszprém, Zala, and Somogy, for instance, about 441 metric centners of aldrin, dieldrin and DDT had been applied between 1st January, 1964 and 1st Juny, 1965, before and during the destruction of fish in Lake Balaton; of this sum, DDT amounted to 328.6 centners (compiled by DONÁSZY, in MS., on the basis of data submitted by the Agricultural Commerce Center).

The data given in the tables show considerable fluctuation. The deviation of values, beyond the subjective errors due to the semiquantitative evaluation, is to be sought for in mainly three other factors:

a) In the course of investigations, individuals belonging to the same age group within the species were not always available. As it is shown by the results (*Tables 1–6*), this fact alone caused considerable deviations.

b) Presumably there arrived various amounts of spray-residues into the several water bodies of the Lake Balaton. This seems to be substantiated by the amounts of DDT used by the three comitats mentioned above: the quantities applied rather differ from one another (Comitat Veszprém: 51.4, Somogy: 123.6., Zala: 153.6 centners). The inference is reasonable, therefore, that the diverse organisms of fish-food received different amounts of spray-residues. Fish individuals belonging to the same species but to different populations (and areas) might thus have accumulated various amounts of pesticide residues.

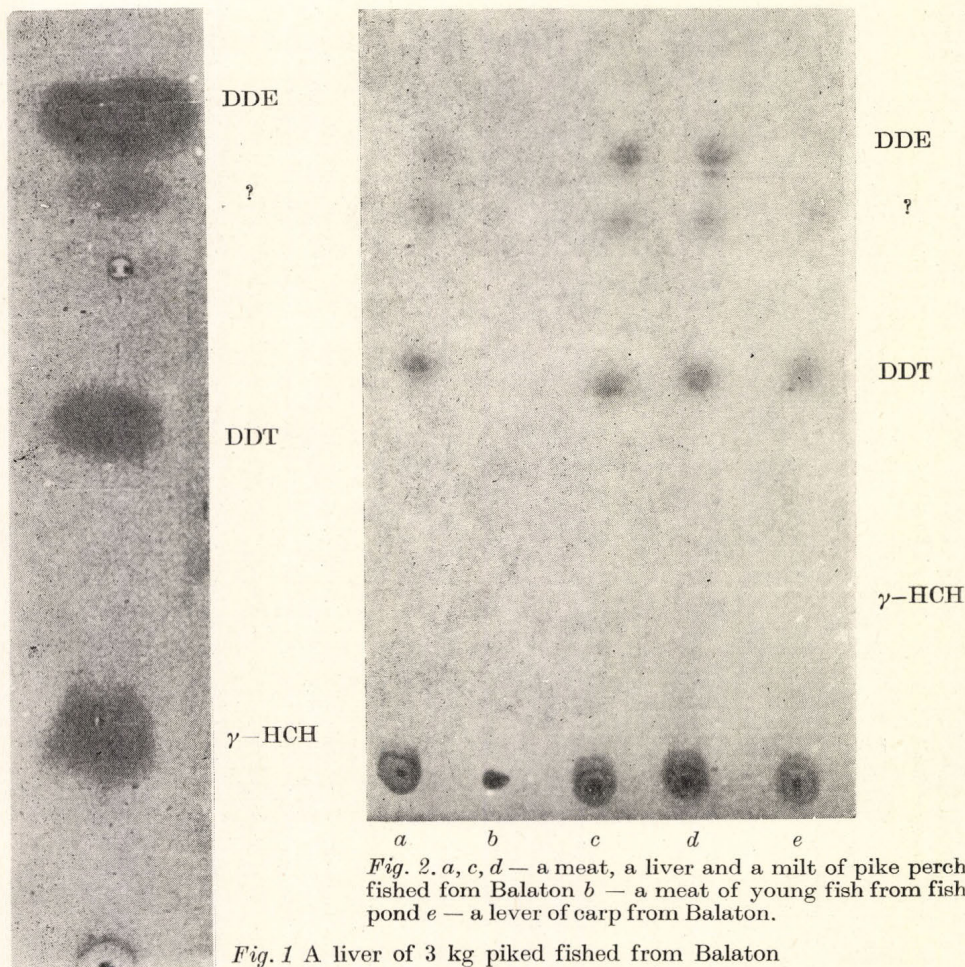


Fig. 1 A liver of 3 kg piked fished from Balaton

Fig. 2. *a, c, d* — a meat, a liver and a milt of pike perch fished from Balaton *b* — a meat of young fish from fish pond *e* — a liver of carp from Balaton.

c) Insufficiency in research material with respect to fish species or organ might also have contributed to the deviation of values.

In the followings, we propose to discuss those investigated species only whose data were suitable for a statistical evaluation, too. In order to be able to point out certain differences or agreements and other connections, we have calculated the average standard error of pesticide residues found in higher quantities in fish and some other groups of organisms. These calculations may possibly have the conceptual error of commensuring the values obtained from individuals of different age groups. In view of the fact, however, that we have aimed at an informative survey, we commit, in our opinion, a smaller mistake by this means than in describing some "extreme" individual cases.

Of the fish (pike-perch, pike, carp) originating from diverse localities, it is only the pike-perch which shows a certain amount of difference. Individuals deriving from fish ponds exhibit rather small values of, and slight fluctuations in, the components γ -HCH, DDT, DDE, and "?", but these differences

Table 6 — 6 táblázat
Mollusk and Crustacean Plankton Samples
Mollusca és crustacea plankton mintái

Period of study (month) Vizsgálat ideje (hónap)	Species investigated Vizsgált faj	Origin of sample Minta származása	Chlorined pesticide residue Klórozott pesticid maradékok (mg/kg)								Humidity content Nedvesség- tartalom, %	
			H C H				DDT	?	DDE	Ald.		Dield.
			α	β	γ	δ						
August	Tavi kagyló*	Balaton	0.00	0.00	0.30	0.00	0.38	0.22	0.30	0.00	0.00	82.7 82.7 91.5
	Folyami kagyló**	Balaton	0.00	0.00	0.20	0.00	0.38	0.22	0.30	0.00	0.00	
September	Festő kagyló***	Balaton	0.00	0.00	0.20	0.00	0.38	0.22	0.30	0.00	0.00	
	Festő kagyló***	Balaton	ny	ny	0.12	ny	0.13	ny	ny	0.00	0.00	
	Tavi kagyló*	Balaton	ny	0.02	0.05	0.02	0.05	ny	ny	0.00	0.00	
	Tavi kagyló*	Győr	ny	ny	0.01	ny	0.03	0.01	ny	0.00	0.00	
October	Crustacea-plankton (szűrt)	Balaton	ny	ny	0.01	ny	0.10	0.03	ny	0.00	0.00	
	Tavi kagyló*	Tata, Öregtő	0.00	0.00	0.00	0.00	ny	0.00	0.00	0.00	0.00	
November	Tavi kagyló*	Balaton	0.00	0.00	0.07	0.00	0.07	0.00	0.00	0.00	0.00	
	Festő kagyló***	Balaton	0.00	0.00	0.03	0.00	0.08	0.00	0.00	0.00	0.00	
	Festő kagyló***	Balaton	0.00	0.00	ny	0.00	0.13	0.09	0.00	0.00	0.00	
	Folyami kagyló**	Balaton	0.00	0.00	ny	0.00	0.15	0.13	0.00	0.00	0.00	
	Folyami kagyló**	Balaton	ny	ny	0.04	ny	0.11	0.11	0.00	0.00	0.00	
	Crustacea plankton ⁰ (szűrt)	Balaton	ny	ny	0.04	ny	0.12	0.13	0.00	0.00	0.00	
	Crustacea plankton ⁰ (szűrt)	Balaton	ny	ny	0.05	ny	0.22	0.19	0.00	0.00	0.00	
	Crustacea plankton ⁰ (szűrt)	Balaton	ny	ny	0.05	ny	0.09	0.08	0.00	0.00	0.00	
	Planktonról leszűrt□ víz mg/l	Balaton	ny	ny	ny	ny	0.12	0.10	0.00	0.00	0.00	

* *Anodonta cygnea* = mussel

** *Unio tumidus zelevori* = river mussel

*** *Unio pictorum balatonicus* = painter's mussel

⁰ Crustacean plankton (filtered)

□ Water extracted from plankton in mg/l

ny = tr = traces-injom

are, with respect to the $\pm$ deviations, rather small as related to those originating from Lake Balaton and the Danube-reach in Comitát Tolna. More precisely, the difference lies in higher pesticide values occurring but sporadically in samples deriving from fish ponds, whereas they occur more frequently in the two latter ones. The toxicity of carps originating from diverse localities fluctuates within the same order of magnitude. The values of the pikes from Comitát Tolna and Lake Balaton also agree (*Table 7*). These data seem to

Table 7 — 7. táblázat

Differences in pesticides, with respect to meat, liver, and roe, between fish species deriving from various localities (on the basis of *Tables I–IV*)

Különböző gyűjtőhelyekről származó halfajok közötti pesticidkülönbségek, hús, máj ikrára vonatkozóan (*I–IV. táblázatok alapján*)

Fish species Halfajok	Locality Gyűjtőhely	Pesticide residue mg/kg Pesticid-maradék mg/kg			
		γ -HCH	DDT	DDE	?
Pike-perch — süllő In Tolna the Danube-reach	Lake Balaton	0.15 ± 0.12	0.49 ± 0.18	0.44 ± 0.17	0.12 ± 0.09
	Tolnai Dunaág	0.16 ± 0.12	0.22 ± 0.11	0.12 ± 0.07	0.10 ± 0.05
Fish ponds	Halastavak	0.01 ± 0.005	0.09 ± 0.02	0.05 ± 0.025	0.00
Pike — csuka In Tolna the Danube-reach	Lake Balaton	0.37 ± 0.33	0.57 ± 0.40	0.90 ± 0.66	0.49 ± 0.23
	Tolnai-Dunaág	0.38 ± 0.22	0.40 ± 0.16	0.65 ± 0.28	0.17 ± 0.12
Bream — keszeg	Lake Balaton	0.20 ± 0.16	0.50 ± 0.03	0.34 ± 0.24	0.23 ± 0.21
Carp — ponty In Tolna the Danube-reach	Lake Balaton	0.03 ± 0.003	0.05 ± 0.03	0.03*	0.02 ± 0.02
	Tolnai-Dunaág	0.01 ± 0.006	0.07 ± 0.01	0.04 ± 0.01	0.02 ± 0.01
Fish ponds	Halastavak	0.02 ± 0.02	0.12 ± 0.06	0.09 ± 0.11	0.07 ± 0.13

* = mean of two data

* = két adat átlagértéke

corroborate the assumptions of CIELESZKY et al. (1965 in MS.), namely that there evolved an approximately identical level in fish deriving from other standing bodies of water beyond those of the Lake Balaton.

If it were examined, however, whether this level of toxicity is the same between raptorial and peaceful fish species within the same aquatic habitat, the answer would not be unequivocal. For the Balaton, the DDT level is about identical in the pike and the pike-perch (0.57 ± 0.40 and 0.49 ± 0.18 , respectively), whereas it is significantly different and very low in the carp (0.05 ± 0.03). It is also striking that the pesticide level of the bream falls within the order of magnitude of the raptorial species. Conditions are similar in the Danube-reach of Comitát Tolna. At the same time, there is no difference between the pike-perch and the carp deriving from fish ponds (*Table 7*). The solution of the problem should obviously be looked for in the food-chain and the concomitant accumulation of the pesticides of the two aquatic habitats

Concerning the organs and tissues, respectively, of the fish species examined in details, spray-residues appear in the greatest quantity in fatty tissues, and least of all in meat (*Table 7*). In the pike-perch, liver and roe show about identical levels of high toxicity, whereas in the pike this refers to the liver, followed by an essentially lower level in the roe.

The analysis of other invertebrate, aquatic organisms (*Table 6*) shows that they contain a noteworthy amount of pesticide residues, especially those inhabiting Lake Balaton. The values of the molluscs living in Lake Balaton are slightly higher than those of the Crustacean plankton.

Animal group	Pesticide residues in mg/kg			
	γ -HCH	DDT	DDE	?
Bivalve shells	0.13 ± 0.03	0.19 ± 0.04	0.11 ± 0.05	0.12 ± 0.03
Crustacean plankton	0.04 ± 0.01	0.13 ± 0.03	0.0	0.11 ± 0.03

Table 8 — 8. táblázat
Pesticide residues found in diverse organs of some fish species
(on the basis of *Tables 1–4*)

Egyes halfajok különböző szerveiben talált pesticid-maradékok
(1–4. táblázat alapján)

Fish species halfaj	Organ szerv	Pesticide residue mg/kg pesticid maradék mg/kg			
		γ -HCH	DDT	DDE	?
Pike-perch — süllő	meat — hús	0.05 ± 0.02	0.22 ± 0.09	0.17 ± 0.07	0.08 ± 0.03
	liver — máj	0.17 ± 0.06	0.20 ± 0.15	0.32 ± 0.13	0.09 ± 0.03
	roe — ikra	0.15 ± 0.10	0.32 ± 0.13	0.14 ± 0.08	0.07 ± 0.03
	fat — zsír	0.48 ± 0.20	0.69 ± 0.37	0.81 ± 0.27	0.22 ± 0.22
Pike — csuka	meat — hús	0.12 ± 0.06	0.24 ± 0.09	0.24 ± 0.10	0.15 ± 0.11
	liver — máj	0.84 ± 0.22	0.95 ± 0.33	1.68 ± 0.66	0.76 ± 0.22
	roe — ikra	0.18 ± 0.06	0.20 ± 0.07	0.35 ± 0.11	0.09 ± 0.02
	fat — zsír	2.59 ± 0.93	1.93 ± 0.86	5.14 ± 0.97	0.96 ± 0.45
Carp — ponty	meat — hús	0.02 ± 0.01	0.08 ± 0.01	0.06 ± 0.01	0.04 ± 0.01
	liver — máj	0.02 ± 0.01	0.05 ± 0.01	0.03 ± 0.01	0.01 ± 0.01
	fat — zsír		0.20 ± 0.09	0.00	0.00
Bream — keszeg	fat — zsír	0.62 ± 0.11	0.80 ± 0.15	1.35 ± 0.53	0.63 ± 0.28

If the significance of the two groups of organisms in the life of the lake is considered, it is the plankton to which the greater importance should be ascribed (considerable biomass, important fishfood).

The results of our investigations also seem to bear out the fact that the destruction of fish in Lake Balaton was primarily caused, similarly to that of other lakes wherein even greater rates of perdition in the fish fauna had been observed (HUNT and BISHOFF 1960), by pesticide residues (primarily DDT) accumulated through the links of the food-chain. This is substantiated by the high DDT content (0.13 ± 0.03) of the Crustacean plankton, as well as the considerable pesticide content found in the stomach of the raptorial fish species and the specifically examined fish spawn (Tables 1, 2, 4). Their accumulation, e.g. in the pike-perch and the perch attains the lower level of the amount toxic for the several species of fish (KLEIN 1962). It is worthwhile to enlarge on the feeding habits of the pike-perch. According to WOYNÁROVICH's (1959) investigations, the bream plays an important role in the winter feeding of the pike-perch (January–February, 33% of all ingested food). It changes to its

Table 9 — 9. táblázat

Combined occurrence (mg/kg) of DDT and its decomposition products in various fish species of Lake Balaton, in 1965 and 1966

DDT és bomlástermékeinek együttes előfordulása (mg/kg), különböző balatoni halakban 1965 és 1966-ban

Fish species — halfaj	Organ — szerv	DÉNES— CIELESZKY Jun. 1965	BARON—CSONTI—PONYI Aug.—Nov. 1966
Pike-perch — süllő	meat — hús	0.1 0.2	1.80 (Aug.) 1.01 (Sept.) 0.09 (Nov.) 0.21 (Nov.)
	liver — máj	0.4 8.4	1.40 (Aug.) 1.85 (Sept.) 0.15 (Nov.)
	inner organs — belső rész	1.1	1.3 (Aug.)
Carp — ponty	meat — hús	0.4 0.8	0.08 (Oct.) 0.13 (Nov.)
	liver — máj	0.4 0.4 0.2	0.05 (Oct.) 0.02 (Nov.)
	milt — tej	0.2	0.18 (Oct.)
Bream — keszeg	meat — hús	0.2 0.1 0.2	1.88 (Aug.) 1.07 (Sept.)
	liver — máj	0.1 0.1 0.2	0.34 (Sept.) 0.24 (Nov.)

staple diet (*Acerina*) in the spring. As was pointed out, the pesticide content of the bream is very high and thus a considerable amount of toxic material might accumulate in the pike-perch by spring. It is quite probable that, aside of other factors, also this one may effectively have contributed to the destruction of fish, commencing in the spring of 1965. In the feeding of the bream, the Crustacean plankton has a significant role (PONYI 1955, BERINKEY 1966), thus they, too, could have accumulated spray-residues.

By comparing data deriving from identical samples in 1965 and 1967 (Table 9), it seems that the pesticide level of the bream had further increased, while, in the case of the pike-perch and the carp, the values received are within the order of magnitude of previous data.

Summary

The authors have determined by thin-layer chromatography the content of pesticide residues of fish originating from different bodies of water (Lake Balaton, the Danube-reach in Comitát Tolna, various fish ponds) as well as those of some other aquatic organisms.

Of the demonstrated residue components, the highest amounts are represented by DDT and its decomposition substances, DDE, γ -HCH, and an unknown factor.

Among the fish species originating from various localities, it was only the pike-perch which showed slight differences as to the quantity of spray-residues. It seems that there evolved an approximately identical level of spray-residues in fish deriving also from waters beyond those of Lake Balaton. On the other hand, there was a sharp difference found between the raptorial fish species (pike-perch, pike) and the carp of the same water area (with respect to Lake Balaton and the Danube-reach in Comitát Tolna). Fish-ponds represent an exception, insofar as corresponding and low values have been demonstrated in both the pike-perch and the carp.

Among the organs and tissues, respectively, of the several fish species, fatty tissues contain the highest amount of pesticide residues, followed by the liver — in some cases the roe — and meat.

The DDT content of the Crustacean plankton of the Lake Balaton is highly significant (0.13 mg/kg), especially in view of its role in the food-chain.

Data obtained from samples similar in composition of the years 1965 and 1967 show that the pesticide level of the bream had increased, while the values referring to the pike-perch and the carp remained within the order of magnitude of the previous data.

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PESTICID-MARADÉKOK VIZSGÁLATA A BALATON ÉS NÉHÁNY MÁS VÍZI ÉLETTÉR HALAIN, EGYÉB VÍZI SZERVEZETEIN

Baron Ferenc, Csontó Ferenc és Ponyi Jenő

Összefoglalás

Szerzők különböző vizekből (Balaton, Tolnai-Dunaág, Halastavak) származó halak és néhány egyéb vízi szervezet pesticid-maradék tartalmát határozták meg vékonyréteg kromatográfiával.

A kimutatott maradék-komponensek közül a legnagyobb mennyiségben a DDT és bomlásterméke a DDE, γ -HCH és egy ismeretlen komponens található.

A különböző gyűjtőhelyekről származó halfajok közül a permet-maradék mennyiségét illetően csak a fogas süllő mutatott kisebb fokú különbséget. Úgy látszik, hogy a balatoni halakon túlmenőleg más hazai vizekből származó halakban is megközelítőleg azonos permetmaradék-szint alakult ki. Ellenben az azonos vízterületről származó ragadozó halak (fogas, süllő, csuka) és a ponty között (Balaton és Tolnai-Dunaágra vonatkozóan) éles különbség adódott. Kivételt mutatnak a halastavak, ahol a süllőben és a pontyban egyaránt alacsony és megegyező értékeket mutattak ki.

Az egyes halfajok szervei, ill. szövetei közül a zsírszövet tartalmazza a legtöbb pesticid-maradékot, majd a máj — egyes esetben az ikra — és a hús következik.

Igen jelentős a Balaton Crustacea-plankton DDT tartalma (0,13 mg/kg), különösen akkor, ha figyelembe vesszük azok szerepét a táplálékláncban.

Az 1965. és 1967. évi azonos mintákból származó adatok azt mutatják, hogy a dévérkeszeg pesticid-szintje emelkedett, míg a fogas süllő és ponty értékek a korábbi adatok értékei körül mozognak.

АНАЛИЗ ОСТАТКА ПЕСТИЦИДОВ В РЫБАХ И ДРУГИХ ВОДНЫХ ОРГАНИЗМАХ В БАЛАТОНЕ И ИНЫХ ВОДНЫХ АРЕАЛАХ

Ференц Барон, Ференц Чонти и Йенэ Поньи

Посредством тонкослойной хроматографии был проведен анализ остатка пестицидов в рыбах и других водных организмах, собранных в Балатоне, Ветви Дуная у Толна и искусственных озерах.

В самом большом количестве обнаружили ДДТ и продукты его распада, а именно γ -ДДЕ, ХЦХ и еще один точно неидентифицированный компонент.

В отношении содержания остатка яда у рыб, происходящих из разных мест обитания, незначительное отклонение обнаружилось только у судака. Примерно одинаковое количество пестицида накапливалось и у тех рыб, которые живут не в Балатоне. В отличие от этого между хищниками и карпом из одного и того же места (Балатон и ветвь Дуная) обнаруживается значительная разница. От этого отличаются искусственные рыбные озера, где содержание пестицидов и у карпа и у судака низкое.

Из органов и тканей разных рыб самое большое количество остатка пестицидов обнаруживается в жировой ткани, затем в печени и наконец в икрах и мышцах.

В планктонных ракообразных Балатона обнаруживается значительное количество ДДТ (0,13 мг/кг), важность которого подчеркивается ролью этих организмов в питательной цепи водных животных.

Сравнивая данные, полученные при анализе образцов, собранных в 1965 и 1967 годах, выяснилось, что уровень пестицидов повышался в леще, и остался без изменения в карпе и судаке.

EXAMINATIONS ON THE FAT METABOLISM IN FRESHWATER FISHES. THE SYMPATHETIC NERVOUS SYSTEM AND THE MOBILIZATION OF FATTY ACIDS

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Evidence has been presented that the sympathetic nervous system regulates the mobilization of fats from adipose tissue of man and mammals. The denervation of the brown or white adipose tissue decreases the mobilization of fats from the adipose tissue even in starving animals (HAUSBERGER 1934, BEZNÁK 1937). In vivo and in vitro administration of norepinephrine increases the production of free fatty acid in adipose tissue (WHITE et al. 1958). The factors stimulating the activity of the nervous system as: anxiety, the talking about exciting events (BOGDONOFF et al. 1959), cold stress (GIGLEN et al. 1962) or electric shock (CORREL 1963) increase the free fatty acid level in the blood plasma. Adrenergic blocking agents block the adipokinetic effect of catecholamines in rat, man and in dog (HAVEL et al. 1959, ZSOTER et al. 1966, SHOTZ et al. 1960, BOGDONOFF et al. 1959). The increase of plasma free fatty acids after physiologic arousal (BOGDONOFF et al. 1960) or the effect of electric stimulation, can be antagonized by sympathectomy (CORREL 1963).

The teleost fishes have a morphologically well-developed sympathetic nervous system (NICOL 1951). The presence of catecholamines in the nerves and different organs of several fish species had already been demonstrated (EULER 1961 et al. ÖSTLUND 1954, CHAVIN 1966). The effect of epinephrine and norepinephrine on the activity of heart (FÄNGE et al. 1954), on gill vessels (FÄNGE 1962) and on blood pressure (MOTT 1957) has already been reported. Catecholamines have the same effect on iris or on intestinal smooth muscle as in the mammals (YOUNG 1933, EULER et al. 1957). No data are yet available on how the metabolic processes are regulated through these compounds.

In our previous work it had already been shown that intensive lipolysis takes place in the adipose tissue of the carp *Cyprinus carpio* L., but the tested lipolytic hormones (epinephrine, norepinephrine, isopropyl norepinephrine, adrenocorticotroph hormone) were ineffective in raising plasma free fatty acid levels (FARKAS 1967). The investigations were extended to other fish species, too. In the present paper we report more data on the effect of norepinephrine on the fat metabolism in fishes. It is hoped that the results might be of value not only for better understanding of the fat metabolism of fishes but also for the understanding of lipid mobilization in general.

Materials and method

The experiments were carried out on the following fish species: carp (*Cyprinus carpio* L.), bream (*Abramis brama* L.), perch (*Perca perca* L.), pike-perch (*Lucioperca lucioperca* L.), shad (*Pelecus cultratus* L.). The weight of the carps was 4–500 g, that of the bream and of the pike-perch 250–300 g; the others weighed 80–100 g. Except the carps, the other fish species were collected in the Lake Balaton 2–6 days before the experiment. The carps were purchased from a near-by fish-hatchery. After collecting they were kept in 200 l aquaria, 5 in each fish-tank. No food was given to the animals in captivity.

For the *in vivo* experiments norepinephrine bitartrate (2 mg/fish) dissolved in olive-oil or carboxy-methylcellulose was injected intramuscularly 2 hours before the death of the animals. The control animals received solvent only.

The *in vitro* experiments were carried out on the adipose tissue surrounding the intestine or the swim bladder. After killing the animals, the adipose tissues were quickly removed and placed into a physiological solution. The tissues were then cut into pieces of 50–60 mg; 200 mg of them were incubated for one hour in Krebs-Ringer phosphate buffer solution at pH 7.4, in the presence or absence of norepinephrine. The physiological solution contained only 0.48% NaCl. Other tissue pieces were homogenized in n-heptane at the beginning of the incubation in order to determine the free fatty acid content of the adipose tissue. At the end of the incubation the incubated adipose tissues were also homogenized in n-heptane. No fatty acid acceptor was added to the incubation medium. Under such circumstances, as in the case of the mammals, the produced fatty acids accumulate in the adipose tissue. 2–3 incubations were carried out simultaneously. The norepinephrine content of the incubation medium was 2 $\mu\text{g/ml}$.

Cold stress was performed by adding ice to the water of the aquarium sufficient to decrease the temperature of the water from 17 °C to 5 °C within 20 minutes. This temperature was maintained through 2 hours.

In other experiments CO₂ was bubbled into the water of the aquarium, and the fishes were allowed to "sniff" on the surface of the water.

Blood was taken by cutting off the caudal vein and collected in pre-chilled heparinized centrifuge tubes.

The quantity of plasma free fatty acids was determined by DOLE's method (1956) from 0.5–1.0 ml blood plasma. In order to determine the free fatty acid content of the adipose tissue, the homogenizates were diluted to 5.0 ml and from this 1.0 ml aliquot was titrated with 0.01 N NaOH in the presence of brom-thymol-blue indicator.

The glycerol content of the blood plasma was determined colorimetrically by LAMBERT and NEISH (1950) method from 0.1 ml blood plasma that had previously been freed from proteins with 3% HClO₄. The blood glucose level, was measured colorimetrically (HYVÄRINEN 1962).

Results

In previous experiments it was shown that norepinephrine and some other lipolytic hormones were ineffective in stimulating the free fatty acid production of the adipose tissue of the carp (FARKAS 1967). As shown in *Table I*, norepinephrine does not stimulate lipolysis in any of the examined fish

species. The free fatty acid content of blood plasma and adipose tissue in the freshly collected bream did not change after administration of the hormone, when, however, the animals had been starved for 3–6 days before the experiment, the free acid content of both the blood plasma and of the adipose tissue has considerably decreased. In these cases the hormone caused strong hyperglycaemia, too. A relationship seems to exist between the glycogenolytic effect of the hormone and the effect on the adipose tissue and plasma free fatty acid levels. However, the situation is not similar to that described by HAVEL et al. (1959) and SHAFIR et al. (1960) on dogs and rats after administration of epinephrine. Epinephrine has caused only initial increase in the plasma free acids in these animals. Parallel with the increase of blood glucose content the plasma free fatty acid level began to decrease, and when the blood glucose level reached its maximum, the amount of plasma free acids fell back to the control value. In the case of fish (carp-unpublished investigation) no such initial increase could be observed. The glycerol content of the blood did not change significantly as a result of hormone treatment (carp, control: $0.238 \pm 0.05 \mu\text{M/ml}$, treated: $0.175 \pm 0.04 \mu\text{M/ml}$; bream control: $0.346 \pm 0.06 \mu\text{M/ml}$, treated: $0.231 \pm 0.06 \mu\text{M/ml}$).

Table 2 presents the results of the in vitro experiments. It appears from these data that the adipose tissues of the examined fish species produced a considerable amount of free fatty acids. In the course of the experiment the quantity of fatty acids was doubled in the adipose tissues. Norepinephrine ($2 \mu\text{g/ml}$) did not stimulate the free fatty acid production of the adipose tissues. The hormone was without stimulating effect if its quantity was raised to $20 \mu\text{g/ml}$ (Fig. 1). The lipolytic activity of the adipose tissue in the animals

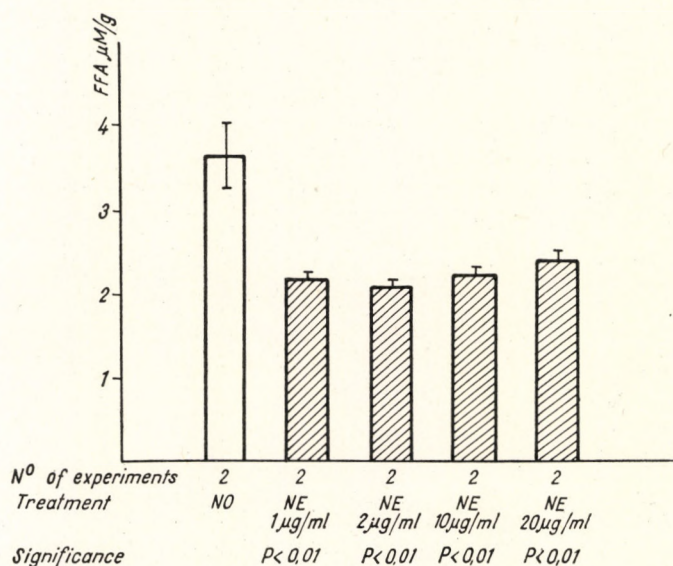


Fig. 1 — 1. ábra

The effect of various doses of norepinephrine on the production of free acids in the adipose tissue of the carpi *Cyprinus carpio* L.
Különböző koncentrációjú noradrenalin hatása ponty *Cyprinus carpio* L. zsírszövet szabad zsírsav termelésére

Table 1 — 1. Táblázat

The in vivo effect of noradrenaline on fatty acid mobilization and on the level of blood glucose in some fresh water fish species

In vivo noradrenalin hatása zsírsavmozgósításra és vércukorszintre néhány édesvízi halban

Name	Number of animals	Treatment	Plasma free fatty acid $\mu\text{M/ml}$	Adipose tissue $\mu\text{M/g}$	Blood glucose mg/ml	Notes
Név	Állatok száma	Kezelés	Plazma szabad zsírsav $\mu\text{M/ml}$	Zsírszövet FFA $\mu\text{M/g}$	Vércukor mg/ml	Megjegyzés
<i>Cyprinus carpio</i> L.	4	Control	1.293 ± 0.035	3.029 ± 0.436	0.330 ± 0.031	Winter — Tél
<i>Cyprinus carpio</i> L.	4	Norepinephrine	1.062 ± 0.094	1.686 ± 0.097	0.706 ± 0.052	
<i>Cyprinus carpio</i> L.	4	Control	0.584 ± 0.018	1.598 ± 0.150	0.548 ± 0.042	Summer — Nyár
<i>Cyprinus carpio</i> L.	4	Norepinephrine	0.403 ± 0.012	1.065 ± 0.217	2.177 ± 0.038	
<i>Abramis brama</i> L.	12	Control	1.138 ± 0.058	6.510 ± 0.181	1.807 ± 0.183	Summer, after collecting — Nyár, fogás után
<i>Abramis brama</i> L.	12	Norepinephrine	$0.956 \pm 0.015^*$	$6.720 \pm 0.477^*$	$2.283 \pm 0.171^*$	
<i>Abramis brama</i> L.	12	Control	0.607 ± 0.041		0.660 ± 0.051	After starvation of 6 days
<i>Abramis brama</i> L.	12	Norepinephrine	0.303 ± 0.025		1.060 ± 0.085	6 nap éhezés után
<i>Lucioperca lucioperca</i> L.	4	Control	1.141 ± 0.242	3.272 ± 0.229	0.430 ± 0.044	Summer — Nyár
<i>Lucioperca lucioperca</i> L.	4	Norepinephrine	0.844 ± 0.041	2.522 ± 0.492	3.308 ± 0.149	

* $P > 0.05 < 0.02$

Table 2. — 2. Táblázat

The in vitro effect of noradrenaline on the free fatty acid production in the fish adipose tissue

Noradrenalin hatása halzsírszövet in vitro szabadzsírsav termelésére

Name	Number of animals	Control t_0 $\mu\text{M/g/h}$	Control t_{60} $\mu\text{M/g/h}$	Noradrenaline 2 $\mu\text{g/ml}$, t_{60} $\mu\text{M/g/h}$	Notes
Név	Állatok száma	Kontroll t_0 $\mu\text{M/g/h}$	Kontroll t_{60} $\mu\text{M/g/h}$	Noradrenalin 2 $\mu\text{g/ml}$ t_{60} $\mu\text{M/g/h}$	Megjegyzés
<i>Cyprinus carpio</i> L.	4	1.956 ± 0.230	4.350 ± 0.449	$3.100 \pm 0.244^*$	Winter — Tél
<i>Cyprinus carpio</i> L.	4	3.933 ± 0.197	7.998 ± 0.672	9.001 ± 0.707	Summer — Nyár
<i>Abramis brama</i> L.	8	6.241 ± 0.259	13.389 ± 0.744	13.100 ± 0.326	Summer — Nyár
<i>Perca perca</i> L.	2	2.385 ± 0.197	5.581 ± 0.479	4.861 ± 0.146	Winter — Tél
<i>Lucioperca lucioperca</i> L.	4	3.295 ± 0.211	6.834 ± 0.479	$5.484 \pm 0.313^*$	Spring — Tavasz
<i>Lucioperca lucioperca</i> L.	4	4.001 ± 0.541	8.886 ± 0.415	9.436 ± 0.507	Summer — Nyár
<i>Pelecus cultratus</i> L.	4	2.815 ± 0.163	3.617 ± 0.286	$2.807 \pm 0.214^*$	Winter — Tél

* = $P < 0.05$

t_0 = free fatty acid content of the adipose tissue at the beginning of the experiment

t_{60} = free fatty acid content of the adipose tissue at the end of the experiment

t_0 = a zsírszövet szabad zsírsavtartalma a kísérlet elején

t_{60} = a zsírszövet szabad zsírsavtartalma a kísérlet végén

Table 3. — 3. Táblázat

Plasma free fatty acid and blood glucose level in stress conditions

Plazma szabad zsírsav- és vércukorszint stress állapotokban

Name	Number of animals	Types of stress	Plasma FFA $\mu\text{M/ml}$	Adipose tissue FFA $\mu\text{M/g}$	Blood glucose mg/ml	Notes
Név	Állatok száma	Stress típusa	Szabad zsírsav $\mu\text{M/ml}$	Zsírszövet, $\mu\text{M/g}$	Vércukor, mg/ml	Megjegyzés
<i>Abramis brama</i> L.	5	Control	0.505 ± 0.043		0.597 ± 0.060	$P < 0.01$
<i>Abramis brama</i> L.		Cold — Hideg	0.576 ± 0.049		0.910 ± 0.030	
<i>Lucioperca lucioperca</i> L.	5	Control	1.141 ± 0.081	3.295 ± 0.146	0.430 ± 0.024	$P < 0.01$
<i>Lucioperca lucioperca</i> L.		Cold — Hideg	1.046 ± 0.029	2.965 ± 0.127	1.866 ± 0.076	
<i>Abramis brama</i> L.	8	Control	0.825 ± 0.073		0.587 ± 0.054	$P < 0.01$
<i>Abramis brama</i> L.		injection (phys. sol.) — injekció (fiz. oldat)	0.568 ± 0.005		0.881 ± 0.098	
<i>Cyprinus carpio</i> L.	4	Control	0.640 ± 0.046		0.423 ± 0.033	
<i>Cyprinus carpio</i> L.		injection (phys. sol.) — injekció (fiz. oldat)	0.600 ± 0.090		0.626 ± 0.088	$P < 0.05$
<i>Abramis brama</i> L.	5	Control	0.698 ± 0.052		0.562 ± 0.035	
<i>Abramis brama</i> L.		Anoxia	0.306 ± 0.010		1.307 ± 0.117	$P < 0.01$

caught in summer remained unchanged in the presence of the hormone while the adipose tissues of the animals collected in winter produced less free fatty acids. This is especially evident in the case of the carp and of the pike-perch where both winter and summer experiments are available. The mechanism through which the hormone decreases the free fatty acid production of the tissue, is not yet clear, it is probable that under *in vivo* and *in vitro* conditions it is the same.

Table 3 demonstrates that stress conditions like a simple intramuscular injection of physiological solution, exposure to cold or hypoxia do not increase the free fatty acid content of the blood in the examined fish species. On the above-mentioned effects the level of blood glucose was increased like in animals treated with epinephrine. Similarly to mammals, the increase of the blood glucose level might be attributed to elevated sympathetic tonus but the increased secretion of catecholamines in fish, does not lead to the increase of the plasma free fatty acid level. In some experiments, like in the case of norepinephrine the free fatty acid content of the blood plasma has decreased.

Discussion

The following evidences suggest that in the fresh water fishes — similarly to mammals — neutral fats are mobilized in the form of free fatty acids:

1. An intensive lipolysis takes place in adipose tissue incubated *in vitro*. The produced fatty acids are released to the incubation medium when it contains fatty acid acceptors (FARKAS 1967).

2. Their blood contains an appreciable amount of free fatty acids. The free fatty acid level of the blood plasma seems to depend on the nutritional state of the animal. Prolonged fasting results in an increase of plasma free fatty acid level. Per os administration of glucose to starving animals decreases the level of the plasma free fatty acids.

The production of the free fatty acids in the adipose tissue of mammals is under a complicated metabolic, endocrine and nervous control. The metabolic regulation is realized by shifting the balance of hydrolytic and re-esterification processes in adipose-cells. If the level of blood glucose is high, the intensity of the re-esterification processes increases and the amount of free fatty acids released from the adipose tissue decreases, and vice versa. That in the adipose tissue of the fish, too, a similar mechanism is existing, which is suggested by the observation that glucose *in vivo* or *in vitro* decreases the production of free fatty acids. The fact that neither norepinephrine nor emergency conditions increase the production of adipose tissue free fatty acids suggest that the sympathetic nervous system does not play a role in mobilizing the fatty acids in the fish.

In mammals the catecholamines stimulate the decomposition of triglycerides in the adipose tissue by increasing the formation of cyclic 3'5' AMP. The hormones act on the adenyl cyclase which is responsible for the formation of the cyclic nucleotide. It seems proved that there is a correlation between intracellular level of cyclic 3'5' AMP and the production of free fatty acids in the adipose tissue (WEISS et al. 1966). The catecholamines stimulate the decomposition of the glycogen in the liver of mammals through a practically similar mechanism; the only difference is that here the cyclic 3'5' AMP exerts an influence on the phosphorylase kinase enzyme, and, through this, on the

phosphorylase. From the fact that the blood glucose level in the fish has increased after administration of catecholamines, it can be concluded that the catecholamine stimulated decomposition of glycogen in the liver of the fish occurs similarly to that in mammals, with other words in the liver of the fish, too, there is a biochemical system, consisting of an adenylyl cyclase-3'5' AMP-cyclic nucleotide-sensitive enzyme (phosphorylase). On the other hand, from the ineffectiveness of norepinephrine in stimulating the lipolytic processes in fish adipose tissue might be inferred that this system is partly or entirely absent in the adipose tissue of fish.

In connection with the above, it is tempting to assume that there is a relationship between the innervation of the adipose tissue and the presence of the adrenergic lipolytic system in it. According to several authors, in the adipose tissue of the mammals the adipose cells are in connection with nervefibres (HAUSBERGER 1934, BOEKE 1933), and recently, GOVIRIN and POPOVA (1965) have demonstrated in rat adipose tissue in contrast to WIRSEN (1964) a three-dimensional adrenergic network surrounding the adipose cells. It is interesting that in the adipose tissue of lower vertebrates these structures could not be detected, adrenergic structures were found only in connection of blood-vessels (GOVIRIN and POPOVA 1965). This hypothesis is also supported by the fact that in most tissues in which there exists some adrenergic biochemical system (phosphorylase), the cells are in connection with sympathetic fibres (liver). Thus, both the innervation of the adipose tissue and the appearance of the adrenergic lipolytic system in the adipose cells, might be a stage in the evolution of control of lipid metabolism.

The mechanism itself through which norepinephrine decreases the free fatty acid level in fish adipose tissue and blood plasma is not yet clear. The assumption that the hormone inhibits directly the lipolytic processes in the adipose tissue, might be excluded on the basis of analytical data obtained on the glycerol level of blood plasma. From the fact that the plasma glycerol level has not changed significantly after injection of norepinephrine, it can be concluded that the decomposition of triglycerides was continuing, with unchanged intensity in the adipose tissue of the treated animals. It seems to be more probable that the "antilipolytic" effect of the hormone is due to its hyperglycaemic action. Norepinephrine and even stress conditions affected the plasma free fatty acid level as if the animals had been treated with glucose. Glucose, on the other hand, increases the intensity of the re-esterification of the liberated fatty acids in the adipose tissue. The uptake of glucose and the re-esterification of fatty acids are also stimulated by catecholamines in the adipose tissue of mammals (VAUGHAN 1961, CAHILL et al. 1960). Thus, the decrease of plasma and adipose tissue free fatty acid level obtained by the effect of norepinephrine, might be the result of a more intensive re-esterification. In mammals, however, this action of norepinephrine is less evident because of slight glycaemic and strong lipolytic effect — in fish however it might be much more conspicuous because of the lack of the adrenergic lipolytic system.

Summary

Noradrenaline *in vivo* (2 mg) did not increase the free fatty acid level in the blood of different freshwater fish species (carp, bream and pike-perch). The blood glucose level was increased and the plasma free fatty acid level

decreased after the administration of the hormone. The hormone did not stimulate, even under in vitro conditions (2 $\mu\text{g/ml}$) the decomposition of triglycerides in the adipose tissue of different fishes (carp, bream, pike-perch, perch, shad). Under its influence the free fatty acid production of the adipose tissue in animals collected in winter, decreased while those of animals collected in summer, did not change. Under stress conditions (cold stress, injection of physiological solution, anoxia) the blood glucose level was increased, however, the plasma free fatty acid level either remained unchanged or decreased (carp, pike-perch, bream). The "antilipolytic" effect of the hormone might be in relation to its hyperglycaemic effect. It is supposed that, in fishes in contrast to mammals the sympathetic nervous system, has no role in mobilizing the fats in the form of free fatty acids.

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VIZSGÁLATOK ÉDESVÍZI HALAK ZSÍRANYAG FORGALMÁN. SZIMPATIKUS IDEGRENDSZER ÉS ZSÍRMOZGÓSÍTÁS

Farkas Tibor

Összefoglalás

Noradrenalin in vivo (2 mg) nem növelte különböző édesvízi halak (ponty, dévér, süllő) vérének szabad zsírsav szintjét. Hatására emelkedett a vércukor szint, és csökkent a plazma szabad zsírsav szintje. A hormon in vitro körülmények (2 µg/ml) között sem stimulálja a trigliceridek lebontását hal (ponty, dévér, süllő, sügér, garda) zsírszövetében. Hatására a télen gyűjtött állatok zsírszövetének szabad zsírsav termelése csökkent, a nyáron gyűjtötteké nem változott. Stressz állapotok (coldstress, egyszerű deszt. víz. injekció, anoxia) hatására növekedett a vércukor szint, de a plazma szabad zsírsav szint változatlan maradt, vagy csökkent (ponty, süllő, dévér). A hormon „antilipolitikus” hatását hiperglikémiás hatásával lehet összefüggésbe hozni. Valószínűnek látszik, hogy a szimpatikus idegrendszer az emlősökkel ellentétben halaknál nem játszik szerepet a zsírok szabad zsírsavak formájában történő mozgósításában.

ИССЛЕДОВАНИЕ ОБМЕНА ЖИРОВ ПРЕСНОВОДНЫХ РЫБ. СИМПАТИЧЕСКАЯ НЕРВНАЯ СИСТЕМА И МОБИЛИЗАЦИЯ ЖИРА

Тибор Фаркаш

Норадреналин (2 мг) in vivo не повышает уровня свободных жирных кислот в крови некоторых пресноводных рыб (каrp, лещ, судак). Под его влиянием повышается уровень сахара в крови и понижается содержание свободных жирных кислот в сыворотке. Этот гормон (2 µг) in vitro тоже не увеличивает распад триглицеридов в жировой ткани рыб (каrp, лещ, судак, окунь, чехонь). Под влиянием норадреналина у животных, собранных зимой, понижается синтез свободных жирных кислот, а у животных, собранных летом—остается без изменения. При шоковых состояниях (холодовой шок, введение дистиллированной воды, аноксия) увеличивается уровень сахара в крови, но содержание свободных жирных кислот в сыворотке остается без изменения или незначительно снижается у карпа, леща и судака. Антилиполитическое действие гормона связано его гипергликемическим воздействием. По всей вероятности, симпатическая нервная система у рыб в отличие от млекопитающих не играет роли в мобилизации жиров и в виде свободных жирных кислот.

INVESTIGATIONS OF THE FATTY ACID COMPOSITION OF FISHES FROM LAKE BALATON

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The fatty acid composition of water organisms is more complicated than that of land animals. The complexity is caused by the polyunsaturated fatty acids of long carbon chains occurring in great quantities in the fat of water organisms. The major part of analytical data are related to marine animals — primarily on fishes — much less is known about the fat of animals living in fresh water. A good part of these data was obtained by fractionated vacuum distillation, a method that does not result in a complete elucidation of the sample's fatty acid composition. Fats of freshwater fishes were investigated first by LOVERN (1932) then by PATHAK and his co-workers (1957—1958) with this method. GRUGER et al. (1964) analyzed the fatty acid composition of three fishes gas chromatographically. Earlier, we already published data on the fatty acid composition of fishes from Lake Balaton; these results (FARKAS and HERODEK 1962) were obtained by fractionating the samples according to TWITCHEL, by hydrogenating the alcohol soluble fraction and by paper chromatographic analyses of the fractions. This way we could determine in the samples the distribution of the fatty acids according to their chain length but no information was received on the proportions of the differently unsaturated fatty acids. In the present work the fatty acid composition of several fishes from Lake Balaton was investigated with gas chromatographic method.

Material and method

The fatty acid composition of the intestinal fat of following fish species was studied: *Aspia aspia* L., bream (*Abramis brama* L.), shad (*Pelecus cultratus* L.), pike (*Esox lucius* L.), pike perch (*Lucioperca lucioperca* L.) and roach (*Leuciscus rutilus* L.). Adipose tissues were excised from freshly killed animals, were grounded with anhydrous Na_2SO_4 and the fats were extracted by petroleum ether. The extracts were evaporated in vacuum then sealed under indifferent atmosphere with some ml of petroleum ether. The samples were stored at -20°C till utilization. Fat samples were obtained from adipose tissue of 5—5 fish. The fatty acid methyl esters were prepared by transesterification of the original samples. It took place with abs. methanol containing 5% HCl at 80°C in sealed test tubes. Previous fractionation of the extract

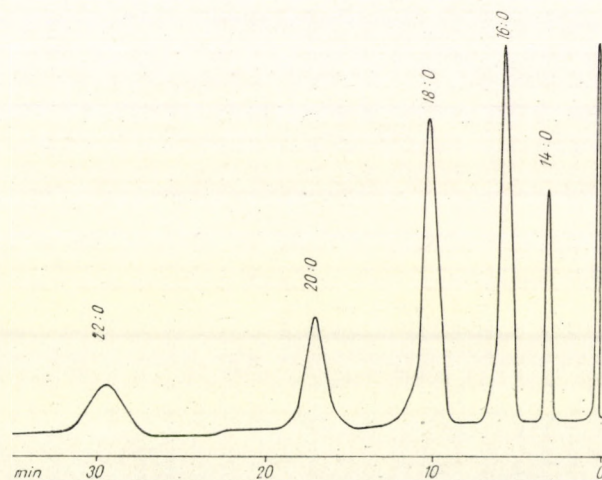
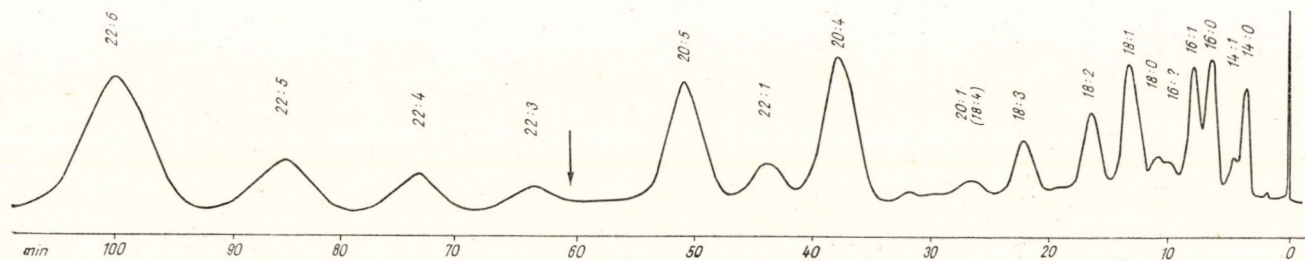


Fig. 1. Chromatogram of pike-perch (*Lucioperca lucioperca* L.) intestinal fat methyl esters a., before and b., after hydrogenation Süllő (*Jucioperca lucioperca* L.) intentiális zsirjának gázchromatografiás képe a., hidrogénezés előtt és b., után

proved to be unnecessary as preliminary thin-layer chromatographic analysis showed that the quantity of lower diglycerides, phospholipids and fatty acids is negligible.

Gas chromatographic analyses were performed with a Chrom III IKZ type equipment operating with flame ionization detector. The column length was 3 m, its inner diameter 6 mm. As stationary phase 20% ethylene glycol succinate was used, the support was Chromosorb W of 80 mesh. The carrier gas was N_2 (flow rate 100 ml/s). The column temperature was 182 °C. The temperature of the sample heater was at the injection 340 °C.

As reference standards for the identification of the peaks the NIH fatty acids ($C_{18} : 0$, $C_{18} : 1$, $C_{18} : 2$, $C_{18} : 3$, $C_{20} : 1$, $C_{20} : 5$, $C_{22} : 6$) and a fish oil sample of known composition (menhaden, *Bevoortia tyrannus*) were used.

Quantitation was performed with triangulation technique. Correction factors were calculated on the base of a mixture of known fatty acid composition. The values were in good agreement with the composition of the hydrogenated samples. Hydrogenation was carried out in acetic acid in the presence of d-catalizator.

Results

In *Fig. 1a*, the chromatogram of fatty acid methyl esters of *L. lucioperca* L. is demonstrated. Similar picture were obtained for other fishes. It can be seen that the fats of fishes consists of several fatty acids. Gas chromatographic analysis of hydrogenated samples showed that the fatty acids belong to the C_{14-22} series (*Fig. 1b*). Nearly all fatty acids reported by other authors for fish fat are to be found in the fat of Lake Balaton fishes. We could not identify reliably one C_{16} polyenoic fatty acid, with a retention time close to that of stearic acid and it is questionable, too, whether the samples contain $C_{18} : 4$ fatty acid at all. The series C_{20-22} was represented by tetra- penta- and hexaenoic forms. However, in the fat of marine fishes also a small amount of less unsaturated C_{20-22} was described, we could not demonstrate these acids in the fat of the investigated fishes.

Table 1 summarizes the percentual distribution of fatty acids. It can be seen that the difference among the fat of individual fishes appears primarily in the quantity of C_{20-22} fatty acids. The quantity of docosaheptaenoic acid is the highest in the three predatory fishes (*A. aspius* L., *L. lucioperca*, and *E. lucius*) and is the lowest in *A. brama* and *P. cultratus*. The quantities of stearic and eicosatetraenoic acids are strikingly high in the fat of *Abramis b.* It can be calculated from *Table 1* that the total quantity of C_{20-22} polyenoic fatty acids (with the exception of *C. carpio*) is near to each other.

In one of his papers LOVERN (1932) demonstrated differences between the fatty acid composition of freshwater and marine fishes, reporting that the quantity of unsaturated fatty acids is lower while that of C_{18} unsaturated and palmitoleic acids are higher in freshwater than in marine fishes. *Table 2* compares the average fatty acid composition of Lake Balaton fishes, and that of marine ones. The average fat composition of marine fishes is calculated from the gas chromatographic data, published by several authors. This table demonstrates that marine fishes in average contain nearly twice as much docosaheptaenoic acid than the fishes in Lake Balaton, but the percentage of eicosatetraenoic acid in our fishes is higher. The quantity of oleic acid is about the

Table 1 — 1. Táblázat

The fatty acid composition of fishes from Lake Balaton

Balatoni halak zsírsav-összetétele

Chain length Zsírsav láncossz	Number of double bonds Kettős kötése- sek száma	<i>Aspius</i> <i>aspius</i> L.	<i>Lucioperca</i> <i>sandra</i> L.	<i>Esox</i> <i>lucius</i> L.	<i>Rutilus</i> <i>rutilus</i> L.	<i>Cyprinus</i> <i>caprio</i> L.	<i>Abramis</i> <i>brama</i> L.	<i>Pelecus</i> <i>cultratus</i> L.
14	0	5.5	3.3	3.9	3.0	1.5	2.4	5.6
	1	1.2	1.6	1.0	0.9	0.7	1.1	1.5
16	0	10.8	14.9	14.8	12.1	14.3	12.7	11.5
	1	11.2	10.2	14.6	13.4	13.4	11.3	16.0
	2	0.9	0.7	1.1	0.5	3.6	—	0.7
18	0	3.0	3.6	3.5	2.7	4.1	8.8	3.2
	1	22.7	25.0	17.8	19.0	19.0	23.7	21.6
	2	6.6	5.4	7.6	8.0	7.0	5.1	10.1
	3	6.0	4.1	5.4	13.9	9.7	4.2	3.4
20	1	2.0	1.7	2.2	2.0	2.2	1.9	1.9
	4	7.9	8.6	7.0	4.1	3.7	3.2	9.6
	5	5.9	6.0	7.1	8.4	0.8	19.9	8.7
22	1	2.0	1.1	1.8	0.1	8.2	0.5	11.8
	4	1.3	1.2	1.1	1.9	2.5	2.3	0.61
	5	4.0	2.8	2.6	4.0	2.7	—	2.3
	6	8.7	10.5	8.2	5.8	6.3	2.7	2.3

same in the two groups. In agreement with LOVERN's classification the quantity of palmitoleic and C_{18} polyenoic fatty acids is higher in the Lake Balaton fishes than in the marine ones.

Table 3 presents the distribution of fatty acids according to their chain length in the fat of fishes originating from different places. It is conspicuous that with regards to the distribution of fatty acids according to their chain length the fishes in Lake Balaton stand near to the fishes common in the Atlantic and Pacific coastal regions of the United States of America.

Discussion

The fats of the investigated fishes from Lake Balaton fit well into the picture formed during the last 30 years on the fatty acid composition of water organisms. On the basis of the work of HILDITCH, LOVERN and others it became evident that water organisms by the complexity of their fatty acid composition differ from land organisms; moreover the unsaturated acids of long carbon chain, characteristic for water organisms, were also found in the fat of those land vertebrates (reptiles, amphibians and birds) that are feeding on water organisms. HILDITCH (1965) KLENK and his co-workers (1960) and MEAD and his co-workers (1966) demonstrated that the structures of these fatty acids may be traced back to the linoleic and linolenic acids, both present in large quantities in vegetable oils. Animals cannot synthesize these

Table 2 — 2. Táblázat

The average fatty acid composition of marine fishes and of fishes sampled from Lake Balaton

Balaton és tengeri halak átlagos zsírsav-összetétele

Chain length Zsírsav láncossz	Number of double bonds Kettős kötések száma	Origin — Gyűjtőhely		*GRUGER et al. (1964) REISER et al. (1963) DEWITT (1963) LASKER et al. (1962)
		Sea — Tenger*	Balaton	
14	0	4.7	3.6	P < 0.01
	1	0.3	1.2	
16	0	21.2	12.7	
	1	8.5	12.7	P < 0.02
	2	1.0	1.2 (?)	
18	0	4.2	4.1	P < 0.01
	1	20.3	21.1	
	2	1.9	7.1	NS
	3	1.1	6.6	
	4	2.0	—	
20	1	4.5	1.7	P < 0.01
	4	2.0	6.3	
	5	9.9	7.1	
22	1	—	2.1	NS
	3	0.3	—	
	4	—	1.6	P < 0.01
	5	2.3	3.0	
	6	13.6	6.3	

acids, but they are able to elongate them. Further experiments (KELLY and his co-workers 1958) demonstrated that the main bulk of the polyunsaturated fatty acids stored in the fat of fishes is of alimentary origin, as also fishes cannot elongate the chain at a greater extent.

The fatty acid composition of fats in fishes is determined obviously by two processes:

1. Synthesis of polyunsaturated fatty acids of long carbon chain at the lower level of food chain;
2. Dilution of polyenoic fatty acids taken up in food with endogenous fatty acids.

Concerning the first step we demonstrated earlier with paper chromatography (FARKAS and HERODEK 1962) and recently with gas chromatography (HERODEK and FARKAS 1967) that in the fat of certain plankton crustaceans (Copepods) the quantity of polyunsaturated fatty acids of long carbon chain is high. If these crustaceans were fed on algae of known fatty acid composition (no C₂₀₋₂₂ were present in their fat) we found in their fat always rather great quantities of C₂₀₋₂₂ polyenoic fatty acids (FARKAS and HERODEK 1964). Thus it is obvious that the main part of these fatty acids originates within the food chain: phytoplankton — crustacean plankton — fish, in the crustaceans.

Gas chromatographic analysis on the fatty acid composition of plankton crustaceans from Lake Balaton demonstrated that in the fat of these organisms

Table 3

The fatty acid composition of fishes
Különböző gyűjtőhelyekről

Sampling site Gyűjtőhely	Number of samples Minta száma	Analytical procedure Elemzési eljárás	SAT.		
			C ₁₄	C ₁₆	C ₁₈
India (Ganges)	6	Vacuum dest.	3.6	23.9	8.6
Balaton	7	GLC.	3.5	14.3	4.1
Tenger — Sea (Atlantic and Pacific coasts of USA) — (USA Atlanti és Pacific part)	20	GLC.	4.3	19.6	3.9
Herring from the North Sea — É-tengeri hering		Vacuum dest.	5.9	11.0	0.2

both the oleic and the palmitoleic acids are present in lower quantities than in fishes (HERODEK and FARKAS 1967). In Table 3 it can be seen that in the fat of fishes collected at different places the quantity of C₁₆ (palmitoleic) and C₁₈ (mainly oleic) unsaturated fatty acids is different. If we arrange the fishes according to the increasing C₂₂ content of their fats a sequence is obtained in which the amount of palmitoleic acid decreases. The C₁₈ unsaturated acids show a similar tendency. This sequence corresponds to the arrangement of fishes according to the temperature of their environment. The decrease of temperature obviously decreases also the formation of the endogenous fatty acids (C₁₈₋₁₈ saturated and monoenoic), and the stored fat gets more and more similar to the alimentary fat. Our earlier investigations demonstrated the increase of the long chain polyenoic fatty acids by decreasing temperature in fats of crustaceans, therefore the true difference exists not between the fatty acid composition of the marine and freshwater fishes but between the fat metabolism of planktonic crustaceans and fishes living under different climatic conditions.

Summary

The fatty acid composition of seven fishes from Lake Balaton was analysed by gas chromatography. The fats of the investigated fishes show the general characteristics known for fats of water origin. The level of C₂₀₋₂₂ fatty acids in fishes from Lake Balaton was higher than in the freshwater fishes reported by other authors.

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— 3. Táblázat

kiving under different climats

származó halak zsírsav-összetétele

Present date

UNSAT.					Note — Megjegyzés
C ₁₄	C ₁₆	C ₁₈	C ₂₀	C ₂₂	
2.0 1.1	16.5 13.9	31.0 35.0	8.0 16.3	5.6 12.7	PATHAK et al. 1957. Jelen adatok
6.3	8.8	23.4	15.2	14.5	GRUGER et al: 1964 REISER et al: 1963 DE WITT: 1963 LASKER et al: 1962
0.2	4.7	20.0	27.3	24.0	LOVERN: 1932

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VIZSGÁLATOK BALATONI HALAK ZSÍRSAV-ÖSSZETÉTELÉN

*Farkas Tibor és Herodek Sándor***Összefoglalás**

Hét balatoni halfaj zsírsav-összetételét elemeztük gázkromatográfiásan. A vizsgált halak zsírjai azokat a jellegzetességeket mutatták, melyek általában a vízi szervezetekre jellemzőek. A C_{20-22} zsírsavak mennyisége magasabb volt, mint az eddig mások által megvizsgált édesvízi halakban.

ИЗУЧЕНИЕ СОСТАВА ЖИРНЫХ КИСЛОТ БАЛАТОНСКИХ РЫБ

Тибор Фаркаш и Шандор Херодек

При помощи газовой хроматографии был изучен состав жирных кислот семи видов балатонских рыб. Жиры изученных видов рыб обладают такими же характерными свойствами, как и жиры других водных организмов. Содержание жирных кислот C_{20-22} было выше, чем у остальных видов рыб, описанное другими авторами.

GAS CHROMATOGRAPHIC STUDIES ON THE FATTY ACID COMPOSITION OF SOME FRESH-WATER CRUSTACEANS

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Received: 10th March, 1967

A very significant part of the enormous biomass of water organisms consists of lipids. Mankind utilizes of this quantity about 1 million metric ton a year. This rate will only increase in the coming years due to the quick progress in sea-fisheries (SWAIN 1958). As the utilization of fish fats depends on their chemical composition numerous data are already known in this field (HILDITCH 1956).

According to these analyses the fats of fishes differ characteristically from those of land animals. Experiments in aquaria showed (KELLY et al. 1958, FARKAS and HERODEK 1964) that food determines basically the composition of fats in fishes. As a source of the fat in fishes primarily plankton crustaceans can be taken into account. With fractionated distillation the fatty acid composition of altogether four crustacean species was investigated previously (LOVERN 1935). In our earlier papers (FARKAS and HERODEK 1959, 1961, 1962, 1964) we published paper chromatographic analysis on the composition of fatty acids of ten species.

The resolving power of both fractionated distillation and paper chromatography is rather restricted. The aim of this paper is to give a more detailed and correct picture on the fatty acid composition of several crustaceans with gas chromatographic method.

Material and methods

Plankton crustaceans were sampled with a No. 6 net trawled by a row-boat. Living animals, kept in water were brought to the laboratory where the species composition of the samples were determined. If a sample contained Cladocerans and Copepods the water was bubbled through in order to separate them, in this way the Cladocerans were brought to the surface while the Copepods stayed at the bottom. Only samples were determined where the species to be investigated was present in at least 99%. Therefore the analytical data are characteristic for the given species. The needed quantity of the Amphipods were collected with pincers.

From each species samples of some grams in fresh weight were obtained. The water was blotted from the animals with filter-paper then they were ground-

ed with anhydrous Na_2SO_4 . The fat was extracted in N_2 atmosphere under reflux three times with petroleum ether. For 1 g sample 30 ml solvent was used. An aliquot of the extract containing 40 mg lipid was evaporated under N_2 and taken up in 1 ml hexane. Fatty acids of this lipid were transmethyated with absolute methanol containing 4% of cc HCl. To the lipids dissolved in 1 ml hexane 5 ml of this hydrochloric acid-methanol mixture was added and the samples were kept for 4 hours at 80°C in a heating block. When they cooled down the upper phase containing the fatty acid methyl esters was removed.

The analysis was carried out by a Chrom III. IKZ (Laboratorni Pstroje CSSR) gas chromatograph. The length of the column was 3 m, the inner diameter was 6 mm. 20% ethylene glycolsuccinate on 80–100 mesh Chromosorb W was used as stationary phase. The carrier gas was N_2 , its flow rate 100 ml/min. The column pressure was 1.5 atmosphere, its temperature 184°C . The equipment operated with flame ionization detector. The fatty acid methyl esters, dissolved in hexane were injected with a micro-syringe. For the time of injection the temperature of the sample heater was 240°C . The identification of the peaks took place by comparing the chromatogram with that of standard fatty acids and of samples of known composition. Peak areas were determined by triangulation. The correction factors for the individual fatty acids were determined by means of known fatty acid mixtures of similar composition as the samples. The percentual fatty acid composition was calculated in using these factors.

Results and discussion

In *Fig. 1* the gas chromatogram of the fatty acid methyl esters of a plankton crustacean species is demonstrated.

The fatty acid composition of different samples is summarized in *Table 1*. The accepted abbreviation techniques were used here, too, fatty acids are characterized with two numbers, the first giving the length of the carbon chain, the second after the colon (:) is the number of double bonds for 1 molecule.

From *Table 1* it can be seen that the same fatty acids are present in all crustaceans only with quantitative differences. These fatty acids are the

Table 1

The fatty acid composition of freshwater crustaceans (per cent wt.)

	14:0	14:1	14:2	16:0	16:1	16:2	18:0
1. <i>Cyclops vicinus</i> ULJ.	7.8	0.3	0.3	13.6	5.9	0.7	4.4
2. <i>Eudiaptomus gracilis</i> (G. O. Sars)	9.7	tr	tr	17.7	7.5	0.2	3.8
3. <i>Daphnia cucullata</i> (G. O. Sars)	7.0	0.8	0.1	16.4	5.7		6.8
4. <i>Daphnia longispina</i> O. F. Müller	2.5	3.0	0.8	11.7	14.6	0.8	3.7
5. <i>Simoecephalus vetulus</i> V. F. M.	3.5	3.8	1.4	12.8	12.1		5.1
6. <i>Bosmina longirostris</i> f. <i>pellucida</i> STINGELIN	2.5	2.3	2.8	14.0	10.3		7.4
7. <i>Gammarus</i> (<i>Rivulogammarus</i>) <i>roeseli</i> GERVAIS	1.4	1.5	1.7	12.1	12.3		4.1

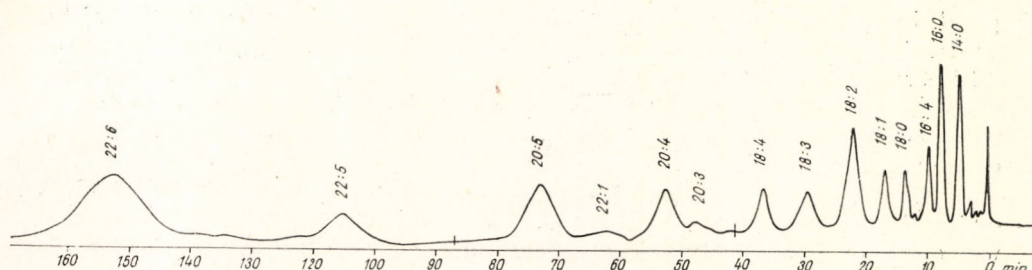


Figure 1. — 1. ábra

The gas chromatogram of the plankton crustacea an *Cyclops vicinus*

A *Cyclops vicinus* planktonrák zsírsav-metilésztereinek gázkromatogramja

same ones considered as characteristic for fats in fishes and even their quantitative relations are greatly resembling to those in fishes (GRUGER 1964, FARKAS and HERODEK 1967). The similarity of the fatty acid composition of crustaceans and fishes also at the resolving level of gas chromatography furnishes further evidence for the hypothesis that plankton crustaceans are the main source of fats for fishes. The only fatty acid occurring in much lower quantities in crustaceans than in fishes is oleic acid. It seems that fishes, like land animals, store their endogenous fatty acids mainly in the form of oleic acid.

Among the species of Table 1 there are two Copepods (*Cyclops vicinus* and *Eudiaptomus gracilis*), sampled in the area before our institute from Lake Balaton at 6 C° water temperature, on the 16th and on the 23rd November resp., 1966. The fatty acid composition of these two species is extraordinarily similar. This may be explained by the identic biotop, equal living habits and the relationship. On the other hand the fatty acid composition of *Daphnia cucullata*, sampled at the same time and from the same place of Lake Balaton was definitely different, deviating chiefly by the lower level of 22 : 6 fatty acids in it. In contrary to the above-mentioned two species *Daphnia cucullata* belongs to the Cladocerans. On the 29th November three further Cladocera species were sampled, *Daphnia longispina* and *Bosmina longirostris* from the

— 1. Táblázat

Édesvízi rákok zsírsav-összetétele súlyszázalékban

18 : 1	18 : 2	18 : 3	18 : 4	20 : 2	20 : 4	22 : 1	20 : 5	22 : 4	22 : 5	22 : 6
5.2	9.9	6.6	9.2	1.5	9.7	1.1	11.9	0.2	4.6	10.1
6.1	10.6	6.9	8.8	1.7	4.2		10.5	tr	3.4	8.9
8.3	15.5	8.2	6.3	1.1	6.7		7.6		5.4	4.1
10.1	4.2	11.3	15.8	0.7	1.3	0.6	17.4			1.5
11.8	6.0	6.8	7.8	2.0	6.6		18.9		0.4	1.0
19.3	4.1	5.7	2.8	1.7	5.4		21.7			
24.5	16.0	6.7	1.9		7.3		10.5			

pond Belső-tó in Tihany and *Simocephalus vetulus* from Lake Velencei-tó. Water temperature of both lakes was 3 °C. In the fatty acid composition of all the four Cladocerans there are definite differences, however, in all of them there is much more less 22 : 6 than in Copepods. To decide the generality of this phenomenon will be only possible in the knowledge of analytical records of much more species.

One Amphipod species, *Gammarus roeseli* was sampled from the detritus of the Aszófői-Séd brook. In this crustacean similarly to *Bosmina longirostris* we could not detect fatty acid of 22 carbon atoms and it also contained great amounts of oleic acid. The crustaceans analyzed show a certain regularity insofar that the less 22 : 6 is present the higher is the level of 18 : 1.

Previously we demonstrated that the fatty acid composition of freshwater crustaceans changes according to a regular yearly cycle (FARKAS and HERODEK 1964). By altering the composition of their fat the crustaceans can assure that the melting point of the fat should be some degrees lower than the water temperature, that means that the fats can stay all the year round in the suitable liquid state. In this sense data of *Table 1* do not represent a constant, unalterable property. A comparison among the different species is possible only in that case if it takes place among samples collected at the same time and at similar water temperatures. In our present investigations all species were sampled in the second half of November. Samples collected during summer presumably will prove to be more saturated. According to our earlier results (FARKAS and HERODEK 1962) parallel with the decrease of water temperature the iodine value of the fat increases, demonstrating the rising unsaturation. Furthermore we found paper chromatographically that the quantity of fatty acids of 20 and 22 carbon atoms increases too. We supposed that these can be penta- and hexaenoic fatty acids and in their quality may contribute to the decrease of the fat's melting point to a great extent. Paper chromatographically this hypothesis could not be stated unequivocally, but our recent gas chromatographic data justify this hypothesis. The 20 : 4 and 22 : 5 fatty acids originate from linoleic acid, the 20 : 5 and 22 : 6 fatty acids from the linolenic fatty acid by chain elongation and by dehydrogenation in divinyl-methane rhythm (MEAD 1960). The data of *Table 1* show that in crustaceans more fatty acid originates in the linolenic than in the linoleic acid.

Summary

The fatty acid compositions of the following crustaceans were determined: *Cyclops vicinus* ULJ., *Eudiaptomus gracilis* (G. O. SARS), *Daphnia cucullata* G. O. SARS, *Daphnia longispina* O. F. MÜLLER, *Simocephalus vetulus* V. F. M., *Bosmina longirostris* f. *pellucida* STINGELIN, *Gammarus (Rivulogammarus) roeseli* GERVAIS.

From the different species the same fatty acids could be demonstrated. The fatty acid composition of crustaceans is greatly similar to those published for fishes suggesting that the bulk of the fats in fishes originates in the crustacean plankton.

There was more C₂₂ polyunsaturated fatty acid in the investigated Copepods than in the Cladocerans. The changes in the quantity of oleic acid in the different samples are showing an inverse tendency to the quantity of C₂₂ polyunsaturated fatty acids.

Acknowledgement

We express our gratitude to Dr. J. PONYI for the species determination and for his helpful informations concerning crustaceans.

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NÉHÁNY ÉDESvíZI RÁK ZSÍRSÁV-ÖSSZETÉTELÉNEK GÁZKROMATOGRÁFIÁS ELEMZÉSE

Herodek Sándor és Farkas Tibor

Összefoglalás

A következő rákok zsírsav-összetételét határoztuk meg: *Cyclops vicinus* ULJ., *Eudiaptomus gracilis* (G. O. SARS), *Daphnia cucullata* G. O. SARS, *Daphnia longispina* O. F. MÜLLER, *Simocephalus vetulus* V. F. M., *Bosmina longirostris* f. *pellucida* STINGELIN, *Gammarus (Rivulogammarus) roeseli* GERVAIS.

A különböző fajokból ugyanazokat a zsírsavakat lehetett kimutatni. A rákok zsírsavösszetétele nagyban hasonlít a halakról közölt adatokhoz, ami arra utal, hogy a halak zsírsavainak zöme a crustacea planktonból származik.

A vizsgált Copepodákban több C₂₂ többszörösen telítetlen zsírsav volt, mint a Cladocerákban. Az egyes minták között az olajsav mennyisége a C₂₂ többszörösen telítetlen zsírsavak mennyiségével ellentétes irányban változik.

Köszönetnyilvánítás

Köszönetünket fejezzük ki dr. PONYI JENŐNEK a rákok meghatározásáért, és a rákokra vonatkozó hasznos felvilágosításaiért.

АНАЛИЗ СОСТАВА ЖИРНЫХ КИСЛОТ НЕКОТОРЫХ ПРЕСНОВОДНЫХ
РАКОВ ПОСРЕДСТВОМ ГАЗОВОЙ ХРОМАТОГРАФИИ

Шандор Херодек и Тибор Фаркаш

Состав жирных кислот определялся у следующих видов: *Cyclops vicinus* ULI, *Eudiaptomus gracilis* (G.O. Sars), *Daphnia cucullata* G.O. Sars, *Daphnia longispina* O.F. MÜLLER, *Simocephalus vetulus* V.F.M., *Bosmina longirostris* f. *pellucida* STINGELIN, *Gammarus (rivulogammarus) roeseli* Gervais.

У разных видов обнаруживается один и тот же состав жирных кислот. Состав жирных кислот раков совпадает с составом жирных кислот рыб, что указывает на то, что большая часть жирных кислот рыб происходит из планктонных ракообразных.

В копеподах было найдено больше C_{22} ненасыщенных жирных кислот чем в кладоцерах. В отдельных пробах содержание олеиновой кислоты изменялось обратно пропорционально количеству многократно-ненасыщенных жирных кислот.

HELMINTHOLOGICAL INVESTIGATIONS OF FISH IN LAKE BALATON I. (PRELIMINARY REPORT) TREMATODES

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Museum; Director: Dr. Z. KASZAB

Received: 22nd February, 1967

On the request of the Biological Research Institute of the Hungarian Academy of Sciences, Tihany, the staff of parasitologists of the Zoological Department of the Hungarian Natural History Museum, Budapest, undertook the project of investigating, in 1966, the worms parasitizing fish in Lake Balaton. The aim of the research program, planned for a number of years, is to obtain further data, by the examination of a great number of fish species, on the fauna parasitizing fishes, with special regard to the distribution per hosts, their infections and seasonal fluctuations.

The present paper submits the results of investigations carried out in the past year.

Studies were cordially supported by the director of the Biological Research Institute at Tihany, Dr. J. SALÁNKI, and the Department head of Hydrobiology, Dr. J. PONYI, as well as their assistants, for whose help thanks are rendered also in this place.

Material and methods

In 1966, fish specimens had been collected and dissected for parasitological investigations on three occasions: 28 June—3 July, 1966; 23—31 August, 1966; and 24—29 October, 1966.

During this time, 160 fish specimens have been examined of the following species: bream (*Abramis brama*), 40 exemplars; roach (*Rutilus rutilus*), 36 ex.; carp (*Cyprinus carpio*), 18 ex.; crucian-carp (*Carassius carassius*), 1 ex.; razor-fish (*Pelecus cultratus*), 10 ex.; balin (*Aspius aspius*), 2 ex.; pike-perch (*Lucioperca lucioperca*), 15 ex.; Volga pike-perch (*Lucioperca volgensis*), 5 ex.; perch (*Perca fluviatilis*), 8 ex.; pike (*Esox lucius*), 14 ex.; European wels (*Silurus glanis*), 4 ex.; bleak (*Alburnus alburnus*), 7 ex.

The collected worms have been preserved, pending further investigations, in 70 per cent alcohol and HEIDENHAIN's "Susa" fixative, respectively. Trematodes have been stained by alcoholic borax-carmin, and embedded in Canada balsam.

Distribution of parasitization of the diverse fish species

Of the 160 examined fish specimens, 128 exemplars were parasitized by digenetic Trematodes, Nematodes, Cestods, or Acanthocephalae.

Total parasitization may be broken down as to species in the following pattern:

Abramis brama: 87.5%, *Rutilus rutilus*: 94.4%, *Cyprinus carpio*: 61.1%, *Pelecus cultratus*: 30%, *Lucioperca lucioperca*: 93.3%, *Lucioperca volgensis*: 100%, *Perca fluviatilis*: 100%, *Silurus glanis*: 50%, *Esox lucius*: 92.8%, *Alburnus alburnus*: 14.2%.

Digenetic flukes

Concerning the Trematodes of the fish in Lake Balaton, the first report was given by RÁTZ (1897). JACZÓ (1941) recorded two monogenetic fluke species, and a digenetic fluke larva (1949), from Lake Balaton. Of the digenetic fluke larvae of the lake, MÖDLINGER discussed (1934) the biology of *Apophallus donicus*.

Recently, MOLNÁR (1962a, b; 1963; 1964; 1966) gave detailed accounts of the flukes occurring in fish living in the Balaton.

In the course of the present study, the following fluke species have been demonstrated:

Subclass I: Aspidogastrea FAUST et TANG, 1907

Family: Aspidogastridae POCHE, 1907

Aspidogaster limacoides DIES., 1835

Host: *Abramis brama*

Date of collection: 28 June—24 October, 1966

Localization: small intestine

Host: *Rutilus rutilus*

Date of collection: 28 June—23 August, 1966

Localization: small intestine

Host: *Cyprinus carpio*

Date of collection: 24 October, 1966

Localization: small intestine

Subclass II: Gasterostomata SKRJABIN et SCHULZ, 1937

Family: Bucephalidae POCHE, 1907

Bucephalus polymorphus BAER, 1827

Host: *Lucioperca lucioperca*

Date of collection: 28 June—24 October, 1966

Host: *Lucioperca volgensis*

Date of collection: 24 October, 1966

Localization: pyloric appendages, small intestine

Rhipidocotyle illense (ZIEGLER, 1883)

Host: *Lucioperca lucioperca*

Date of collection: 28 June—24 October, 1966

Host: *Lucioperca volgensis*

Date of collection: 24 October, 1966

Localization: pyloric appendages, small intestine

Subclass III: Prosostomata ODHNER, 1905

Family: Azygiidae ODHNER, 1911

Azygia lucii (MÜLLER, 1776)

Host: *Esox lucius*

Date of collection: 28 June—24 October, 1966

Localization: gaster, intestine

Host: *Perca fluviatilis*

Date of collection: 24 October, 1966

Localization: gaster

Family: Monorchidae ODHNER, 1911

Asymphyiodora imitans (MÜHLING, 1898)

Host: *Abramis brama*

Date of collection: 28 June—23 August, 24 October, 1966

Localization: intestine

Family: Opecoelidae OZAKI, 1925

Crowcrocoecum skrjabini (IWANITZKY, 1928)

Host: *Pelecus cultratus*

Date of collection: 28 June, 1966

Localization: intestine

Host: *Lucioperca lucioperca*

Date of collection: 24 October, 1966

Host: *Lucioperca volgensis*

Date of collection: 24 October, 1966

Localization: pyloric appendages

Family: Diplostomatidae Poirier, 1886

Diplostomum spathaceum (RUD., 1819), *metacercaria*

Host: *Abramis brama*

Date of collection: 28 June—24 October, 1966

Host: *Rutilus rutilus*

Date of collection: 28 June—23 August—24 October, 1966

Host: *Cyprinus carpio*

Date of collection: 23 August—24 October, 1966

Host: *Carassius carassius*

Date of collection: 28 June, 1966

Localization: crystalline lens of eye

Tylodelphis conifera (MEHLIS, 1864), *metacercaria*

Host: *Abramis brama*

Date of collection: 24 October, 1966

Host: *Rutilus rutilus*

Date of collection: 23 August—24 October, 1966

Localization: eye—vitreous body

Summary

The present paper discusses the results of the helminthological examination of 160 specimens of 12 fish species of Lake Balaton, as well as the extensivity of parasitization per fish species and the collected digenetic Trematode taxa.

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A BALATONI HALAK HELMINTOLÓGIAI VIZSGÁLATA. I

(Előzetes közlemény)

Trematodák

Matskási István

Összefoglalás

A szerző előzetes közleményben ismerteti 12 fajhoz tartozó 160 db balatoni hal helmintológiai vizsgálatának eredményét, a fertőzőtség extenzitását halfajok szerint, valamint a talált digenetikus Trematoda fajokat.

ГЕЛЬМИНТОЛОГИЧЕСКОЕ ИССЛЕДОВАНИЕ БАЛАТОНСКИХ РЫБ. I
(ПРЕДВАРИТЕЛЬНОЕ СООБЩЕНИЕ)

Иштван Мачкаши

Автор предварительно сообщает результаты гельминтологического исследования 160 балатонских рыб, относящихся к 12 видам, по экстенции зараженности отдельных видов а также описывает обнаруженный дигенетический вид трематода.

HELMINTHOLOGICAL INVESTIGATIONS OF FISH IN LAKE BALATON I. (PRELIMINARY REPORT) NEMATODES

FERENC MÉSZÁROS

Zoological Department of the Hungarian Natural History Museum

Director: Dr. Z. KASZAB

Received: 22nd February, 1967

The project of the complex biological study of Lake Balaton also provided for helminthological investigations in 1966. The present paper, submitting the elaboration of the collected nematode material, represents a general, informative report on the series of research studies planned for several years.

The first data with respect to the fish parasite fauna of Lake Balaton were given by RÁTZ (1897). He reported on the occurrence of *Camallanus lacustris*, by the name *Cucullanus elegans* ZEDER, in the intestine of *Perca fluviatilis*, *Lucioperca lucioperca*, *Esox lucius*, *Rutilus rutilus*, and *Acerina schraetzer*, as well as the species *Philometra sanguinea* (RUD., 1819), under the name *Ichthyonema sanguinea* RUD., from *Abramis brama*. MOLNÁR (1962) reported on two species from Lake Balaton, new for our fauna, namely *Camallanus truncatus* (RUD.) from *Lucioperca lucioperca* and *Aspius aspius*, and *Philometra rischta* SKRJABIN, 1917, from the gill flap and orbital cavity of *Alburnus alburnus*. In his recent papers, MOLNÁR (1966a, b) discussed the parasites, belonging to the genera *Philometra* and *Skrjabillanus*, of our home fish species; the same author (1966c) also studied, among others, the seasonal changes of *Camallanus lacustris* and *C. truncatus*.

Material and methods

Originating from two points of Lake Balaton (the Tihany—Füred bay, Siófok), a total of 160 fish specimens, collected on three occasions, have been examined, namely: pike (*Esox lucius*), roach (*Rutilus rutilus*), balin (*Aspius aspius*), bleak (*Alburnus alburnus*), bream (*Abramis brama*), razor-fish (*Pelecus cultratus*), crucian-carp (*Carassius carassius*), carp (*Cyprinus carpio*), European wels (*Silurus glanis*), pike-perch (*Lucioperca lucioperca*), Volga pike-perch (*Lucioperca volgensis*), and perch (*Perca fluviatilis*).

The nematodes were fixed in Barbagallo solution, and cleared up by lactic acid for identification.

Identifications were based on MARKEVICH's (1951), BYKHOVSKY's (1962), and AGAPOVA's (1966) works.

Results

Of the twelve investigated fish species, seven were found to harbour Nematode parasites. *Table 1* shows the rate of infection of the examined fish species.

Table 1 — 1. Táblázat
Rate of infection of the fish species examined
A fertőzöttség mértéke a vizsgált halaknál

Fish species — Halfajok	Number of examined specimens Vizsgált példányok száma	Number of parasitized specimens Fertőzött példányok száma	Percentage of extensity Extenzitás százaléka
<i>Abramis brama</i>	41	7	17
<i>Alburnus alburnus</i>	7	—	—
<i>Aspius aspius</i>	2	—	—
<i>Carassius carassius</i>	1	—	—
<i>Cyprinus carpio</i>	18	—	—
<i>Esox lucius</i>	14	8	57.1
<i>Lucioperca lucioperca</i>	14	14	100
<i>Lucioperca volgensis</i>	5	5	—
<i>Pelecus cultratus</i>	10	1	10
<i>Perca fluviatilis</i>	8	8	—
<i>Rutilus rutilus</i>	36	1	2.7
<i>Silurus glanis</i>	4	—	—
Total — Összesen	160	44	27,5

Six nematode species have been identified in the examined fish species. They are as follows: *Camallanus lacustris*, *C. truncatus*, *Raphidascaris acus*, *Philometra ovata*, *Capillaria* sp., *Contracaecum* sp. larva.

The occurrence of the nematodes is given in *Table 2*.

Table 2 — 2. Táblázat
Nematodes occurring in the fish species
Nematodák előfordulása a halakban

Fish species Nematode	<i>Abramis brama</i>	<i>Esox lucius</i>	<i>Lucioperca lucioperca</i>	<i>Lucioperca volgensis</i>	<i>Pelecus cultratus</i>	<i>Perca fluviatilis</i>	<i>Rutilus rutilus</i>
<i>Camallanus lacustris</i>					+	+	
<i>Camallanus truncatus</i>	+	+	+	+		+	
<i>Raphidascaris acus</i>		+					
<i>Philometra ovata</i>	+						+
<i>Capillaria</i> sp.	+						
<i>Contracaecum</i> sp. larva	+						

Camallanus lacustris (ZOEGER, 1776)Hosts: *Perca fluviatilis*, *Pelecus cultratus*

Localization: gaster, intestine

Length of males: 3—4.2 mm, length of females: 5.2—7.4 mm; width: 0.12—0.17 mm and 0.19—0.26 mm, respectively. Buccal capsule yellowish-brown, chitinous, 0.094—0.105 mm in males, and 0.10—0.142 mm in females, ribbed. Number of ribs is generally 25. Two sides of buccal capsule with a trident-shaped chitinous process each.

Length of median branch 0.06—0.07 mm in males, 0.10—0.12 mm in females. The trident-like chitinous process failing to reach half distance between buccal capsule and nerve ring. Esophagus consisting of a shorter, muscular (0.373—0.380 mm in males, 0.46—0.76 mm in females), and a longer, glandular (0.48—0.52 mm in males, 0.70—0.81 mm in females) section.

Caudal portion of males with narrow alae and 7 pairs of pre-, and 5 pairs of postcloacal, papillae. Measurements of the two different sized spicula 0.09—0.11 mm and 0.19—0.26 mm. Gubernaculum absent.

Vulva opening in middle (or slightly behind) of body. Viviparous. Length of larvae: 0.39—0.43 mm.

In the course of examinations, this species was found to occur together with *C. truncatus* in *Perca fluviatilis*. *C. lacustris* was found by MOLNÁR (1962) also in *Lucioperca volgensis* and *Acerina cernua*. The intensity of infection is 9—38 specimens per fish individual.

Camallanus truncatus (RUDOLPHI, 1814)

Hosts: *Abramis brama*, *Esox lucius*, *Lucioperca lucioperca*, *L. volgensis*, *Perca fluviatilis*. MOLNÁR (1962) found it also in *Aspius aspius*.

Localisation: gaster, intestine, pyloric appendages.

Similar to the preceding species, but differing in the branches of the trident-like process subtending a smaller angle with one another, the branches extending also beyond the half length of the distance between the buccal capsule and the nerve ring.

Length of males: 2.70—4.80 mm, length of females: 3.80—10.60 mm. Length of buccal capsule: 0.078—0.083 mm in males, 0.077—0.130 mm in females. Median branch of trident-shaped chitinous process 0.097—0.10 mm and 0.077—0.13 mm, respectively for the two sexes. Muscular portion of esophagus 0.48—0.52 mm and 0.58—0.62 mm, while glandular portion 0.45—0.58 mm and 0.62—0.82 mm, respectively for the two sexes.

The most commonly occurring nematode species in the examined fish species. The intensity of the infection is the highest in *Lucioperca volgensis*, the maximum being 41 nematodes in one fish exemplar; it is the smallest in *Esox lucius*, 1—6 nematodes per specimen.

Raphidascaris acus (BLOCH, 1779) RAILLIET et HENRY, 1915

Host: *Esox lucius*

Localisation: gaster

The length of the single examined specimen is 19.2 mm. Cuticle transversally ringed. A lateral wing behind lip, on anterior portion of body. Buccal aperture delimited by three lips (a dorsal and two latero-ventral ones). Esophagus 3.10 mm long, forming an appendix posteriorly, directed caudal. Caudal portion ventrally curved, with 17 pairs of pre- and 4 pairs of postanal papillae. Spicula uniform, 1.02 mm long.

As far as I know, the species has not yet been collected from a fish of Lake Balaton. In Hungary, it was first demonstrated by EDELÉNYI (1963) in *Esox lucius* and *Perca fluviatilis* originating from the Lake Fertő.

Philometra ovata (ZEDER, 1803)

Hosts: *Abramis brama*, *Rutilus rutilus*

Localisation: body cavity

MOLNÁR (1966 a) published a detailed description. The length of the specimens collected from *Abramis brama*, at the end of October, was 13.2—30.8 mm (females) and 2.2—2.3 mm (males). Intensity: 29—71 nematodes per fish specimen. Fishes surrendering *Philometra ovata* exemplars were infected by *Ligula*. There was a single exception: one *Philometra ovata* female (body length 16.8 mm) has been found in the body cavity of a *Rutilus rutilus*, captured on 24th October.

Contracaecum sp. larv.

Host: *Abramis brama*

Localisation: intestine

Capillaria sp.

Host: *Abramis brama*

Localisation: intestine

Of the two latter species, only a single individual was found each; I was unable to identify them as to species.

Summary

In the course of examination of 160 fish specimens representing 12 species, 6 nematodes have been demonstrated. Of these, *Raphidascaris acus* has not yet been reported from Lake Balaton. The other species reported are: *Camallanus lacustris*, *C. truncatus*, *Philometra ovata*, *Contracaecum* sp. larv., *Capillaria* sp.

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A BALATONI HALAK HELMINTOLÓGIAI VIZSGÁLATA I (előzetes közlemény) nematodák

Mészáros Ferenc

Összefoglalás

12 fajhoz tartozó 160 hal vizsgálata során 6 Nematoda fajt állapítottam meg. Ezek közül a *Raphidascaris acus* fajt a Balatonból még nem írták le. További vizsgált fajok: *Camallanus lacustris*, *Camallanus truncatus*, *Philometra ovata*, *Contracaecum* sp. larv., *Capillaria* sp.

ГЕЛЬМИНТОЛОГИЧЕСКОЕ ИССЛЕДОВАНИЕ БАЛАТОНСКИХ РЫБ I (ПРЕДВАРИТЕЛЬНОЕ СООБЩЕНИЕ)

Ференц Месарош

В ходе исследования 160 экземпляров рыб, относящихся к 12 видам, было обнаружено 6 видов Nematoda. Из них *Raphidascaris acus* был найден впервые в Балатоне. Остальные выявленные виды: *Camallanus lacustris*, *Camallanus truncatus*, *Philometra ovata*, *Contracaecum* sp. larv., *Capillaria* sp.

STUDIEN ÜBER DAS CRUSTACEEN-PLANKTON DES BALATON III. BEITRÄGE ZUR SYSTEMATIK UND CYCLOMORPHOSE VON ACANTHO- CYCLOPS VERNALIS (FISCHER), 1853

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Im Laufe der im Jahre 1965 durchgeführten Schlammuntersuchungen (PONYI, 1966) haben wir das im Balaton bisher nicht mit Bestimmtheit erwiesene Vorkommen des Copepoden *Acanthocyclops vernalis vernalis* (FISCHER) 1853 sowie dessen Unterart, *A. vernalis robustus* (SARS) 1863 festgestellt. Bisher hatten wir die genannte Art und Unterart im Schlamme des offenen Wassers der Bucht von Keszthely beobachtet. Die Art bzw. Unterart betrug etwa 5% der reichen Crustaceen-Gemeinschaft.

Gelegentlich der Untersuchung des im selben Jahre gesammelten Crustaceen-Planktons haben wir mit Überraschung beobachtet, daß der genannte Copepode sich im Sommer als dominant erwies. Beim Studium der großen Menge des Tiermaterials stellte es sich heraus, daß wir die Art und ihre Unterart nicht eindeutig voneinander auseinanderhalten konnten (die Unterart soll laut einiger Forscher eine selbständige Art darstellen).

Die Streitfrage bezüglich der genannten Arten ist nicht neuesten Datums, die Anfänge reichen bis zu den 1890er Jahren zurück. SARS beschrieb (1863) eine dem *Acanthocyclops vernalis* nahestehende Art unter der Bezeichnung *Cyclops robustus* cit. ap. SARS 1913). In den nachfolgenden Jahren erschienen (1895—1927) zahlreiche Studien (ausführlich bei LOWNDES, 1929), welche größtenteils (z. B. KIEFER, ROY, SARS, THALLWITZ) ein Bestehen der genannten Art erhärteten, andere wieder (z. B. SCHMEIL, MARSH) sie bloß als Varietät anerkannten. LOWNDES (1929) erklärte auf Grund seiner an gezüchteten Exemplaren vorgenommenen Untersuchungen, daß »*Cyclops robustus* SARS is not a separate species but only a form of *Cyclops vernalis* FISCHER«. Später wird dieselbe z. B. bei WAGLER (1937) in seinem Handbuch als selbständige Art erwähnt.

Die Frage »*vernalis* — *robustus*« ist auch heute noch nicht genügend geklärt, hierfür bringen wir einige Beispiele aus der neueren Fachliteratur: 1948. RYLOW sieht in »*robustus*« bloß eine Varietät von »*vernalis*«.

1950. LINDBERG hält sie bloß für eine Form.

1954. ŠRÁMEK—HUŠEK stellen eine neue Kombination auf und erwähnen ein »*Acanthocyclops robustus* f. *vernalis*«.

1960. KIEFER hält »*robustus*« als selbständige Art in Evidenz.

1963. DAMIAN-GEORGESCU erkennen sie als Unterart an.

Wir selbst haben sie — unter dem Eindruck der fortwährend wechseln-

den Auffassung — (PONYI E. J. und L. PONYI 1961) am Anfang als Varietät behandelt, später jedoch (PONYI, 1966) als Unterart.

Ziel der vorliegenden Studie ist es, auf Grund einer eingehenden Analyse zu einer endgültigen Klärung der Artenzugehörigkeit von »*vernalis*« und »*robustus*« beizutragen. Zwei Umstände motivieren die Berechtigung einer Untersuchung:

a) Das Tier trat als dominierendes Mitglied des in der Bucht von Keszthely vorkommenden Crustaceen-Planktons auf; also müssen wir bei den quantitativen Untersuchungen darüber im klaren sein, ob es sich um eine oder um zwei Arten (oder um sonstige systematische Kategorien) handelt;

b) Ohne eine genaue Artenbestimmung ist es uns unmöglich, die in den Crustaceen-Gemeinschaften vorkommenden eventuellen Veränderungen in entsprechender Weise zu verfolgen.

Einsammlung des Tiermaterials und Methodik

Die Sammlungen wurden in der Bucht von Keszthely mittels eines Planktonnetzes Nr. 6 am 8. Juni, 30. Juli, 2. August und 12. Oktober 1965 zwischen 21—22 Uhr von einem Ruderboot aus, aus einer mittleren Tiefe von anderthalb Metern, durchgeführt. Zu einer eingehenden Analyse nahmen wir das am 8. Juni, 2. August und 12. Oktober gesammelte Material vor, um auch Angaben über die saisonalen Veränderungen der Krebse zu gewinnen.

Aus den Proben wurden die zu einer Untersuchung bestimmten Exemplare auf folgende Weise gewonnen:

Ein Teil des Inhaltes einer aufgeführten Probe wurde in eine mit quadratischer Einteilung versehene Schale gefüllt und die geschlechtsreifen Exemplare wurden, der Reihe nach ohne Wahl herausgehoben. Die Tierchen wurden in Glycerin gelegt, sodann einzeln auseinander präpariert. Bei einem Teil wurden die Beine (P_1 — P_5) und das Postabdomen gesondert auf den Objektträger gesetzt — zur Dokumentierung der Untersuchungen — und daraus Dauerpräparate angefertigt. Bei den zu diesem Zwecke verwendeten Exemplaren wurde ebenfalls keine Selektion vorgenommen. Auf diese Weise wurden 24 weibliche und 22 männliche Exemplare aufgearbeitet, deren Angaben wir in zwei Tabellen zusammenstellten. Darüber hinaus haben wir noch cca 50 Tierchen untersucht (Weibchen und Männchen gemischt), welche die nachstehend aufgezählten Ergebnisse bestätigten. Unsere Untersuchungen beschränkten sich auf die Gliedmaßen P_1 — P_4 , wobei auch auf die innerhalb eines und desselben Beinpaars vorkommende Variabilität Bedacht genommen wurde, da nach den bisherigen Angaben der Unterschied zwischen den beiden Arten (»*robustus*« — »*vernalis*«) nach den hier gefundenen Angaben und Zeichen (Anzahl der Borsten und Dornen, deren Qualität, Beschaffenheit usw.) beurteilt wird.

Ergebnisse und Folgerungen

Die Ergebnisse sind in *Tab. 1* und *2* zusammengefaßt und mit Zeichnungen und Abbildungen der Präparate ergänzt (*Tafel. 1, 2.*).

Vorerst wollen wir feststellen, daß die Dornenformel in der Mehrzahl der Fälle 3444 beträgt. Wir haben jedoch ebenso wie LOWNDES (1929) bei demselben Individuum Abweichungen beobachtet:

$$\text{z. B. } \frac{3443}{3444}, \frac{3442}{3444}, \frac{2343}{2333}.$$

Früher wurden bei der Sonderung von »*vernalis*« und »*robustus*« gerade die in der Dornenformel enthaltenen Verschiedenheiten als wichtigstes Zeichen angesehen. Bei *vernalis* wurde 2333, bei *robustus* 3444 festgesetzt.

Heute werden die obigen Formeln, — eben infolge der großen Variabilität der Dornen — von der Mehrzahl der Forscher nicht mehr als Charakteristika der in Rede stehenden Art angenommen. In Bestimmungstabellen treffen wir sie, wenn auch seltener, auch heute noch an (z. B. bei KIEFER, 1960).

Desgleichen kommt der sogenannten Borstenformel ebenfalls eine große Bedeutung zu, deren Anzahl wir für alle vier Beinpaare als beständig gefunden haben. Dagegen haben wir hinsichtlich der Gestaltung (Struktur und Form) in Übereinstimmung mit LOWNDES (1929) und THALLWITZ (1926) große Variabilität beobachten können. Einige Borsten — insbesondere die an den äußeren Endopodit-Rändern bzw. die P_2 und P_3 Endopoditspitzen (terminale Borsten) stehenden — haben sich zu vollständigen Dornen entwickelt. Doch auch im allgemeinen haben wir zwischen den Dornen- und Borstenformeln mehrere Übergangsformen beobachtet. Am häufigsten kamen zwei Varietäten vor (Tafel 1, 2.).

Zumal die Dornenformel der beiden genannten Arten ihre in der Differentialdiagnose eingenommene Rolle verloren hatte, legten die Copepoden-Forscher immer mehr Gewicht auf die Beschaffenheit der am Außenrande des 3. Gliedes der Endopodite P_4 , P_3 und P_2 befindlichen Formel (ob Dorn oder Borste!). SARS (1913) fand diese bei »*robustus*« als Dornen und erwähnt sie als wesentliche Verschiedenheit gegenüber »*vernalis*«. Demgegenüber beobachteten wir daß bei unseren Individuen, und zwar ebenso bei Männchen wie bei Weibchen, die Dornen in der Frühjars- bzw. Herbstperiode erscheinen, die Borsten dagegen sowie die Übergangsformen in der Mehrzahl der Fälle im Sommer anzutreffen sind. Diese Erscheinung läßt sich bei den Männchen schärfer beobachten als bei den Weibchen (Tab 1. und 2.). Wir wollen besonders darauf aufmerksam machen, daß die in Rede stehende Formel des Endopodites P_2 im Sommer stets als Borste erscheint und bloß in den kühleren Jahreszeiten modifizierte Formen aufweist.

Für die Variabilität der Borsten der Exopodite P_2 — P_4 gilt im wesentlichen dasselbe. In den kühleren Jahreszeiten (Frühjahr und Herbst) können mehr, in der wärmeren Jahreszeit (im Sommer) weniger oder überhaupt keine Borstenveränderungen beobachtet werden.

Die zur selben Zeit lebenden Tiere kommen im allgemeinen nicht als reine »*vernalis*«- bzw. »*robustus*«-Formen vor, da die Lebensdauer der Copepoden verhältnismäßig lang ist (so kann z. B. *Acanthocyclops viridis* (JUR.) 8—14 Monate lang am Leben bleiben). Es wurde auch beobachtet, daß die Lebensdauer der Männchen wesentlich kürzer als die der Weibchen ist (KIEFER, 1960). Aus diesem Umstand läßt es sich erklären, daß die jahreszeitliche Veränderung bei den Männchen deutlicher beobachtet werden kann als bei den Weibchen.

Früher wurde auch die Cyclomorphose eines anderen Copepoden (*Eudiaptomus gracilis* SARS) beobachtet. In diesem Falle war die jahreszeitliche Veränderung bedeutend geringer; ein Außerachtlassen dieses Umstandes bei den Weibchen führte oft zu falschen Artbestimmungen (WOYNÁROVICH, 1938).

Tabelle 1

Variabilität der ♀♀ Beinborsten und Beindornen von *Acanthocyclops*Az *Acanthocyclops vernalis* (FISCHER) ♀♀ lábsertéinek

Datum der Sammlung und Proben-Nr. Gyűjtés ideje és minta száma	Präparat-Nr. Preparátum száma	Dornformel Tuskeképlet	Borsten — Serte —									
			P ₁					P ₂				
			Exopodit		Endopodit			Exopodit		Endopodit		
					innerer Rand belső szegély					innerer Rand belső szegély		
			Borste — serte	modifizierte Borste módosult serté	Borste — serte	modifizierte Borste módosult serté	äußerer Rand külső szegély	Borste — serte	modifizierte Borste módosult serté	Borste — serte	modifizierte Borste módosult serté	äußerer Rand külső szegély
8. VI. (Nr. 1001)	23/28—31	3444	1 1 4	—	1 2 4	—	Borste serte	1 1 4	—	1 2 3		Borste serte 1
	24/34—37	3444	1 1 4	—	1 2 4	—	Borste serte	1 1 4	—	1 2 4	—	Borste serte
	25/40—43	3444	1 1 4	—	1 2 4	—	Borste serte	1 1 4	—	1 2 4	—	Borste serte
	26/46—49	3444	1 1 4	—	1 2 4	—	Borste serte	1 1 3	1	1 2 4	—	Borste serte
	27/52—55	3444	1 1 4	—	1 2 4	—	Borste serte	1 1 3	1	1 2 3	1	B. D. s. t.
2. VIII. (Nr. 1074)	28/58—61	3444	1 1 4	—	1 2 4	—	Borste serte	1 1 4	—	1 2 3	1	Borste serte
	1/3—6	3444	1 1 4	—	1 2 4	—	Borste serte	1 1 4	—	1 2 4	—	Borste serte
	2/9—12	3444	1 1 4	—	1 2 4	—	Borste serte	1 1 4	—	1 2 4	—	Borste serte
	3/15—18	3444	1 1 4	—	1 2 4	—	Borste serte	1 1 4	—	1 2 4	—	Borste serte
	4/21—24	3444	1 1 4	—	1 2 4	—	Borste serte	1 1 4	—	1 2 4	—	Borste serte

1. táblázat

vernalis (FISCHER) in den verschiedenen Jahreszeiten

tüskéinek és változékonysága az év különböző időszakában

Verhältnisse viszonyok										Anmerkung — Megjegyzés
P_3					P_4					
Exopodit		Endopodit			Exopodit		Endopodit			
		innerer Rand belső szegély		äußerer Rand külső szegély			innerer Rand belső szegély		äußerer Rand külső szegély	
Borste — serte	modifizierte Borste módosult serté	Borste — serte	modifizierte Borste módosult serté		Borste — serte	modifizierte Borste módosult serté	Borste — serte	modifizierte Borste módosult serté		
1 1 1(2)		1 2 1	3	B. D. s. t.	1 1 0	4	1 1 0	2	Dorn tüske	s. f. robustus
1 1 2	2	1 2 2	2	B. D. s. t.	1 1 0	4	1 1 0	1 2	Dorn tüske	s. f. robustus
1 1 4(3)	(1)	1 2 3	1	B. D. s. t.	1 1 2	2	1 2 0(1)	2(1)	Dorn tüske	s. f. robustus
1 1 2	2	1 2 1	3	B. D. s. t.	1 1 0	4	1 1 0	1 2	Dorn tüske	s. f. robustus
1 1 1(2)	3(2)	1 2 0	4	Dorn tüske	1 1 0	4	1 0 0	2 2	Dorn tüske	s. f. robustus
1 1 3(2)	1(2)	1 2 2	2	B. D. s. t.	1 1 1	3	1 2 0	2	B. D. s. t.	Übergangsform átmeneti forma
1 1 3	1	1 2 4	—	Borste serte	1 1 3	1	1 2 1	1	B. D. s. t.	s. f. vernalis
1 1 3	1	1 2 3	1	Borste serte (B. D.) (s. t.)	1 1 3	2	1 2 1	1	B. D. s. t.	Übergangsform átmeneti forma
1 1 4	—	1 2 4	—	Borste serte	1 1 4	—	1 2 2	—	Borste serte	s. f. vernalis
1 1 4	—	1 2 4	—	Borste serte	1 1 4	—	1 2 2	—	Borste serte	s. f. vernalis

Tabelle 1 (Fortsetzung)

Datum der Sammlung und Proben-Nr.
Gyűjtés ideje és minta száma

2. VIII. (Nr. 1074).

12. X. (Nr. 1153)

Präparat-Nr. Preparátum száma	Dornformel Tuskeképlet	Borsten Serte	Borste — serte	modifizierte Borste módosult serte	Borste — serte	modifizierte Borste módosult serte	äußerer Rand külső szegély	Borste — serte	modifizierte Borste módosult serte	Borste — serte	modifizierte Borste módosult serte	äußerer Rand külső szegély
		P ₁										
		Exopodit		Endopodit				Exopodit		Endopodit		
		Borste — serte	modifizierte Borste módosult serte	Borste — serte	modifizierte Borste módosult serte	äußerer Rand külső szegély		Borste — serte	modifizierte Borste módosult serte	Borste — serte	modifizierte Borste módosult serte	äußerer Rand külső szegély
5/27—30	3444	1 1 4	—	1 2 4	—	Borste serte		1 1 4	—	1 2 4	—	Borste serte
11/58—61	3444	1 1 4	—	1 2 4	—	Borste serte		1 1 4	—	1 2 4	—	Borste serte
12/64—67	3444	1 1 4	—	1 2 4	—	Borste serte		1 1 4	—	1 2 4	—	Borste serte
13/70—73	3444	1 1 4	—	1 2 4	—	Borste serte		1 1 4	—	1 2 4	—	Borste serte
14/76—79	3443	1		1		Borste		1		1		Borste
	3444	1 4	—	2 4	—	serte		1 4	—	2 4	—	serte
15/82—85	3444	1 1 4	—	1 2 4	—	Borste serte		1 1 4	—	1 2 4	—	Borste serte
16/88—91	3444	1 1 4	—	1 2 4	—	Borste serte		1 1 4	—	1 2 4	—	Borste serte
17/94—97	3444	1 1 4	—	1 2 4	—	Borste serte		1 1 4	—	1 2 4	—	Borste serte
35/3—6	3444	1 1 4	—	1 2 4	—	Borste serte		1 1 4	—	1 2 4	—	Borste serte
36/9—12	3444	1 1 4	—	1 2 4	—	Borste serte		1 1 3	1	1 2 3	1	B. D. s. t.
37/15—18	3444	1 1 4	—	1 2 4	—	Borste serte		1 1 4(3)	(1)	1 2 3	1	B. D. s. t.

1. táblázat (folytatás)

Verhältnisse viszonyok											Anmerkung — Megjegyzés
P ₃					P ₄						
Exopodit		Endopodit			Exopodit		Endopodit				
		innerer Rand belső szegély		äußerer Rand külső szegély			innerer Rand belső szegély		äußerer Rand külső szegély		
Borste — serte	modifizierte Borste módosult serté	Borste — serte	modifizierte Borste módosult serté		Borste — serte	modifizierte Borste módosult serté	Borste — serte	modifizierte Borste módosult serté		Borste — serte	
1 1 4	—	1 2 4(3)	(1)	Borste serte	1 1 2	— 2	1 2 1	1	B. D. s. t.	s. f. vernalis	
1 1 3	1	1 2 3	1	B. D. s. t.	1 1 2	2	1 2 0	2	B. D. s. t.	Übergangsform átmeneti forma	
1 1 4	—	1 2 4	—	Borste serte	1 1 4	—	1 2 2	—	Borste serte	s. f. vernalis	
1 1 3	1	1 2 3	1	B. D. s. t.	1 1 2	2	1 2 1	1	B. D. s. t.	Übergangsform átmeneti forma	
1 1 4(3)	(1)	1 2 3	1	Borste serte	1 1 2	2	1 2 1	1	B. D. s. t.	s. f. vernalis	
1 1 3	1	1 2 3	1	B. D. s. t.	1 1 2	2	1 2 1	1	Dorn tüske	s. f. robustus	
1 1 3	1	1 2 3	1	Borste serte	1 1 2	2	1 2 1	1	B. D. s. t.	s. f. vernalis	
1 1 4	—	1 2 4(3)	(1)	Borste serte	1 1 3	1	1 2 2(1)	(1)	B. D. s. t.	s. f. vernalis	
1 1 2	2	1 2 2	2	B. D. s. t.	1 1 1	3	1 1 0	1 2	B. D. s. t.	Übergangsform átmeneti forma	
1 1 1	3	1 2 0	4	B. D. s. t.	1 0 0	1 4	1 0 0	2 2	Dorn tüske	s. f. robustus	
1 1 2	2	1 2 2	2	B. D. s. t.	1 1 1	3	1 1 0	1 2	Dorn tüske	s. f. robustus	

Tabelle 1 (Fortsetzung)

12. X. (Nr. 1153)	Datum der Sammlung und Proben-Nr. Gyűjtés ideje és minta száma	Präparat-Nr. Preporátum száma	Dornformer Tuskeképlet	Borsten — Serte —									
				P_1					P_2				
				Exopodit		Endopodit			Exopodit		Endopodit		
						innerer Rand belső szegély					innerer Rand belső szegély		
				Borste — serte	modifizierte Borste módosult serte	Borste — serte	modifizierte Borste módosult serte		äußerer Rand külső szegély	Borste — serte	modifizierte Borste módosult serte	Borste — serte	
38/21—24	3442 3444	1 1 4	—	1 2 4	—	Borste serte	1 1 4(3)	(1)	1 2 3	1	B. D. s. t.		
39/27—30	3444	1 1 4	—	1 2 4	—	Borste serte	1 1 3	1	1 2 3	1	B. D. s. t.		
42/43—46	3444	1 1 4	—	1 2 4	—	Borste serte	1 1 4	—	1 2 3	1	B. D. s. t.		

- Erklärung: a) In den $P_1 - P_4$ Exopodit- und Endopodit-Rubriken untereinander geschriebene Zahlen beziehen sich auf die an den 1., 2., 3. Gliedern befindlichen Borsten.
- b) In den $P_1 - P_4$ Exopodit- und Endopodit-Rubriken zwischen Klammern befindliche Zahlen weisen auf die innerhalb desselben Beinpaars bestehenden Verschiedenheiten hin.
- c) B. D. (Borste-Dorn) bezeichnen die Übergangsform zwischen Borsten und Dornen.
- d) s. f. = saisonale Form.

In einer früheren Arbeit (PONYI 1965) haben wir uns mehr eingehend mit der Problematik der Cyclomorphose der pelagischen Organismen des Balaton befaßt. Deshalb wollen wir an dieser Stelle bloß erwähnen, daß diese Erscheinung zwar wohlbekannt, ihre Erklärung jedoch auch heute noch nicht eindeutig bestimmt ist. Einige Forscher führen den periodischen Formenwechsel auf den Wechsel in der Temperatur und der Viskosität des Wassers zurück, andere wieder erklären diesen aus den Vermehrungsverhältnissen. Neuestens wird eher der Wasserströmung erstrangige Bedeutung zugemessen. Wahrscheinlich ist es, daß ein jeder der genannten Umstände mehr oder weniger die Ausbildung dieser Erscheinung beeinflusst, doch können je nach der Beschaffenheit des Wassers und der Arten immer noch andere Umstände mit entscheidender Bedeutung auftreten. Im vorliegenden Falle kann die Formveränderung von *Acanthocyclops vernalis* nicht nur mit dem Temperaturwechsel, sondern auch mit dem Wechsel der Zahl der im Wasser in Menge schwelenden Algen in Zusammenhang gebracht werden.

Aus den in Tab. 3 mitgeteilten Angaben kann man natürlich keine weitgehenden Folgerungen ableiten. Doch erscheint es sicherlich zutreffend, daß

1. táblázat (folytatás)

Verhältnisse viszonyok										Anmerkung — Megjegyzés
P_3					P_4					
Exopodit		Endopodit			Exopodit		Endopodit			
		innerer Rand belső szegély					innerer Rand belső szegély			
Borste — serte	modifizierte borste módosult serté	Borste — serte	modifizierte borste módosult serté	äußerer Rand külső szegély	Borste — serte	modifizierte borste módosult serté	Borste — serte	modifizierte borste módosult serté	äußerer Rand külső szegély	
1 1 2	2	1 2 1	3	B. D. s. t.	1 1 0(1)	4(2)	1 1 0	1 1 2	Dorn tüske	s. f. robustus
1 1 2	2	1 2 1	3	B. D. s. t.	1 1 0	4	1 1 0	1 1 2	Dorn tüske	s. f. robustus
1 1 2	2	1 2 1	3	B. D. s. t.	1 1 1	3	1 1 0	1 1 2	Dorn tüske	s. f. robustus

Magyarázat: A $P_1 - P_4$ exopodit és endopodit rubrikákban egymás alá írt számok az 1., 2., 3. ízen található sertére vonatkoznak.
A $P_1 - P_4$ exopodit és endopodit rubrikákban ()-ben található számok az azonos lábpáron belüli különbözőségekre utalnak
s. t. (serte-tüske) = a serté és a tüske között átmenetet mutató képletek

nebst dem Wechsel in der Viskosität des Wassers auch die Algemasse von Chrysophyten einer 10–20 μ Größenordnung die Schwebeverhältnisse des Tierchen zu beeinflussen vermag.

Tabelle 3

Datum der Unter- suchung	Temperatur in $^{\circ}$ auf Grund eines Durch- schnittes von 14 Tagen*	Gesamte Algenzahl Stück/Lit (TAMÁS, 1967)	Chrysophyten Stück/Lit (TAMÁS, 1967)
8. VI	$17,5 \pm 0,2$	85 660	78 590
2. VIII	$22,6 \pm 1,2$	4 204 340	4 178 020
12. X	$16,3 \pm 1,6$	54 920	49 520

* 26. V.—8. VI; 20. VII—2. VIII; 29. IX—12. X.

2. táblázat

vernalis (FISCHER) in den verschiedenen Jahreszeiten
és tüskéinek változékonysága az év különböző időszakában

Verhältnisse
viszonyok

P_3					P_4				
Exopodit		Endopodit			Exopodit		Endopodit		
		innerer Rand belső szegély					innerer Rand belső szegély		
Borste — serte	modifizierte Borste módosult serte	Borste — serte	modifizierte Borste módosult serte	äußerer Rand külső szegély	Borste — serte	modifizierte Borste módosult serte	Borste — serte	modifizierte Borste módosult serte	äußerer Rand külső szegély

Anmerkung — Megjegyzés

1 1 2	2	1 2 0(1)	4(3)	B. D. s. t.	1 0 0	1 4	1 1 0	1 2	Dorn tüske	s. f. robustus
1 1 2	2	1 2 1(2)	3(2)	Dorn tüske	1 0 0	1 4	1 1 0	1 2	Dorn tüske	s. f. robustus
1 1 2	2	1 2 1	3	B. D. s. t.	1 1 0	1 4	1 1 0	1 2	Dorn tüske	s. f. robustus
1 1 3	1	1 2 3	1	B. D. s. t.	1 1 2	1 2 2	1 2 0	2	B. D. s. t.	Übergangsform átmeneti forma
1 1 3	1	1 2 3	1	B. D. s. t.	1 1 1	1 3	1 2 0	2	B. D. s. t.	Übergangsform átmeneti forma
1 1 2	2	1 2 1	3	Dorn tüske	1 1 0	1 4	1 1 0	1 2	Dorn tüske	s. f. robustus
1 1 4	—	1 2 4	—	Borste serte	1 1 4	—	1 2 2	—	Borste serte	s. f. vernalis
1 1 4	—	1 2 4	—	Borste serte	1 1 4	—	1 2 2	—	Borste serte	s. f. vernalis
1 1 4	—	1 2 4	—	Borste serte	1 1 2	2	1 2 2	—	Borste serte	s. f. vernalis
1 1 3	1	1 2 3(2)	1(2)	B. D. s. t.	1 1 1	1 3	1 2 0	2	B. D. s. t.	Übergangsform átmeneti forma

Tabella 2 (Fortsetzung)

Datum der Sammlung und Proben-Nr. Gyűjtés ideje és minta száma	Präparat-Nr. Preparátum száma	Dornformel Tűskeképlet	Borsten — Serte —									
			P ₁					P ₂				
			Exopodit		Endopodit			Exopodit		Endopodit		
					innerer Rand belső szegély					innerer Rand belső szegély		
			Borste — serte	modifizierte Borste módosult serte	Borste — serte			modifizierte Borste módosult serte	äußerer Rand külső szegély	Borste — serte		
2. VIII. (Nr. 1074)	10/52—55	3444	1 1 4	—	1 2 4	—	Borste serte	1 1 4	—	1 2 4	—	Borste serte
	18/2—5	3444	1 1 4	—	1 2 4	—	Borste serte	1 1 4	—	1 2 4	—	Borste serte
	19/7—10	3444	1 1 4	—	1 2 4	—	Borste serte	1 1 4	—	1 2 4	—	Borste serte
	20/12—15	3444	1 1 4	—	1 2 4	—	Borste serte	1 1 4	—	1 2 4	—	Borste serte
	21/17—20	3444	1 1 4	—	1 2 4	—	Borste serte	1 1 4	—	1 2 4	—	Borste serte
	22/22—25	3444	1 1 4	—	1 2 4	—	Borste serte	1 1 4	—	1 2 4	—	Borste serte
12. X. (Nr. 1153)	40/32—35	3444	1 1 4	—	1 2 4	—	Borste serte	1 1 4	—	1 2 3	1	Borste serte
	41/37—40	3444	1 1 4	—	1 2 4	—	Borste serte	1 1 4	—	1 2 3	1	B. D. s. t.
	43/48—51	3444	1 1 4	—	1 2 4	—	Borste serte	1 1 4	—	1 2 3	1	Borste serte
	44/53—56	3444	1 1 4	—	1 2 4	—	Borste serte	1 1 4	—	1 2 4	—	Borste serte
	45/58—61	3444	1 1 4	—	1 2 4	—	Borste serte	1 1 3	1	1 2 3	1	B. D. s. t.
	46/63—66	3444	1 1 4	—	1 2 4	—	Borste serte	1 1 3	1	1 2 3	1	B. D. s. t.

Erklärung siehe bei Tabelle 1

2. táblázat (folytatása)

Verhältnisse viszonyok										Anmerkung — Megjegyzés		
P ₃					P ₄							
Exopodit		Endopodit			Exopodit		Endopodit					
		innerer Rand belső szegély		äußerer Rand külső szegély			innerer Rand belső szegély		äußerer Rand külső szegély			
Borste — serte	modifizierte Borste módosult serte	Borste — serte	modifizierte Borste módosult serte		Borste — serte	modifizierte Borste módosult serte						
1 1 4	—	1 2 4	—		Borste serte	1 1 4	—	1 2 2		—	Borste serte	s. f. vernalis
1 1 4	—	1 2 4	—		Borste serte	1 1 4	—	1 2 2		—	Borste serte	s. f. vernalis
1 1 4	—	1 2 4	—	Borste serte	1 1 3	1	1 2 2	—	Borste serte	s. f. vernalis		
1 1 4	—	1 2 4	—	Borste serte	1 1 4	—	1 2 2	—	Borste serte	s. f. vernalis		
1 1 4	—	1 2 4	—	Borste serte	1 1 4	—	1 2 2	—	Borste serte	s. f. vernalis		
1 1 3	1	1 2 3	1	Borste serte	1 1 3(2)	1(2)	1 2 1	1	Borste serte (B. D.) (s. t.)	s. f. vernalis		
1 1 2	2	1 2 1	3	B. D. s. t.	1 1 0	4	1 2(1) 0	(1) 2	B. D. s. t.	Übergangsform átmeneti forma		
1 1 3(2)	1(2)	1 2 2	2	B. D. s. t.	1 1 1	3	1 2 0	2	B. D. s. t.	Übergangsform átmeneti forma		
1 1 2(3)	2(1)	1 2 2	2	B. D. s. t.	1 0(1) 0	1(0) 4	1 1 0	1 2	B. D. s. t.	Übergangsform átmeneti forma		
1 1 3	1	1 2 2	2	B. D. s. t.	1 1 2	2	1 2 0	2	B. D. s. t.	Übergangsform átmeneti forma		
1 1 2	2	1 2 1	3	B. D. s. t.	1 1 0	4	1 1 0	1 2	Dorn tüske	s. f. robustus		
1 1 2	2	1 2 2	2	B. D. s. t.	1 1 2	2	1 1(2) 0	1(0) 2	Dorn tüske	s. f. robustus		

Magyarázatot lásd 1. táblázatnál

Zusammenfassung

1. Der zur Auseinanderhaltung der »beiden Arten« (*Acanthocyclops vernalis* (FISCHER) und *Acanthocyclops robustus* (SARS)) angewendete äußere Rand von Endopodit P_4 , derselbe Dorn von P_3 und P_2 , ferner die Exopodit-Borsten von P_2 – P_4 entwickeln sich in recht variabler Form und fluktuieren je nach dem Wechsel der jahreszeitlichen Veränderung. Im Falle des Balaton erscheint »*A. robustus*« in der kühleren und »*A. vernalis*« in der wärmeren Periode des Wassers. Dieser Umstand zeigt sich insbesondere scharf bei den Männchen.

2. Auf Grund unserer Untersuchungen ist es unsere Ansicht, daß wir nur mit einer einzigen Art — *Acanthocyclops vernalis* (FISCHER) — zu tun haben, deren verschiedene Formen (*robustus*, *vernalis* und die Übergangsformen zwischen diesen beiden) bloß saisonale Formen darstellen.

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CRUSTACEA PLANKTONTANULMÁNYOK A BALATONON. III.
ADATOK AZ ACANTHOCYCLOPS VERNALIS (FISCHER) 1853 RENDSZER-
TANÁHOZ ÉS CYCLOMORPHOSISÁHOZ

Ponyi Jenő

Összefoglalás

1. A „két faj” (*Acanthocyclops vernalis* (FISCHER) és *Acanthocyclops robustus*, (SARS)) elkülönítésére felhasznált P_4 endopodit külső szegély, a P_3 , P_2 ugyanazon tüskéjes valamint P_2-P_4 exopodit serték igen változatos formában fejlődnek és az évszakos változásnak megfelelően fluktuálnak. A Balaton esetében a „robustus” a hidegebb, a „vernalis” a melegebb víz időszakában jelenik meg. E jelenség különösen élesen mutatkozik meg a hímeken.

2. A vizsgálatok alapján az a véleményünk, hogy egyetlen fajjal — *Acanthocyclops vernalis* (FISCHER) — állunk szemben, melynek a különböző alakjai (s. f. *robustus*, s. f. *vernalis* és a köztük közötti átmeneti formák) csak szezonális alakok.

ИЗУЧЕНИЕ ПЛАНКТОННЫХ РАКООБРАЗНЫХ БАЛАТОНА III
ДАННЫЕ К СИСТЕМАТИКЕ И ЦИКЛОМОРФОЗУ
ACANTHOCYCLOPS VERNALIS (FISCHER) 1853

Йенэ Поньи

1. — Эндоподитный внешний край P_4 и его P_3P_2 иглы и P_2-P_4 щетинки, служащие для разделения «двух видов» (*Acanthocyclops vernalis* (FISCHER) *Acanthocyclops robustus* (SARS)) развиваются во многообразных формах и показывают сезональные изменения. В Балатоне форма „robustus” появляется при холодной воде, а „vernalis” при теплой. Это явление особенно резко выражено на самцах.

2. — На основе наших исследований мы придерживаемся точки зрения, согласно которой существует только один вид *Acanthocyclops vernalis* (FISCHER). Разные формы которого (s. f. *robustus*, s. f. *vernalis* и переходные между ними формы) являются только сезональными изменениями.

DESCRIPTION OF NEW PLANKTONIC DIATOMS FROM EGYPT

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Received: 15th November, 1966

The microscopic investigation on the plankton composition of Egypt, from the various aquatic habitats (SALAH and TAMÁS 1966) has revealed the presence of a number of peculiar diatoms new to science. Some of these have already been recorded (SALAH and TAMÁS and in press) and the others are included in this part. The area investigated needs no further description after that previously given by the author. One might repeat here again, however, that the area can be roughly divided into three main types of habitat, as follows:

1. Marine habitat includes the Mediterranean Sea, Bitter lakes, Suez Gulf and the Red Sea.
2. Brackish-water habitat comprises the Delta lakes and Lake Karoun.
3. Freshwater habitat such as the Nile River and its tributaries.

The localities from which the collectings were made, are shown in the map, published in the previous paper (SALAH and TAMÁS 1966).

The material was treated and mounted in a medium of high refractive index (SALAH, 1963). Photographs were produced of diatoms which gave sufficient contrast and a Zeiss photomicrographic apparatus was used. The irregular shape of the *Campylodiscus*, renders it rather difficult to focus the whole surface simultaneously, even under the low power of the microscope. This explains the deficiencies of the figures as some portions were out of focus, while the others were distinct. Type-specimens of the new diatoms are lodged in the Institute of Hydrobiology at Alexandria, Egypt and at the Biological Research Institute of the Hungarian Academy of Sciences, Tihany.

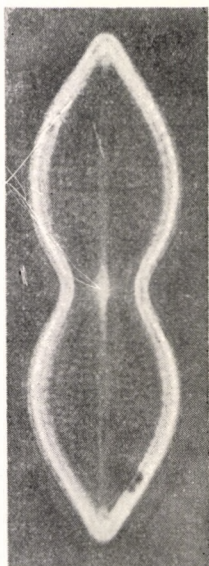
Description of new species

Dictyoneis prominentis n. sp. SALAH

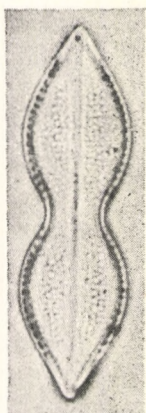
Plate I, Figs 1 to 6

Valvis brevibus latis, lateribus panduraeformibus; 72—75 μ longis; profunde abrupteque medio constrictis; labio paullo obtusisque, ad constrictionem 10—12 μ , ad lobos 20—25 μ latis; apicibus delicate productis, subacutis; raphe rami undata rectis, filiformis subattingentibus, poris centralibus mediocriter distincto adiantibus, ad fissura terminali aliquantum ab apicibus snbremostis, baculi pastoralis modo flexuosa

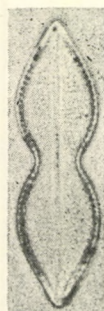
I. PLATE



1.



2.



3.



4.



5.



6.

Plate I

Figs 1 to 6. *Dictyoneis prominentis* n. sp. SALAH

et versa in contraria valvae latera; areis axialibus centralibusque distinctis; nodulo centrali rotundo; nodulis terminalibus spectantibus; superficie structura pruinosa subtiliter punctata, transversis, serie punctorum parvorum 9—10 in 10 μ , in media parte valvae crassae punctatis et solitario dispositis, irregulariter intercalatis longitudinalis formantibus; prope aream axialem oppositum arcuatum et margini coniuncto delicatissimis punctatis; punctis minoribus in lineam transversas; margine serie longitudinali loculorum (cellularum) numerosorum bene visibilibus, granulis distinctis, 6 in 10 μ ornato, ad constrictionem centralem, et ad apicalibus nullis (exceptis). — Hab. in aquis marinis ad Suez Gulf.

Valves elliptical panduriform, deeply constricted in the middle; segments cuneate, obtuse; apices finely produced, acute, 72—75 μ long, 20—25 μ broad (constr. 10—12 μ); widest transverse diameter of each lobe midway between centre and apex; axial area prominent; raphe straight with terminal fissures in opposite directions at either end, central pores approximate; valve surface loosely spattered with coarser wavy beads, transverse 9—10 in 10 μ ; outer and inner stratum finely punctate; middle stratum arranged in irregular, transverse rows, more or less coarsely reticulate; valve margin ornamented with a line of larger loculi (cells) 6 in 10 μ , except constrictions and apices.

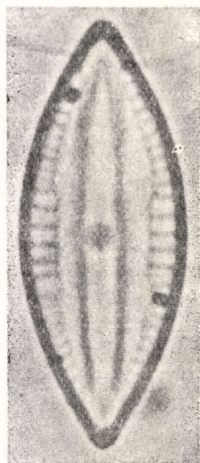
The valve structure, especially its peculiar margin, renders this diatom quite distinct from all the other members of the genus. It cannot, however, be assigned to any hitherto described species (cf. MILLS, 1933—1934). The only nearest relative is *Dictyoneis marginata* (LEWIS) CLEVE, as given in HUSTEDT (1930—1962, p. 576, Fig. 1009); also in CLEVE (1894—1895, p. 30); but that is a narrower and more angular form with finer beadings (12 in 10 μ) so spaced as to produce wavy longitudinal lines (HENDEY, 1958, p. 72). Further, it differs specifically on account of its characteristic arrangement of the marginal loculi, which clearly distinguish it. *Dictyoneis prominentiis* occurs rather sporadically, though not infrequent, in collections from Suez Gulf. Position in the halobion system: euhalobous.

Mastogloia delicata n. sp. SALAH

Plate II, Figs 1—6

Valvae ovato—vel elliptico, apicibus productis curtis, rostratis obtusis; 43—57 μ longis, 17—20 μ latis; valva superiore raphe leniter undata, cum poris centralibus approximatis; area axiali angusta; centralis parva rotundatis cincta, paene dialata, in utroque raphes latere per lineam longam hyalinam ad nodulum centralem coniunctum interruptis, ad formam lyrae dilatata, semilunaris; areovalva area axiali angusta sine area centrali; loculamentis numerosis (fere 30 loculis), in medianas breves lineas arcuatis dispositis; mediis loculis maioribus superantibus, paucissimis (saepe tantum 5—7), ambita elongatis, 4—5 in 10 μ , a latere (11—13 loculis) minoribus attingentibus, leniter decrescentibus, 10—12 in 10 μ ad polos percurrentibus interruptis, marginibus convexis; striis transapicalibus valvorum duorum similibus, tenuissimis rectis, previis parallelis vel subradiantibus, moniliformibus, delicatissimis subtilis, inconspicue punctatis. — Hab. in aquis brackish ad Karoun lacum.

II. PLATE



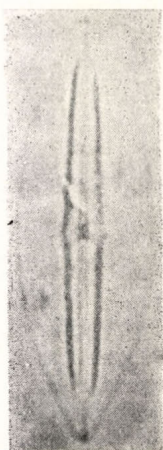
1.



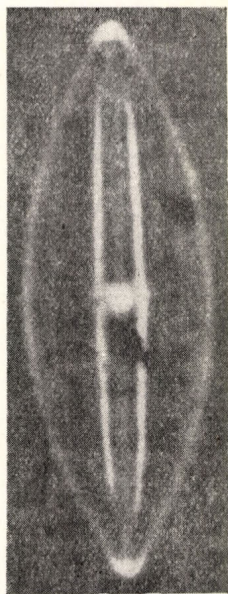
2.



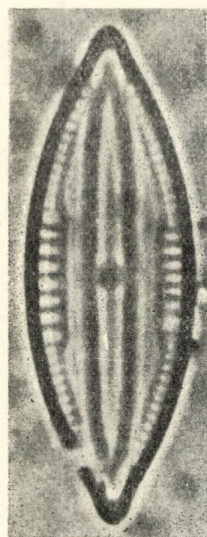
3.



4.



5.



6.

Plate II

Figs 1 to 6. Mastogloia delicata n. sp. SALAH

Valves elliptic oblong with produced rostrate apices; length 43—57 μ , breadth 17—20 μ ; furnished with marginal loculi, extend almost along the whole margin, unequal in size, longer than wide; median loculi being largest and convex towards the centre, terminal one tapered and terminate slightly further from the apices; loculi usually about 30 in numbers; central loculi (5—7), 4—5 in 10 μ ; lateral loculi (11—13), 10—12 in 10 μ ; raphe straight, delicate; axial area not evident; central nodule prominent, narrow, circular; a small hyaline expansion on either side of the median line; lower (rapheless) valve with narrow pseudoraphe, lyred form hyaline area, convergent towards the apices; striation on both valves alike, moniliform, faintly striate, parallel throughout, extremely fine, indistinctly punctate.

The general peculiar distinction of this curious *Mastogloia* is, however, its extremely delicate structure, with remarkably constant marginal loculi. It shows certain similarities to *Mastogloia angulata* LEWIS, figured in HUSTEDT (1930—1962, p. 465, Fig. 885); which is very common in the tropical and subtropical waters (VOIGT, 1942; PERAGALLO, 1897—1908). The new species is fundamentally distinguished by the arrangement and shape of its chambers, its finer striation and especially the dimensions of its valve (cf. also the new dimensions given by VOIGT, 1942, for the East Indies *Mastog. angulata*).

Mastogloia delicata is fairly well distributed throughout Lake Karoun where it shows a wide range of level. So however, it appears to be classed as mesohalobous and euryhaline in its ecological requirements.

Diploneis ornamentalis n. sp. SALAH

Plate III, Figs. 1 to 6

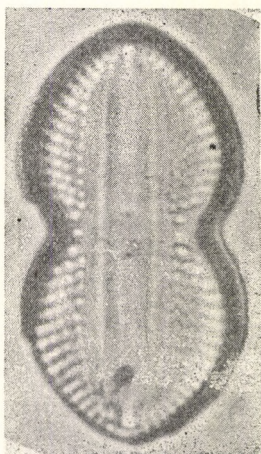
Valvis latis lateribus panduraeformibus; leviter profunde constrictis; ad locos circiter 25—40 μ longis, 12—22 latis (ad. constrictionem 7—17 μ); apicibus superiore valde rotundatis; raphe zona ampla hyalina cincta; nodulo centrali quadrato magno, rectis comibus; nodulis terminalibus spectantibus; poris centralibus aliquanto distantibus; appendicibus valde evolutis; sulcibus ad modum latis, arcuato-seriata praebentibus; spatii marginibus suis exterioribus inclusi tertiam quartamve partem includentibus, parallelis, non dilatis adversus nodulum centrale, ordinem ocellorum magnorum habentibus; costis transapicalis validae 9 in 10 μ ; moniliformibus, leviter in medio parallelis, quarum omnes, 3 centralibus exceptis, lineam marginalem longitudinalem transversam habent, et ad apicalibus exceptis quae leniter convergent curvatis; parte valvae media tantum margaritas nonnullas maiusculas solitarias praebente; costae transapicalis non cum ordinibus alveolorum alterant. — Hab. in aquis brackish ad Karoun lacum.

Cells solitary; valve panduriform, constricted in the middle, with rounded ends; 25—40 μ length, 12—22 μ breadth (constr. 7—17 μ); the median constriction broad and gently concave; widest diameter of each half is midway between the centre and the apex; central nodule conspicuous, quadrate, prolonged into strong siliceous arcuate horns enclosing the raphe, the ends of which are not set back from the ends of the valve; horns parallel; raphe straight, strong; sulcus (furrows) narrow, protracted around the central nodule and bordered with a single row of imperfect beads corresponding in

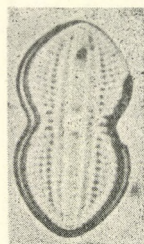
III. PLATE



1.



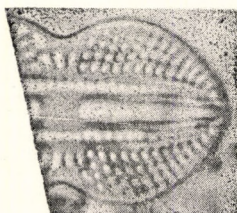
2.



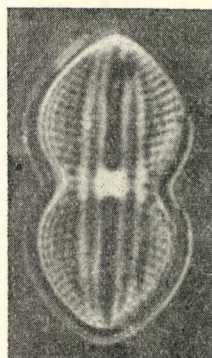
3.



4.



6.



5.

Plate III

Figs 1 to 6. *Diploneis ornamentalis* n. sp. SALAH

numbers and portion to the adjacent rows of costae; lunula more or less narrow, lunate; costae 9 in 10 μ , smooth, wavy beads, crossed by one to three longitudinal lines except the three median ones on each side which are much shorter than the rest, being vertical to the median line and distant from the remaining costae, which are strongly radial and progressively curved as approach the apices; round blotch near the middle margin, the width of this band varies in exact proportion to the width of the valve, being widest midway and narrowing to the middle and to the apices; no alveoli between the trans-apical costae.

This new diatom is clearly distinct by the character of its coastal markings as well as the shape and outline of the valve. It has far more affinity with *Diploneis bombus* (EHR.) KÜTZ. in SCHMIDT's Atlas (1874—1959, Pl. 69, Figs 28, 29) and in CLEVE's (1894—1895, p. 90); but its peculiarly rounded contour, middle margin and coastal bars, make its specific distinctness much more evident. Moreover, *Diploneis bombus* differs from it in the subelliptical character and in the details of the heading together with the wider costae (cf. PERAGALLO, 1897—1908, p. 119, Pl. 18, Figs 10, 11; HUSTEDT, 1930—1962, p. 704, Fig. 10). In spite of these differences, *Diploneis ornamentalis* bears also close connection to *Diploneis suezii*, a marine form recently described from the Suez Gulf. However, the present specimen is distinguished by the measurements of the valve, being smaller and much broader in proportion, and especially the costae are very distinctive.

In general, *Diploneis ornamentalis* is exceedingly abundant in Lake Karoun, being found in rather large numbers, where it tolerates a wide range of habitat. It is, however, fairly well distributed on the spot and it appears to be classed ecologically as both mesohalobous and euryhaline.

Campylodiscus orientalis n. sp. SALAH

Plate IV, Figs 1 to 3; Plate V, Figs 4 to 6

Disco suborbiculare, valde flexuosus; 92—107 μ diam. metientibus; margine lato costato; utroque latere circiter costas in series 2 per spatium leve angustum discretas gerente, semel arcuatis (4—5 in 10 μ); prope marginem subtiliter striatum inter seriem prominentiarum truncatarum (2,5 μ d, et 5—6 in 10 μ); costis interioribus radiantibus leniterve incurvis validis, brevibus cir. 3 in 10 μ ; polos versus arcuatis, ad marginem versus bifidis et hic per 2 striolas arcuatas discretis, non interstitiis punctatis (nullis); exterioribus linearibus interioribus coniunctis; area mediana (centrali) subquadrangulari vel subrotunda, maxima, totam valvae occupantae, 62—70 μ lata, plicis curvatis instructa, medio discum parvum lineas apice incurvas utrique ferentem radiisque cinctum ostendentae, dorsum concavis praesentibus; centro obscure hyalina. — Hab. in aquis marinis ad Bitter lacum.

Frustules saddle-shaped in girdle view, somewhat flexuosus; valve orbicular or suborbicular; 92—107 μ in diameter; its border consisting of an outer narrow band of a single row of small polygonal divisions (4—5 in 10 μ), rounded on their inner side and forming an angle on their outer side, the apex of each angle ending in a minute bead or bar reaching to the rim of the valve margin (2.5 μ d. and 5—6 bars in 10 μ); within this band is a single row of broad tongue-like

IV. PLATE

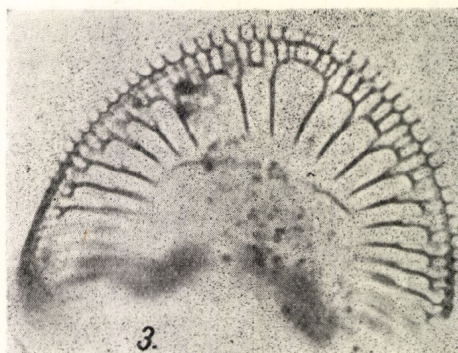
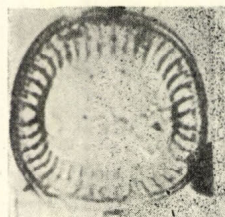
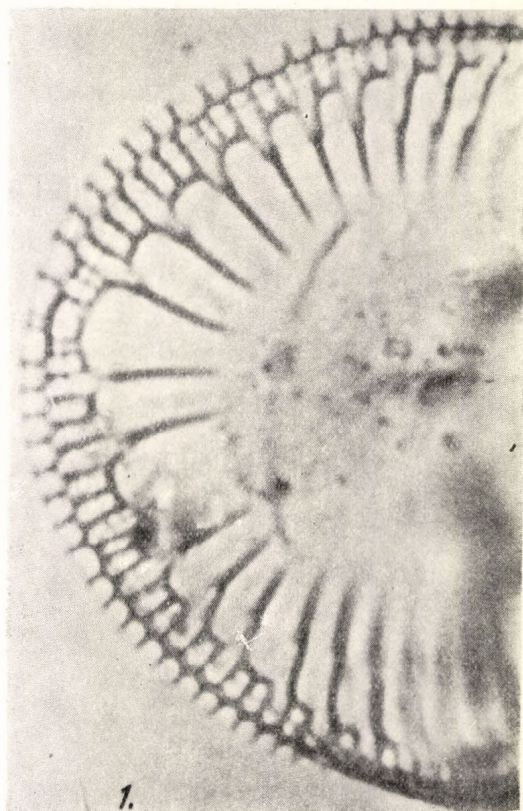
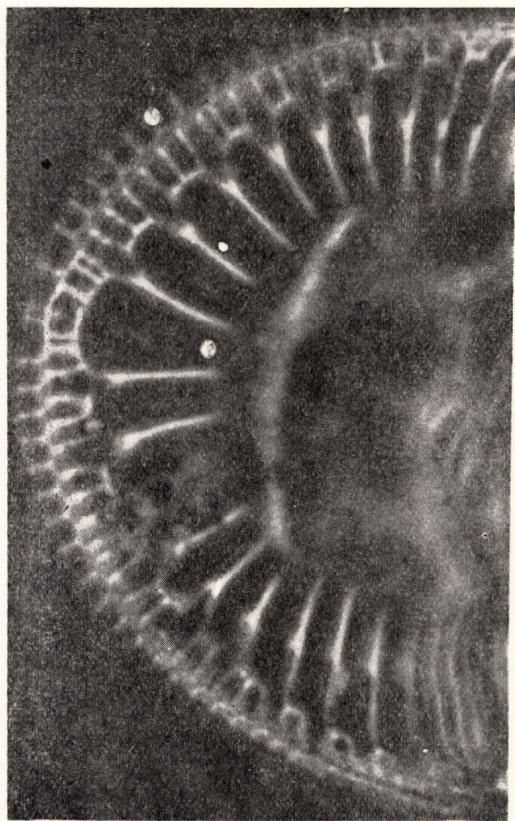


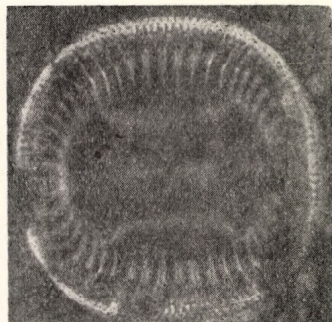
Plate IV

Figs 1 to 3. *Campylodiscus orientalis* n. sp. SALAH

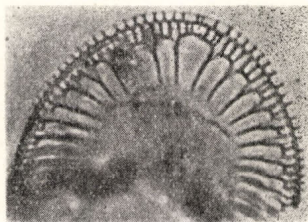
V. PLATE



4.



5.



6.

Plate V

Figs 4 to 6. Campylodiscus orientalis n. sp. SALAH

and glossy scallops of slightly unequal length and very irregular width, being from two to five times as wide as the polygonal partitions of the outer band (flap margin), the largest scallops being prominent at the two ends of the valve, marking the two pollar areas; costae (rays) robust, short and converging inward to the hyaline central space, about 3 in 10 μ , without interstitial puncta or lines between the main costae; being progressively radial and curved as approach to the ends; the central portion (median space) of the valve suborbicular or subquadrate, about two-third its diameter, without markings, except for a short central, rugose line, running towards but not reaching the end, diameter 62—70 μ .

The new diatom is related to *Campylodiscus adriaticus* GRUN. (GRUNOW, 1862, p. 440, Pl. 11, Fig. 8) and var. *massiliensis* GRUN. as figured in SCHMIDT's Atlas (1874—1959, Pl. 16, Figs 13—16). *Campylodiscus orientalis* separates principally on the bases of its peculiar characteristic structure; as in these forms, the costae (rays) are forked near the margin, with fine interstitial puncta as well as the median areas are two-fold; which sharply differentiate them. Moreover, the present species differs in the dimensions of the valve (cf. DEBY, 1891, Pl. 5, Fig. 34; DE-TONI, 1891—1894, p. 619; PERAGALLO, 1897—1908, p. 239, Pl. 53, Fig. 5). *Campylodiscus orientalis* is one of the most widespread and fairly well represented throughout the Bitter lakes. It is, however, widely distributed in marine habitat and to be classed ecologically as euhalobous within the halobion system.

Acknowledgements

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ÚJ PELAGIKUS KOVAMOSZATOK EGYIPTOMBÓL

M. Salah

Összefoglalás

Szerző az egyiptomi (tengeri, brakvízi és édesvízi) planktonminta-sorozatok mikroszkópiai meghatározása során a tudományra új kovamoszatfajokat talált. Ebben a tanulmányában 4 új faj leírását közli.

1. *Dictyoneis prominentiis* SALAH, a Szezi-csatorna planktonmintáiban szórva-nyosan fordul elő, de nem ritka. A kovamoszatok sőtűrésének fokozatában e u h a l o b. A taxonómiai irodalomban egyedül a *Dictyoneis marginata* (LEWIS) CLEVE fajhoz áll közel.

2. *Mastogloia delicata* SALAH, a Karoun tó planktonmintáiban gyakori. Sőtűrés szempontjából mezohalob (brakvízi), euryhalin szervezet.

Taxonómiaiailag közel áll a trópusi és subtrópusi vizekben nagyon elterjedt *Mastogloia angulata* LEWIS fajhoz.

3. *Diploneis ornamentalis* SALAH, ugyancsak a Karoun tóból származó planktonmintákban szerepelt rendkívül nagy számban. A sőtűrés mezohalob (brakvízi) fokozatába sorolható, euryhalin szervezet.

Rendszertanilag rokonságban áll a *Diploneis bombus* (EHR.) KÜTZ. fajjal. Meglehetősen közel áll a *Diploneis suezii* SALAH et TAMÁS tengeri kovamoszatokhoz is, melyet egy korábbi tanulmányban a Szezi-csatornából írtak le.

4. *Campylodiscus orientalis* SALAH, a nagy keserűsós tó (Bitter lakes) lakója. A tengerek magas sótartalmát eltűrő e u h a l o b szervezet.

Taxonómiaiailag közel áll a tengeri *Campylodiscus adriaticus* GRUN. és *C. adriaticus* var. *massiliensis* GRUN. formaköréhez.

НОВЫЕ ПЕЛАГИЧЕСКИЕ КРЕМНЕВЫЕ ВОДОРОСЛИ ИЗ ЕГИПТА

М. Салах

При микроскопическом анализе образцов планктона морских и пресных вод Египта автором были обнаружены новые виды кремневых водорослей. В данном сообщении описывается 4 новых вида.

1. — *Dictyoneis prominentiis* SALAH был найден в образцах планктона Суецского канала. Таксономически близок к *Dictyoneis marginata* (LEWIS) CLEVE.

2. — *Mastogloia delicata* SALAH часто встречается в планктоне озера Кароун. Таксономически близок к *Mastogloia angulata* LEWIS.

3. — *Diploneis ornamentalis* SALAH присутствует в планктоне озера Кароун. Систематически близок к *Diploneis bombus* (EHR.) KÜTZ. и *Diploneis suezii* SALAH et TAMÁS.

4. — *Campylodiscus orientalis* SALAH живет в соляных озерах (Биттеры). Таксономически близок к *Campylodiscus adriaticus* GRUN. и к *C. adriaticus* var. *massiliensis* GRUN.

HORIZONTALE PLANKTON-UNTERSUCHUNGEN IM BALATON V. ÜBER DAS PHYTOPLANKTON DES SEES AUF GRUND DER IM JAHRE 1965 GESCHÖPFTEN UND NETZFILTER-PROBEN

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Eingegangen am 4. April 1967

Vorliegende Studie schließt sich an die bereits früher erschienenen Arbeiten an, welche Angaben über die horizontale Verbreitung der Planktonorganismen des Balaton enthalten (SEBESTYÉN 1960, 1964, TAMÁS 1961, 1965a).

Bereits seit Ende des vorigen Jahrhunderts erschienen Studien zur Erkenntnis und Verbreitung des Phyto- und Zooplanktons des Balatonsees. Ausführliche Literaturangaben enthält die Studie von TAMÁS (1965a).

In der Zeit von Juni 1965 bis Oktober desselben Jahres haben wir an 5 Quersegmenten der Tiefenlängsachse des Sees Plankton- und Schlammproben-Sammlungen durchgeführt. Die Bestimmung der in den Schlammproben gefundenen mikroskopischen Pflanzen und schlammbewohnenden Crustaceen (Individuenzahl pro dm²) und sonstige diesbezügliche Angaben finden wir in den Studien von PONYI (1966) und TAMÁS (1966a). Vorliegende Studie befaßt sich mit der algologischen Aufarbeitung der Planktonproben-Serien, mit der Auswertung von Angaben über die Populationsdichte (Individuenzahl pro Liter) sowie mit der Verbreitung einiger häufiger vorkommenden Arten.

Ort und Zeit der Sammlungen, Materialaufarbeitung

Infolge der im Frühjahr 1965 eingetretenen bedeutenden Fischseuche im Balaton haben wir in Organisation der Hydrobiologischen Abteilung Untersuchungen und Sammlungen bezüglich der Umstände und biologischen Auswirkung der Seuche unternommen.

Wir haben die Planktonproben-Serien von Juni bis Oktober monatlich an drei Stellen des südwestlichen Seeteiles und an zwei Punkten des nordöstlichen Seeteiles in auf die Längsachse des Wasserspiegels senkrechten Querprofilen (*Abb. 1*) gesammelt (vgl. SEBESTYÉN 1960, 118—119.). Zwischen den aus den südwestlichen und nordöstlichen Teilen des Sees entnommenen Proben bestehen wohl tageszeitliche und auch tägliche Verschiedenheiten, welche sich aus dem Umstände erklären, daß auf einem recht weit ausgebreiteten Gebiet die Sammlungen von einem einzigen Fahrzeuge aus durch eine einzige Arbeitsgruppe ausgeführt wurden.

Die Sammlung der Probeserien erfolgte auf zweierlei Arten:

1. Aus vier verschiedenen Tiefen des offenen Wassers des Sees wurden im mittels eines FRIEDINGERSCHEN Apparates (LUND und TALLING 1957, 537;

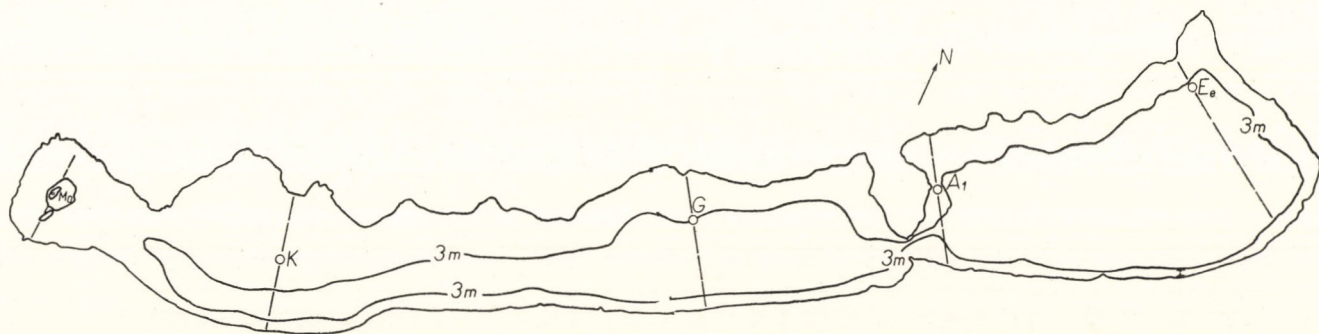


Abb. 1. Skizzenhafte See-Karte des Balaton, mit Bezeichnung der Probenentnahme-Stellen. M_0 = zwischen Gyenesdiás und der Mündung des Zala-Flusses, cca 2800 m vom Nordufer; K = zwischen Szigliget und Balatonmária, cca 4000 m vom Nordufer; G = zwischen Ságpusztá und Balatonszemes, cca 2500 m vom Nordufer; A_1 = zwischen Balatonfüred-Fenékfürdő und Zamárdi, cca 500 vor dem Biologischen Forschungsinstitut; E_e = zwischen Balatonalmádi und Balatonvilágos, cca 2000 m vom Nordufer; N = Nord

1. ábra. A Balaton vázlatos térképe a mintavételi helyek megjelölésével. M_0 = Gyenesdiás — Zala folyó torkolata, Gyenesdiás parttól kb. 2800 m. K = Szigliget—Balatonmária, az északi parttól kb. 4000 m. G = Ságpusztá—Balatonszemes, az északi parttól kb. 2500 m. A_1 = Balatonfüred, Fenékfürdő — Zamárdi, Tihany, Biológiai Kutatóintézet előtt kb. 500 m. E_e = Balatonalmádi—Balatonvilágos, északi parttól kb. 2000 m. N = észak

SCHWOERBEL 1966, 54—55, Bild 30) geschöpften je 1 bzw. je 0,25 Liter Wasser zur Ermittlung der Populationsdichte der mikroskopischen pflanzlichen Organismen qualitative und quantitative Untersuchungen vorgenommen. Die Wassertiefe betrug — mit Ausnahme einiger Proben — im allgemeinen mindestens 3 m.

2. Durch Netzfilterproben (Netzgewebe Nr. 6 und 25), aus welchen wir die zur Ordnungsbestimmung der Arten erforderlichen ergänzenden Untersuchungen vornahmen. Die Netze wurden jedesmal von einem Ruderboot aus in der Nähe der Entnahmestelle in einer Tiefe von $\pm 1,5$ m geschleppt. In der Bucht von Keszthely, im Gebiete vor dem Biologischen Forschungsinstitut von Tihany und im Segment vor Balatonalmádi haben wir aus der abendlichen Netzfilterprobe (Tab. 1) hinsichtlich je einer Algenart, Rotatorie (P. ZÁNKAY und KERTÉSZ 1967) und Planktonkrebse (PONYI 1967) wertvolle Beobachtungen machen können.

Die geschöpften Proben wurden an Ort und Stelle mittels Jodjodkalium fixiert und später in 2%iger Formalinlösung konserviert. Aus den geschöpften Wasserproben haben wir die quantitative Zusammensetzung des Phytoplanktons nach der UTERMÖHLschen Sedimentationsmethode (UTERMÖHL 1958) mit einem UTERMÖHL Planktonmikroskop (Oc. 8 $\times$, Obj. 40) abgezählt. Aus je einer Wasserprobe haben wir 5 Stück, 10 ml fassende Kammern mit zu untersuchendem Material angefüllt. Demgemäß entfällt auf die Menge je einer Algenart ein aus 5 Angaben errechneter Durchschnittswert als Zahlenangabe in der Tabelle. Bezüglich der stellenweisen Populationsdichte der *Ceratium*-Art zeigte sich die Untersuchung des Inhaltes von 5 Stück 25 ml fassenden Kammern notwendig. So konnten wir in der Tabelle bei *Ceratium* den aus je 10 Zahlenangaben errechneten Durchschnitt anführen. Die Individuum pro Liter Angaben der Tab. 2 und 3 stellen die aus vier Wassertiefen (0—1—2—3 m) errechneten Mittelwerte dar.

Ähnlich den früheren Phytoplankton-Untersuchungen (TAMÁS 1954, 1965a) haben wir auch diesmal die Kolonien bildenden und Fadenalgen je nach Kolonien bzw. Faden (durchschnittlich aus 20 Zellen bestehenden Faden teil als Einheit gerechnet) angegeben. Bei *Microcystis flos-aquae* haben wir jedoch die Zellen einzeln gerechnet. Die in die *Chrysophyceae*-Klasse des *Chrysophyten*-Stammes fallenden *Dinobryon*-Arten sowie die *Asterionella*- und *Melosira*-Arten der *Bacillariophyceae*-Klasse haben wir ebenfalls zellenweise aufgezeichnet.

Die Lage der Querprofile sowie die mit der Einsammlung zusammenhängenden sonstigen Daten (Temperatur, Durchsichtigkeit des Wassers usw.) sind in Tab. 1 enthalten.

Die Gestaltung des Wasserstandes im Balaton im Jahre 1965 haben wir in Abb. 2, den jährlichen Verlauf der Wassertemperatur in Abb. 3 dargestellt.

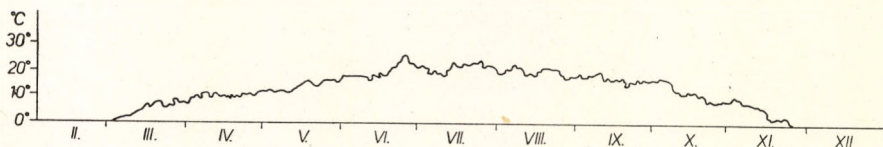


Abb. 2. Jahrestemperatur des Balaton-Wassers (1965) in der Kisöböl-Bucht, Tihany (± 30 cm Tiefe gemessen)

2. ábra. A Balaton vizének hőmérséklete az 1965. évben

Tabelle 1 — 1. táblázat
Ort und Zeitpunkt der Probenentnahme in 1965 usw.
Az 1965. évi gyűjtések helye, ideje és egyéb adatai

Sammelstellen Gyűjtőhelyek	Zeitpunkt — Időpont	Wasser- temperatur Víz hőfok C°	Luft- temperatur Levegő- hőfok C°	Wassertiefe Víz mélység, cm	*Durch- sichtigkeit *Átlátszó- ság, cm	Bemerkungen Megjegyzés
M ₀	VI. 8. 21 h	—	—	—	—	Die Farbe des Wassers war braunlich
	VI. 9. 7 „	18	17,8	300	45	
	VI. 30. 21 „	—	—	—	—	
	VII. 1. 7 „	22	23	290	80	A víz színe barnás árnyalatú volt
	VIII. 2. 22 „	—	—	—	—	
	** VIII. 3. 7 „	20	21	300	39	
	IX. 6. 21 „	—	—	—	—	
	+ IX. 7. 8 „	18	19	276	62	
	X. 12. 20 „	—	—	—	—	
	X. 13. 7 „	13	6	250	114	
K	VI. 9. 12 h	19,5	18	420	36	Die Farbe des Wassers war gelblich
	VII. 1. 9 „	24	25	380	40	A víz színe sárgás árnyalatú volt
	** VIII. 3. 9 „	20	23	367	35	
	+ IX. 7. 10 „	19	21,5	365	51	
	X. 13. 11 „	13	16	330	66	
G	VI. 9. 16 h	18,5	20	420	42	Die Farbe des Wassers war gelblich
	VII. 1. 16 „	27	32	400	92	A víz színe sárgás árnyalatú volt
	** VIII. 3. 16 „	21	25	396	56	
	IX. 7. 16 „	19	24	400	50	
	X. 13. 16 „	15	15	370	95	
A ₁	VI. 9. 21 h	—	—	—	—	
	VI. 10. 16 „	19	18,5	350	50	
	VII. 2. 15 „	24	24	355	92	
	VII. 2. 24 „	—	—	—	—	
	VIII. 4. 15 „	22	26	335	51	
	VIII. 4. 23 „	—	—	—	—	
	IX. 8. 15 „	20	24	371	86	
	IX. 8. 23 „	—	—	—	—	
	X. 14. 15 „	14	18	370	120	
E _c	VI. 10. 18 h	19	18,5	327	64	
	VI. 10. 21 „	—	—	—	—	
	VII. 2. 18 „	23	25	330	66	
	VII. 2. 22 „	—	—	—	—	
	VIII. 4. 18 „	21	26	373	64	
	VIII. 4. 21 „	—	—	—	—	
	IX. 8. 19 „	20	20	280	—	
	IX. 8. 21 „	—	—	—	—	
	X. 14. 18 „	14	16	320	—	
	X. 14. 20 „	—	—	—	—	

Zeichenerklärung — Jelmagyarázat

* = Die Werte beziehen sich auf Messungen mit der Secchischeibe — Mérések Secchi-koronggal

** = Das Massenhafte Auftreten von *Melosira granulata* und *M. granulata* var. *angustissima* verursachte in aus offenem Wasser entnommenen Schöpf- und Netzfilterproben eine Vegetationsfärbung

Merített és hálópilanktonmintákban a *Melosira granulata* és a *M. granulata* var. *angustissima* tömeges fellépése következében víz színeződés

+ = Das massenhafte Auftreten von *Microcystis flos-aquae* und *Aphanizomenon flos-aquae* var. *klebahnii* verursachte im offenen Wasser das Erscheinen zerstreuter Wasserblüte

Merített és hálópilanktonmintákban *Microcystis flos-aquae* és *Aphanizomenon flos-aquae* var. *klebahnii* szórt vízvirágzás

Zur systematischen Bestimmung der pflanzlichen Mikroorganismen haben wir die in der Literatur angegebenen taxonomischen Werke herangezogen.

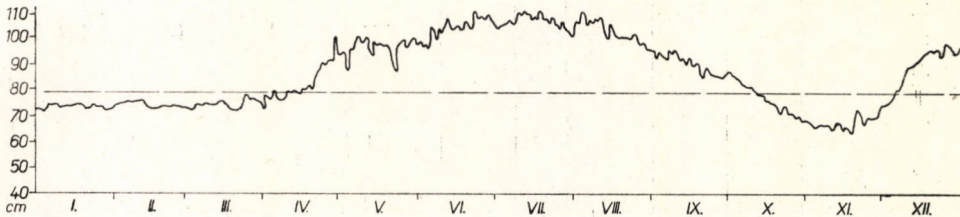


Abb. 3. Wasserstand des Balaton-Sees im Jahre 1965 nach Messungen in Tihany (0 Punkt = 104,075 m über dem Meeresspiegel)

3. ábra. A Balaton vízállásának 1965. évi menete a tihanyi mérce adatainak alapján (0 pont = 104,075 m az Adria felett)

Untersuchungsergebnisse

Die an fünf Sammelstellen aus 97 geschöpften und 76 Netzfilterproben bestimmten mikroskopischen Pflanzen gehören zusammen mit dem Wasserpilz zu 6 großen systematischen Stämmen. Diese sind — nach der Häufigkeit ihres Vorkommens geordnet — die folgenden:

	Arten	Varietät	Form
<i>Chrysophyten</i>	78	6	1
<i>Chlorophyten</i>	48	8	1
<i>Cyanophyten</i>	17	—	—
<i>Euglenophyten</i>	14	—	—
<i>Pyrrophyten</i>	7	—	—
<i>Mycophyten</i>	1	—	—
Zusammen	165	14	2

In den Proben waren die Arten aller drei Klassen des *Chrysophyten*-Stammes (*Xanthophyceae* 3, *Chrysophyceae* 8, *Bacillariophyceae* 74) vertreten. Aus den geschöpften und Netzfilterproben erhellt, daß von den pelagischen Arten der *Bacillariophyceae*-Klasse *Asterionella formosa*, *Attheya zachariasii*, *Cyclotella bodanica* und *C. ocellata*, *Melosira granulata*, *Melosira granulata* var. *angustissima*, *Nitzschia acicularis*, *Stenopterobia pelagica*, *Synedra acus* var. *angustissima* stellenweise große Populationsdichte erreicht hatten (Tab. 2).

Von den tychoplanktischen Kieselalgen sind *Amphora ovalis*, *Diploneis elliptica*, *Fragilaria construens*, *Navicula cryptocephala*, *N. gracilis*, *Nitzschia amphibia*, *N. sigmoidea*, *Surirella robusta* var. *splendida* bedeutend (vgl. TAMÁS 1966a, 200—205).

Amphora ovalis var. *pediculus*, *Cocconeis placentula*, *C. placentula* var. *euglypta*, *Synedra parasitica* benutzen die im offenen Wasser des Sees fast ständig vorfindbare, großgestaltige *Cymatopleura elliptica*, *C. solea* (vgl. TAMÁS 1954, 209; 1961, 144) und *Nitzschia sigmoidea* als Wirtspflanzen.

<i>Chroococcus limneticus</i> LEMM.	VI.	—		—		—	+	—		—	
	VII.	—		—		—	+	0,15	+ N	—	
	VIII.	—	+	0,3		—	+	—	+	0,05	+
	IX.	—	+ N	0,25		—	+	0,1	+ N	—	+ N
	X.	—		0,05		—		0,05		—	+
<i>Chroococcus turgidus</i> (KÜTZ.) NAEG.	VIII.	—		—	+	—		—		—	
	IX.	—		—		—			+	—	N
	X.	—		0,05		—		—		—	
<i>Coelosphaerium kützingianum</i> NAEG.	VI.	—		1,25	+	4,4	+	3,5		1,3	N
	VII.	—		0,65	+	1,0	+	4,0	N	2,45	+ N
	VIII.	1,21	+ N	3,3	+	1,45	+	1,35	+	1,85	N
	IX.	0,2	+	0,7	+	2,6	+	2,15	+ N	1,8	+ N
	X.	0,33		4,6	+	2,0	+	0,4	+	0,26	+
<i>Gomphosphaeria lacustris</i> CHOD.	VI.	—		0,25		2,7	+	1,15	+	0,05	N
	VII.	—	+	—		—	+	0,35	+	0,75	
	VIII.	—	+	—		0,7		0,2		—	+
	IX.	—		0,05		0,05	+	—	+ N	0,1	+
	X.	—		1,0	+	0,35	+	0,4	+	1,0	
<i>Lyngbya circumcreta</i> G. S. WEST	VI.	0,26	+	0,8	+	1,3	+	1,7	+ N	0,95	N
	VII.	0,25	+	0,5	+	0,95	+	4,2	+ N	3,4	+ N
	VIII.	0,3	+	1,2	+	1,35	+	6,3	+ N	7,2	+ N
	IX.	0,33	+	0,35	+	3,85	+	5,0	+ N	2,87	+ N
	X.	0,13	+	0,25	+	0,95	+	0,45		0,95	+
<i>Lyngbya limnetica</i> LEMM.	VI.	0,35	+ N	0,5	+	0,45	+	2,4	+ N	1,9	+ N
	VII.	0,6		0,4		0,5		7,65	+ N	7,45	+ N
	VIII.	0,3		0,3		0,2	+	3,4	+ N	2,55	+ N
	IX.	0,13	N	0,25		0,9	+	6,3	+ N	7,73	+ N
	X.	0,6	+ N	0,6	+	2,7	+	3,65	+	3,2	+
<i>Merismopedia glauca</i> (EHR.) NAEG.	IX.	—		—		—		—		—	N
	X.	—		—		—		0,1		—	

Tabelle 2 (Fortsetzung) — 2. táblázat (folytatás)

Sammelstellen, Zeitpunkt Gyűjtőhelyek, időpont		M ₀		K		G		A ₁		E ₀	
Artenverzeichnis Fajok felsorolása		i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25
<i>Merismopedia tenuissima</i> LEMM.	VI.	0,4		0,45	+	0,65		1,1		—	
	VII.	—		—	+	—		0,05		—	
	IX.	—		—		—		0,8		—	
	X.	—		0,6		—		—		—	
<i>Microcystis flos-aquae</i> (WITTR.) KIRCHN.	VI.	—	+ N	—	+	—	+	—	+ N	—	
	VII.	0,05	+	—	+	0,05	+	—	+ N	0,1	
	VIII.	—	+	—	+	0,15	+	—	+ N	—	+ N
	IX.	—	+	—		—	+	—	+ N	—	
	X.	0,07	+	—	+	—	+	—	+	—	
<i>Oscillatoria tenuis</i> Ag.	VI.	—		—		—		—	+	—	
	VII.	—	+ N	—		—	+	0,05		—	
	VIII.	—	N	—		0,15		—		—	
	IX.	—		—		—	+	—		—	
<i>Phormidium</i> sp.	X.	—	N	—		—		—		—	
EUGLENOPHYTA											
<i>Colacium cyclopicola</i> (GICKLH.) BOUVR.	VII.	—	+ N	—	+	—	+	—	+	—	
	X.	—	+ N	—	+	—	+	—	+	—	+
<i>Colacium simplex</i> HUBER—PESTALOZZI	VI.	—	N	—		—		—		—	
	VII.	—	+	—	+	—	+	—	+	—	
	VIII.	—	+ N	—	+	—		—		—	
	IX.	—		—		—		—		—	+
	X.	—		—		—		—		—	+
<i>Colacium vesiculosum</i> EHR.	VI.	—		—		—	+	—	N	0,1	+ N
	VII.	—	+ N	—	+	—	+	0,7	+ N	—	+ N

<i>Colacium vesiculosum</i> Ehr.	VIII.	—	N	0,6	+	0,05		0,2	+ N	—	+ N
	IX.	—	+ N	—	+	—		—	+ N	—	+ +
	X.	—	+ N	—	+	—	+	—	+	—	+
<i>Euglena acus</i> EHR.	VI.	0,01		—		—		0,1		0,05	
	VII.	—		0,05		—		0,05		—	
	VIII.	—		0,02		—		0,1		0,05	N
	IX.	—		0,2		—		0,3		—	
	X.	—		0,35	+	0,05		0,1		—	
<i>Euglena ehrenbergii</i> KLEBS	VI.	0,05		0,15	+	—		0,05		—	
	VII.	—		—		—		—		0,25	+ +
	VIII.	0,06		0,41	+	0,1		0,05	N	0,07	+ N
	IX.	—	+	0,12	+	0,24	+	0,1	+	0,03	N
	X.	—		0,05		—		0,01		0,05	
<i>Euglena klebsii</i> (LEMM.) MAINX	VI.	—		—		—		0,35		—	
	VII.	—		—		0,05		0,05		0,2	
	VIII.	—		0,6		0,1		0,1		—	
	IX.	—		—		0,55		0,55	N	0,4	
	X.	—		0,25		1,25		0,6		0,35	+
<i>Euglena limnophyla</i> var. <i>minor</i> DREZ.	VI.	0,5		—		—		0,1		—	
	VII.	0,05		—		—		—		—	
	VIII.	—		0,01		0,1		0,1	+	—	
	IX.	—		0,2	+	0,2		0,2		—	
	X.	0,4		0,2	+	—		0,05		—	
<i>Euglena oxyuris</i> SCHMARDT	VI.	0,07	+	0,15	+	—		0,1	+ N	0,07	+ N
	VII.	0,05	+	0,25		0,05	+	0,1		0,05	+
	VIII.	0,05		1,8	+	0,05	+	0,11	+ N	—	
	IX.	0,2	+	0,3	+	0,17		0,21		—	
	X.	—	+	0,05		0,01	+	0,28		—	
<i>Euglena</i> sp.	VI.	0,03		—		—		0,25		0,1	
	VIII.	0,3		—		—		—		—	
	IX.	—		—		—		0,2		—	
	X.	—		—		—		0,15		—	

Tabelle 2 (Fortsetzung) — 2. táblázat (folytatás)

Sammelstellen, Zeitpunkt Gyűjtőhelyek, időpont		M_e		K		G		A_1		E_e	
Artenverzeichnis Fajok felsorolása		i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25
<i>Phacus acuminatus</i> STOKES	VI.	—		—		—		—		0,1	
	VII.	—		—		—		—		0,25	
	VIII.	—		—		—		0,1		—	
	IX.	—	+	0,15	+	—		0,1		—	
	X.	0,13		0,65		—		0,1		—	
<i>Phacus tortuosus</i> ROLL	VI.	0,05		0,05		—		0,05		—	
	VII.	—		—		—		0,1		—	
	IX.	—	+	—		—		0,1		—	
<i>Phacus</i> sp.	VI.	0,16		—		0,05		0,6		—	
	VII.	—		—		—		0,05		0,1	
	VIII.	—		0,3		—		—	+	0,05	
	IX.	0,13		0,1		—		0,1		—	
	X.	0,13	N	0,05		0,05		0,2		0,05	
<i>Trachelomonas volvocina</i> EHR.	VI.	0,05		—		—		—		—	
	VII.	—		—		—		0,05		—	
	VIII.	—		—		—		0,1		—	
	IX.	0,07		—		—		—		—	
<i>Trachelomonas</i> sp.	X.	—	N	—		—		—		—	
PYRROPHYTA											
<i>Cryptophyceae</i>											
<i>Cryptomonas erosa</i> EHR.	VI.	0,2		—		—		—		—	+
	VII.	—		—		—		—		—	N
* <i>Cryptomonas pusilla</i> BACHM.	VI.	—		—	+	—	+	—		—	

<i>Peridineae</i> <i>Ceratium hirundinella</i> (O. F. MÜLL.) SCHRANK	VI.	0,02	+ N	0,33	+	0,8	+	1,1	+ N	1,7	+ N
	VII.	0,7	+ N	1,82	+	15,77	+	4,2	+ N	13,87	+ N
	VIII.	7,41	+ N	15,31	+	49,5	+	11,25	+ N	20,75	+ N
	IX.	4,83	+ N	46,32	+	33,04	+	5,74	+ N	12,0	+ N
	X.	0,02	+ N	0,02	+	1,31	+	0,71	+	0,91	+
<i>Diplopsalis acuta</i> ENTZ	VI.	—		—		—		—	N	—	N
	VII.	0,02	N	0,01		0,15		0,12	N	0,05	+ N
	VIII.	0,59	+ N	1,17	+	0,09	+	0,1	+ N	0,27	+ N
	IX.	0,1	+	0,16	+	0,19		0,1	+ N	0,12	+ N
	X.	0,03	N	0,01	+	0,04	+	—	+	0,04	
<i>Glenodinium gymnodinium</i> PENARD	VII.	—		—		—		0,01		—	
<i>Gonyaulax apiculata</i> (PENARD) ENTZ	VI.	—		—		—		0,02		—	
	VII.	—		—		0,04		0,04		0,02	+
	VIII.	0,06		0,09		0,07		0,01	N	0,25	+ N
	IX.	0,02		0,07		0,06	+	0,06		0,12	+ N
	X.	—		—		—	+	—		—	+
<i>Peridinium inconspicuum</i> LEMM.	VI.	—		—		—		0,05		—	
CHRYSOPHYTA											
<i>Xanthophyceae</i>											
<i>Botryococcus braunii</i> KÜTZ.	VI.	—		—		—		—		0,05	+
	VII.	—	+ N	—		—	+	—	+ N	0,05	+ N
	VIII.	—		—		—		0,6	+ N	0,7	+ N
	IX.	—	+	0,25	+	0,3		0,65	+	0,4	+ N
	X.	0,07	N	0,4		0,45	+	0,6	+	0,65	+
<i>Planktonema lauterborni</i> SCHMIDLE	VI.	—	+	0,5	+	4,75	+	3,9	+ N	1,15	+ N
	VII.	0,15		0,15	+	1,35	+	0,75	+ N	1,1	+ N
	VIII.	—		0,6		0,95	+	0,9	+ N	0,4	+ N
	IX.	0,07	+	0,5	+	1,0	+	0,25	+ N	0,47	+ N
	X.	0,27	+	2,55	+	4,15	+	1,95	+	1,05	+
<i>Stipitococcus urceolatus</i> W. et G. S. WEST	VII.	—		—	+	—		—		—	+
	VIII.	—	+	—		—		—		—	
	IX.	—		—		—		—	+	—	+

Tabelle 2 (Fortsetzung) — 2. táblázat (folytatás)

Sammelstellen, Zeitpunkt Gyűjtőhelyek, időpont		M_e		K		G		A_1		E_e	
Artenverzeichnis Fajok felsorolása		i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25
<i>Chrysophyceae</i>											
<i>Cephalothamnion cyclopum</i> STEIN	VII.	—	N	—		—		—		—	
	VIII.	—	N	—		—		—		—	
	IX.	—		—		—		—	+	—	+
<i>Dinobryon divergens</i> IMH.	VI.	—	+ N	—		—		—		—	+
	VII.	39,75	+ N	22,25	+	0,3	+	0,25	+ N	—	
	VIII.	—	+ N	—		0,5		0,15	+ N	—	
	IX.	—		—		—		—	+ N	—	
	X.	—		—		0,15	+	0,05	+	—	+
<i>Dinobryon sociale</i> EHR.	VII.	—	+	—	+	—		—		—	
<i>Mallomonas acaroides</i> PERTY	VI.	0,21	+ N	—		—		—		—	
	VII.	—	N	—		—		—		—	
	VIII.	—	N	—		—		—		—	
	IX.	—	N	—		—		—		—	
* <i>Mallomonas elongata</i> REVERDIN	VI.	—	N	—		—		—		—	
	VII.	—	+ N	—	+	—		—		—	
<i>Mallomonas tonsurata</i> TEILING	VI.	0,01	N	—		—		—		—	
	VII.	0,1	N	—		—		—		—	
	VIII.	—	N	—		—		—		—	
	IX.	—	+ N	—		—		—		—	
<i>Salpingoeca frequentissima</i> (ZACH.) LEMM.	VIII.	—	+	—	+	—		—		—	+
	X.	—		—		—		—		—	+

<i>Synura uvella</i> EHR.	VI. VII. VIII. IX.	0,1 — — —	N	— — 0,9 0,05		— — — —		— — — —		— — — —	
<i>Bacillariophyceae</i> <i>Achnanthes minutissima</i> KÜTZ.	IX. X.	— —	N	— —		— —		— —		— —	N
<i>Amphora ovalis</i> KÜTZ.	VI. VII. VIII. IX. X.	4,25 0,15 0,3 0,33 0,13	+ N + N + N	18,5 0,2 0,6 0,3 1,95		20,1 — 0,3 0,15 0,6		7,05 4,1 2,05 0,85 0,9	N + 	0,6 0,45 0,5 0,27 0,3	 + + +
<i>Amphora ovalis</i> var. <i>pediculus</i> KÜTZ.	VI. VII. VIII. IX. X.	— — — — 0,67	+ N	— — — — 1,06	+ 	— — 0,05 0,15 —	+ 	— — — 1,05 0,25	+ 	— — — 0,13 0,05	N +
<i>Asterionella formosa</i> HASSAL	VII. VIII. IX. X.	0,4 1293,9 0,27 —	+ + N + N +	— 143,8 — —	+ + 	1,0 — — —	+ +	0,4 — — —	+ 	— — — —	
<i>Attheya zachariasii</i> J. BRUN.	VI. VII. VIII. IX. X.	— — — — —	 + N + N 	— — — — —	 + +	— — 0,05 — —	+ + + + +	— 0,1 — — —	+ N + N + N +	— — — — —	N + + N + N
<i>Caloneis schumanniana</i> var. <i>biconstricta</i> GRUN.	VI. VII. VIII. IX.	— — — —		— — — —		0,1 — — —		0,1 — 0,05 —		— 0,1 — 0,07	 +
<i>Campylodiscus noricus</i> var. <i>hibernica</i> (EHR.) GRUN.	IX.	—		—		—		0,01		—	

Tabel'e 2 (Fortsetzung) — 2. táblázat (folytatás)

Sammelstellen, Zeitpunkt Gyűjtőhelyek, időpont		M_0		K		G		A_1		E_e	
Artenverzeichnis Fajok felsorolása		i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25
<i>Cocconeis placentula</i> EHR.	VI. X.	0,05 —	N	— —		— —		— —		— —	
<i>Cocconeis placentula</i> var. <i>euglypta</i> (EHR.) CLEVE	X.	—	N	—		—		—		—	
<i>Cyclotella bodanica</i> EULENST.	VI. VII. VIII. IX. X.	31,85 7,5 8,1 3,2 1,8	+ N + N +	44,5 39,0 6,0 1,55 7,2	 + +	30,0 35,5 1,75 2,7 4,0	+ + +	30,55 15,25 10,75 3,75 3,65	+ N N + +	15,1 16,5 2,75 3,8 2,6	+ N N +
<i>Cyclotella meneghiniana</i> KÜTZ.	VIII. IX.	— 0,07		— —		— —		— —	+	— —	
<i>Cyclotella ocellata</i> PANT.	VI. VII. VIII. IX. X.	16,75 9,8 7,8 3,8 5,0	+ N + N 	34,5 64,5 8,1 3,75 10,55	+ + 	23,75 58,25 2,75 5,75 5,85	+ + +	30,0 26,0 11,3 7,75 4,95	+ N N + + N +	19,35 21,35 4,05 7,07 4,3	+ N + N + N +
<i>Cymatopleura angulata</i> GREV.	VI.	0,01		—		—		—		—	
<i>Cymatopleura elliptica</i> (BRÉB.) W. SMITH	VI. VII. VIII. IX. X.	0,32 — 0,05 — 0,02	+ N N + N + +	0,6 0,07 0,46 0,1	+ + + +	1,1 0,01 0,15 0,2 —	+ + + 	0,4 0,31 0,32 0,05 0,07	+ N + N + N + N +	0,05 0,16 0,1 0,2 0,02	+ N + N + N + N +
<i>Cymatopleura solea</i> (BRÉB.) W. SMITH	VI. VII. VIII. X.	— — — —	N N 	— — — —		0,02 — — —	+ 	0,07 0,04 0,04 —	N + N 	0,05 0,02 — 0,05	 +

<i>Cymatopleura solea</i> var. <i>regula</i> (EHR.) GRUN.	VI.	—	+	—		—	+	—		—	
<i>Cymbella affinis</i> KÜTZ.	VI.	0,1		—		—		—		—	N
	VII.	—		—		—		—		—	
	VIII.	—		—		—		0,1		—	
	IX.	—		0,05		—		0,05		—	
	X.	—		0,05		—		—		—	
<i>Cymbella cymbiformis</i> (KÜTZ.) V. HEURCK.	VI.	—		0,05		—		0,2	N	0,05	
	VII.	—		—		—		0,05		—	
	VIII.	—	N	—		—		—		—	
	IX.	—		—		—		—		0,08	
	X.	—	N	—		—		—		—	
<i>Cymbella lanceolata</i> (KÜTZ.) V. HEURCK.	VII.	—	N	—		—		—		—	N
	IX.	—		—		—		—		—	+ N
	X.	—	N	0,05		—		—		—	
<i>Cymbella prostata</i> (BERK.) CLEVE	VI.	—		—		0,05		—		—	
	IX.	—		—		—		—		—	+
	X.	—	N	—		—		—		—	
<i>Diatoma vulgare</i> var. <i>brevis</i> GRUN.	X.	—	N	—		—		—		—	
<i>Diatoma vulgare</i> var. <i>producta</i> GRUN.	VI.	—		—		—		0,1		—	
<i>Diploneis domblittensis</i> (GRUN.) CLEVE	VI.	—		—		—		0,15		—	
	VIII.	0,3	N	—		—		—	+	—	
	IX.	—		—		—		—		0,07	
	X.	—	N	—		—		0,2		—	
<i>Diploneis elliptica</i> (KÜTZ.) CLEVE	VI.	0,2		—		0,2		1,7	+	0,3	
	VII.	—		—		0,05		0,9	N	0,4	N
	VIII.	—		—		0,2		1,85		0,3	
	IX.	—		—		—		1,0		0,6	
	X.	—	N	—		—		0,45		0,1	
											+

Tabelle 2 (Fortsetzung) — 2. táblázat (folytatás)

Sammelstellen, Zeitpunkt Gyűjtőhelyek, időpont		M_0		K		G		A_1		E_0	
Artenverzeichnis Fajok felsorolása		i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25
<i>Diploneis puella</i> (SCHUM.) CLEVE	VI. VII. IX. X.	0,1 — — —		— — — —		— — — —		— 0,05 — —		— — 0,13 0,1	N
<i>Epithemia hyndmanni</i> W. SMITH	VI. VII. VIII.	— — —	N N	— — —		— — —		— — —	+	— — —	
<i>Epithemia sorex</i> KÜTZ.	VI. VII. IX.	— — —		— — —		— — —		— — 0,05		0,05 0,05 —	
<i>Epithemia turgida</i> (EHR.) KÜTZ.	VI.	0,01		—		—		—		—	
<i>Eunotia valida</i> HUST.	VI.	0,05		—		—		—		—	
<i>Fragilaria construens</i> (EHR.) GRUN.	VI. VII. VIII. IX. X.	11,25 0,6 10,8 0,33 1,0	N N N +	0,9 1,75 3,0 0,5 0,75	++ +	1,0 — — 0,25 1,25	 + 	9,65 5,6 7,85 0,5 2,0	+ N + 	— 0,35 — 0,13 1,0	 +
<i>Fragilaria crotonensis</i> KITTON	VII. VIII.	— 0,07	+ +	— —	+ 	— —	 	— —	 	— —	
<i>Fragilaria pinnata</i> EHR.	VI. VII. VIII. X.	4,4 — — —	+ 	0,47 — — —	 	— — — —	+ 	1,0 0,5 0,25 0,5	 	— — 0,5 0,5	
<i>Gomphonema intricatum</i> var. <i>vibrio</i> (EHR.) CLEVE	VIII.	—		—		—		0,05		—	

<i>Gomphonema olivaceum</i> (LYNGB.) KÜTZ.	VI.	0,1		—		—		—		—	+ N
	IX.	—		—		—		—		0,07	
	X.	—	+ N	—		—		—		—	
<i>Gyrosigma acuminatum</i> (KÜTZ.) RABH.	VI.	—		—		—		—	N	—	N
	VII.	—		—		—		—		0,1	
	VIII.	—		—		—		—		0,05	
	X.	—	N	—		—		—		—	
<i>Gyrosigma attenuatum</i> (KÜTZ.) RABH.	VI.	—	N	—		—		—	+	—	
	VIII.	—		—		—		0,01		—	
	IX.	—	N	—		—		—		—	
	X.	—	N	—		—		—		—	
<i>Gyrosigma distortum</i> var. <i>parkeri</i> HARRIS	VI.	0,1	N	—		—		—		0,15	
	VII.	—		—		0,05		0,1		0,45	
	VIII.	—	N	—		—		0,1		0,25	
	IX.	—		—		—		—		0,27	
<i>Gyrosigma kützingii</i> (GRUN.) CLEVE	VI.	0,31	N	0,02		0,1		—		0,15	+ N
	VII.	—	N	—		—		0,25		0,3	
	VIII.	—		—		—		—		—	
	IX.	—	N	—		0,1		0,05		0,53	
	X.	—	N	—		—	+	0,05		0,3	
<i>Gyrosigma prolongatum</i> (W. SMITH) CLEVE	VI.	—		—		—		—	N	—	
	VII.	—	N	—		—		—		—	
	VIII.	—	N	—		—		—		—	
	IX.	—	N	—		—		—		—	
	X.	—	N	—		—		—		—	
<i>Mastogloia smithii</i> var. <i>amphicephala</i> GRUN.	VII.	—		—		—		0,05		—	
<i>Melosira granulata</i> (EHR.) RALFS	VI.	2,25	+	2,35	+	2,4	+	3,3	+ N	0,85	+ N
	VII.	7,5	+	23,0	+	2,0	+	6,1	+ N	3,15	+ N
	VIII.	1612,0	+ N	441,0	+	2,05	+	25,0	+ N	9,7	+ N
	IX.	76,0	+ N	23,25	+	1,25	+	1,5	+ N	4,47	+ N
	X.	16,7	N	8,1	+	—		0,4	+	0,45	+

Tabelle 2 (Fortsetzung) — 2. táblázat (folytatás)

Sammelstellen, Zeitpunkt Gyűjtőhelyek, időpont		M_0		K		G		A_1		E_e	
Artenverzeichnis Fajok felsorolása		i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25
<i>Melosira granulata</i> var. <i>angustissima</i> O. MÜLL.	VI.	—	+ N	0,92	+	—	+	—	N	0,25	+ N
	VII.	44,6	+ N	45,0	+	4,5	+	2,05	+ N	—	+ N
	VIII.	1236,0	+ N	544,5	+	5,15	+	5,5	+ N	5,25	+ N
	IX.	95,33	+ N	37,5	+	5,0	+	2,25	+ N	1,07	+ N
	X.	23,73	+	21,0	+	—	+	0,5	—	0,75	+
<i>Melosira granulata</i> var. <i>angustissima</i> f. <i>spirale</i> MÜLL.	VII.	1,8	+	1,0	+	—	—	—	—	—	—
	VIII.	7,2	+ N	0,01	—	—	—	—	—	—	—
	IX.	0,33	N	0,25	—	—	—	—	—	—	—
	X.	—	—	—	—	—	+	—	—	—	—
<i>Melosira varians</i> C. A. AG.	VIII.	—	N	—	—	—	—	—	—	—	—
	IX.	—	N	—	—	—	—	—	—	—	—
	X.	—	N	—	—	—	+	—	—	—	—
<i>Navicula costulata</i> GRUN.	VI.	0,5	—	—	—	—	+	—	—	—	—
	VIII.	—	N	—	—	—	—	—	—	—	—
<i>Navicula cryptocephala</i> KÜTZ.	VI.	0,25	—	—	—	0,55	—	1,1	—	0,35	—
	VII.	—	—	0,05	—	—	—	0,75	—	0,7	—
	VIII.	—	—	—	—	—	—	0,15	—	0,35	—
	IX.	0,07	—	—	—	0,05	—	0,05	—	0,47	—
	X.	—	N	—	—	—	—	—	—	0,1	—
<i>Navicula dicephala</i> (EHR.) W. SMITH	VI.	0,05	—	—	—	—	—	0,1	—	0,05	—
	VII.	—	—	—	—	—	—	0,05	—	—	—
	X.	—	N	—	—	—	—	—	—	—	—

<i>Navicula gracilis</i> EHR.	VI.	0,65		1,15		1,15		0,8		0,3	
	VII.	0,1		0,05		—		0,85		0,3	
	VIII.	0,3		—		—		0,05		—	
	IX.	—	+ N	—		—		—		—	+
	X.	—	+ N	0,05		—		—		0,1	
<i>Navicula hungarica</i> var. <i>capitata</i> (EHR.) CLEVE	VI.	0,15		0,8		0,75		—		—	
	VIII.	—	N	—		—		0,3		—	
	IX.	—		0,1		—		0,05		—	
	X.	—	N	—		0,1		—		—	
<i>Navicula placentula</i> (EHR.) GRUN.	VI.	0,3		0,1		—		0,1		—	
	VIII.	—		—		—		0,05		—	+
	IX.	—		—		—		—		0,13	
	X.	—		0,1		0,25		0,15		0,1	
<i>Navicula pupula</i> KÜTZ.	X.	—		—		—		0,15		—	
<i>Navicula reinhardtii</i> GRUN.	VI.	0,1		—		—		—		—	
<i>Neidium dubium</i> f. <i>constricta</i> HUST.	VI.	—		—		—		0,05		—	
<i>Nitzschia acicularis</i> W. SMITH	VI.	1,15		0,2		—		0,95		0,2	N
	VII.	—		0,05		—		1,15		0,5	
	VIII.	—		—		—		0,6		0,2	
	IX.	—		—		0,7		0,15		0,67	
	X.	—		0,8		0,75		1,1		0,45	
<i>Nitzschia amphibia</i> GRUN.	VI.	1,3		0,45		1,45	+	0,1		0,2	
	VII.	0,2	N	0,05		—		0,2		0,4	
	VIII.	—	N	—		—		—		0,1	
	IX.	—		—		0,2		0,05		0,07	
	X.	0,13	N	0,1	+	0,05		0,2		0,35	
<i>Nitzschia angustata</i> (W. SMITH) GRUN.	VI.	0,25		—		—		—		—	
	X.	—	N	—		—		—		—	

Tabelle 2 (Fortsetzung) — 2. táblázat (folytatás)

Sammelstellen, Zeitpunkt Gyűjtőhelyek, időpont		M_e		K		G		A_1		E_e	
Artenverzeichnis Fajok felsorolása		i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25
<i>Nitzschia commutata</i> GRUN.	X.	—	N	—		—		—		—	
<i>Nitzschia palea</i> (KÜTZ.) W. SMITH	VI.	—		—		—	+	—		—	
	VII.	—	N	—		—		—		—	
	VIII.	—		—		—		0,15		—	
	IX.	0,07		—		—		—		—	
<i>Nitzschia sigmoidea</i> (EHR.) W. SMITH	VI.	0,09	+ N	0,32	+	0,02		0,35	+ N	0,05	N
	VII.	0,3		0,1		—		0,4	+ N	0,15	+
	VIII.	—	N	—		0,05		0,35	+	0,07	N
	IX.	0,07	N	—		—	+	—	+	0,07	+
	X.	—	N	0,1		—		0,17	+	0,11	
<i>Nitzschia tryblionella</i> var. <i>debilis</i> (ARNOTT) A. MAYER	VI.	0,3		0,1		0,7	+	—		—	
	VII.	0,05		0,05		—		0,2		0,15	
	VIII.	—	N	0,3		0,05		0,1		0,15	+
	IX.	—		—		—		0,1		—	
	X.	—		0,05		—		0,1		—	
<i>Opephora martyi</i> HÉRIBAUD	VI.	0,2		—		—		0,1		—	
	VIII.	—		—		—		0,05		—	
	IX.	0,07		—		0,05		0,05		—	
	X.	—		0,05		—		0,15		—	
<i>Pinnularia microstauron</i> (EHR.) CLEVE	VI.	0,01		—		—		—		—	
<i>Rhoicosphenia curvata</i> (KÜTZ.) GRUN.	VI.	—		—		—		0,05		—	
	VIII.	—		—		—		0,05		—	
	X.	—	N	—		—		—		—	
<i>Rhopalodia gibba</i> (EHR.) O. MÜLL.	IX.	—		—		—		—		—	+
	X.	—	N	—		—		—		—	

<i>Stenopterobia pelagica</i> HUST.	VI.	0,06	N	0,05		0,1		0,05	+	—	
	VII.	—		0,05		—		0,24	++ N	0,05	
	VIII.	—	N	—		0,05		0,12	+	0,1	
	IX.	—		0,05		0,1		—		—	
	X.	—		—		—		0,02		—	
<i>Surirella biseriata</i> BRÉB.	VII.	—	N	—		—		—		—	
	IX.	—	N	—		—		—		—	
	X.	—	N	—		—		—		—	
<i>Surirella linearis</i> W. SMITH	VI.	—	+ N	—		—		—		—	
	IX.	—	N	—		—		—		—	
<i>Surirella robusta</i> var. <i>splendida</i> (EHR.) V. HEURCK	VI.	0,16	+ N	0,3	+	0,2	+	0,15	+ N	0,07	N
	VII.	—	+	0,05		0,02		0,35	+ N	0,06	+ N
	VIII.	—	N	—		—		0,14	+	0,04	+ N
	IX.	0,02	+ N	—		0,07	+	0,02	+ N	0,03	
	X.	—	+ N	—	+	—		—	+	0,01	
<i>Surirella tenera</i> var. <i>nervosa</i> A. SCHMIDT	VI.	—	N	—		—		—	N	—	
	VII.	—		—		—		—	N	—	+ N
	IX.	—		—		—		—	+	—	
<i>Surirella turgida</i> W. SMITH	VII.	—		—		—		0,1		0,05	
	VIII.	—		—		—		—		0,05	
<i>Synedra acus</i> var. <i>angustissima</i> GRUN.	VI.	0,55	N	0,05	+	0,5	+	0,7	+ N	1,25	N
	VII.	—		0,05	+	—		0,85	N	0,05	N
	VIII.	1,2	+ N	—		0,15		0,95	+	0,3	+ N
	IX.	—		0,05		0,7		0,15		0,13	+ N
	X.	—	+	0,1		—		—	+	—	
<i>Synedra parasitica</i> (W. SMITH) HUST.	VI.	0,05		—	+	—		—		—	
	VII.	—		—		—		—		0,05	
<i>Synedra ulna</i> (NITZSCH) EHR.	VI.	0,05		—		—		—		0,05	
	VII.	—		—		—		—	+	—	
	VIII.	—	N	—		—		—		—	

Tabelle 2 (Fortsetzung) — 2. táblázat (folytatás)

Sammelstellen, Zeitpunkt Gyűjtőhelyek, időpont		M_0		K		G		A_1		E_e	
Artenverzeichnis Fajok felsorolása		i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25
<i>Synedra ulna</i> var. <i>spatulifera</i> GRUN.	VII. VIII. X.	— — —	N N	— — —	 	— — —	 	— — —	 + 	— — —	
CHLOROPHYTA											
<i>Actinastrum hantzschii</i> LAGERH.	VI.	0,15		—		—		—		—	
<i>Ankistrodesmus falcatus</i> (CORDA) RALFS	VI. VII. VIII. IX. X.	0,25 0,2 0,3 — 0,13	 + 	0,9 — — — 0,55	 + 	0,15 0,4 2,9 — 0,35	+ + 	2,8 1,05 0,55 0,35 0,2	N + N 	1,2 0,4 0,7 0,2 0,35	N N
<i>Ankistrodesmus falcatus</i> var. <i>acicularis</i> (A. BRAUN) G. S. WEST	VI. VII. VIII. IX. X.	0,1 0,05 1,2 0,47 0,8	 + + 	0,45 0,4 0,9 2,25 2,55	 + 	— 1,15 — 2,55 1,9	 + 	0,9 2,4 3,1 3,45 1,35	N N + 	0,45 3,45 2,75 2,7 0,45	N N + + N +
<i>Ankistrodesmus falcatus</i> var. <i>mirabile</i> W. et G. S. WEST	VI. VII. VIII. IX. X.	0,16 0,25 0,3 — —	 + 	— — — 0,05 —	 	0,35 — 1,8 0,05 —	+ + 	0,1 — 1,1 — —	 	0,4 1,25 1,3 — —	
<i>Ankistrodesmus falcatus</i> var. <i>spirillifor-</i> <i>mis</i> G. S. WEST	VI. VII. VIII. IX. X.	— — — — 0,07	+ 	0,05 — 0,6 0,15 0,1	+ 	— 0,03 0,55 — 0,15	+ 	0,5 0,5 0,05 0,1 0,25	N 	1,6 0,2 — 0,47 0,25	+ N +

<i>Ankistrodesmus lacustris</i> (CHOD.) OSTENF.	VI.	0,21		1,2	+	5,75	+	4,6	+ N	1,1	N
	VII.	—		—		—		1,15		1,0	N
	VIII.	0,6		0,6	+	0,2		1,4		0,35	N
	IX.	—		—		0,55		0,65		0,4	N
	X.	0,13		0,05		0,3		0,35		0,2	
<i>Ankistrodesmus longissimus</i> (LEMM.) WILLE	IX.	—		—		0,05		—		—	
	X.	—		—		—	+	—		—	
<i>Ankistrodesmus setigerus</i> (SCHRÖDER) G. S. WEST	VI.	0,05		—		—		—		—	
	VIII.	0,3		—		—		0,15		1,0	
	IX.	—		0,1		—		—		—	
	X.	—		—		—		—		0,1	
<i>Chlamydomonas</i> sp.	VI.	—		—		—	+	—		—	+ N
	VII.	0,1	N	—		0,05		—		—	
	IX.	—	N	—		—		—		—	
<i>Closterium acerosum</i> (SCHRANK.) EHRENB.	VI.	0,02		0,2		—		0,3		0,15	
	VII.	—		—		0,1		—		—	
	VIII.	—		0,3		0,02		—		—	
	IX.	—		0,15		0,05		0,05		—	
	X.	—	N	0,05		—		—		—	
<i>Closterium acerosum</i> var. <i>elongatum</i> BRÉB.	VII.	—		—		—		—		0,05	
	VIII.	—		—		—		—		0,35	
	IX.	—		—		—		0,15		—	
<i>Closterium aciculare</i> WEST	VI.	—		—		0,4		0,45	+	0,17	+ N
	VII.	—		—		—		0,05	+ N	0,65	+ N
	VIII.	—		—		0,3		0,5	+ N	2,05	+ N
	IX.	—		0,2		0,3	+	0,3	+ N	0,1	+ N
	X.	—		0,05		0,15	+	0,05		0,04	
<i>Closterium polystictum</i> NYGAARD	VIII.	—		—		—		—	N	—	
<i>Closterium pronum</i> BRÉB.	VIII.	—		—		—		0,05		—	

Tabelle 2 (Fortsetzung) — 2. táblázat (folytatás)

Sammelstellen, Zeitpunkt Gyűjtőhelyek, időpont		M_0		K		G		A_1		E_e	
Artenverzeichnis Fajok felsorolása		i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25
<i>Closterium strigosum</i> BRÉB.	VI. VII. VIII. IX.	0,01 — — 0,07		0,4 — — —		0,2 — — 0,05		0,05 — — —		0,05 0,15 0,05 —	
<i>Closterium venus</i> KÜTZ.	VIII.	—		—		—		0,05		—	
<i>Coelastrum microporum</i> NAEG.	VI. VII. VIII. IX. X.	0,1 — 0,31 — —	+ N	— — — — —	+ +	— — — — —		— — — — —	+ + N + N +	— — 0,01 0,07 —	+ + N + N + N +
* <i>Cosmarium depressum</i> (NAEG.) LUND.	VI. VII.	— —		— —		— —		0,05 0,4		— 0,1	
<i>Cosmarium undulatum</i> CORDA	VI. VIII.	— —		— —		— —		0,2 —	+ 	0,15 —	
<i>Crucigenia quadrata</i> var. <i>octogona</i> SCHMIDLE	VI. VII. VIII. IX. X.	0,46 — 2,11 0,27 0,53		5,57 1,6 — 0,55 1,95		0,85 0,2 0,4 0,6 1,55		0,6 1,0 2,7 3,6 1,05	 N + N +	2,05 4,45 4,95 1,27 —	 N + N +
<i>Dictyosphaerium ehrenbergianum</i> NAEG.	VI. VIII.	— —		— —	+ 	— —		— —	 N	—	
<i>Dictyosphaerium pulchellum</i> WOOD	VI. VII. VIII. IX. X.	0,6 0,1 0,9 0,07 1,0	 + + + +	3,85 0,5 0,6 0,65 1,0	+ + + + +	2,25 0,3 1,05 1,15 0,5	+ + + + +	2,95 1,7 0,75 0,45 0,1	+ + + N + +	0,35 0,6 0,65 0,33 0,2	N + N N N +

<i>Eudorina elegans</i> EHR.	VI. VII.	0,01 —	N N	— —	+	— —		— —		— —	
<i>Gloeococcus schroeteri</i> (CHOD.) LEMM.	VI.	0,01		—		—		—		—	
<i>Gonium pectorale</i> MÜLLER	VIII.	—	+	—		—		—		—	
<i>Hofmania lauterborni</i> (SCHMIDLE) WILLE	VII.	—	+	—		—		—		—	
<i>Kirchneriella lunaris</i> (KIRCHN.) MOEBIUS	VI. VII. VIII. X.	0,15 — — —	 N	— — — —		— — — —		— — — —	+ N	— — — —	N +
<i>Kirchneriella lunaris</i> var. <i>dianae</i> BOHLIN	IX.	—		—		—		—		—	+
<i>Kirchneriella obesa</i> (W. WEST) SCHMIDLE	VI. VII. IX.	0,1 — —	 + 	— — —		— — —		— — —	N	0,15 — —	+ N + N + N
<i>Oocystis elliptica</i> f. <i>minor</i> W. WEST	VI. VII. IX. X.	— — — —		— — — —	+	— — — —	+	0,1 0,05 — —	+	— 0,2 — —	N +
<i>Oocystis solitaria</i> WITTR.	VI. VII. VIII. IX. X.	0,35 0,25 3,6 0,2 —	+ + 	2,0 0,35 3,0 0,22 0,12	 + +	1,25 0,25 0,75 0,09 0,05	+ + + 	0,55 0,7 0,4 0,3 0,2	+ + N + + N +	0,15 0,2 0,55 0,2 0,3	N N + N +
<i>Oocystis solitaria</i> f. <i>wittrockiana</i> PRINTZ	VI. VII. VIII. IX. X.	— — 2,4 0,07 0,07	 + + 	0,05 — 0,6 — 0,15	 + +	0,05 — 0,15 0,15 0,45	 + +	0,15 0,15 0,3 0,15 0,25	+ + N + N N	0,05 0,35 1,15 0,13 0,45	+ + N + + +

Tabelle 2 (Fortsetzung) — 2. táblázat (folytatás)

Sammelstellen, Zeitpunkt Gyűjtőhelyek, időpont		M _o		K		G		A ₁		E _o	
Artenverzeichnis Fajok felsorolása		i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25
<i>Oocystis submarina</i> LAGERH.	VI. VII. VIII. IX. X.	0,1 0,3 2,1 — 0,07	+	1,4 0,5 0,6 — 0,2		0,65 0,05 0,2 0,05 0,1	+ + + +	0,45 0,25 0,3 0,3 —	 + + N	0,15 0,4 0,35 0,1 0,12	 + + +
<i>Pandorina morum</i> (MÜLLER) BORY	VIII. IX. X.	— — —	 + + N	0,3 — —		— — —	 +	— — —		— — —	
<i>Pediastrum boryanum</i> (TURP.) MENEGH.	VI. VII. VIII. IX. X.	0,1 — 0,01 — —	+ N + N N N +	0,1 — — — —	+ 	— — 0,02 — —	+ +	— — — — —	N + 	— — — — —	 N
<i>Pediastrum clathratum</i> (SCHROET.) LEMM.	VI. VII. VIII. IX. X.	— 0,1 0,04 — —	+ N + N +	0,05 — 0,02 0,1 0,01	+ + + + +	0,05 0,05 0,01 0,12 0,06	+ + + + +	0,05 — — 0,02 —	+ N + N + + N +	0,01 — 0,07 0,08 0,04	+ N + N + + +
<i>Pediastrum duplex</i> var. <i>genuinum</i> A. BRAUN.	VI. VIII. IX. X.	— — — —	+ N 	— — — —	 +	— — — —	+ 	— — — —	 +	— — — —	 +
<i>Pediastrum duplex</i> var. <i>reticulatum</i> LAGERH.	VI. VII. VIII. IX. X.	0,07 0,25 0,01 — —	+ N + N N + N +	0,1 0,7 0,32 0,15 0,3	+ + + + +	0,1 0,1 0,05 — —	+ + + + +	0,15 0,21 0,05 0,15 0,09	+ N + N + N + N +	0,07 0,11 0,06 — 0,02	+ N + + N + N +

<i>Pediastrum simplex</i> RALFS	VI.	0,01		—		—		—	N	—	N
	VII.	0,05	N	—		0,02		—	N	—	N
	VIII.	0,01	N	0,02		—		0,04	N	—	+
	IX.	—		—	+	0,02	+	—	N	—	+
	X.	—	+ N	—		0,02		—	+	—	+
<i>Rhopalosolen sebestyeniae</i> FOTT	VII.	—		—		—		—	+	—	+
	VIII.	—		—	+	—		—	+	—	+
	IX.	—		—		—		—	+	—	+
<i>Scenedesmus acuminatus</i> (LAGERH.) CHOD.	VI.	0,01		—		—		—		—	
	X.	0,07		—		—		—		—	
<i>Scenedesmus balatonicus</i> HORTOB.	VI.	—		—		—		0,02		—	
	VII.	—		—		—		0,07	N	0,11	
	VIII.	—		—		0,01		0,09		0,02	
	IX.	—		—		0,02		0,4		0,13	+
	X.	—		—		0,01		0,02		0,01	N
<i>Scenedesmus ecornis</i> (RALFS) CHOD.	VI.	—		—		—	+	—		—	
	VII.	—		—		—		—	N	—	
	VIII.	—	+	—		0,1		0,35		0,05	
	IX.	—		—		—		—		0,03	N
	X.	—		0,1	+	—	+	0,3		0,3	
<i>Scenedesmus ecornis</i> var. <i>disciformis</i> CHOD.	VII.	—		—		—		—		—	N
	VIII.	0,3		—		—		—		—	
<i>Scenedesmus intermedius</i> var. <i>balatonicus</i> HORTOB.	VI.	0,31	+	—		—		—	N	—	
	IX.	—	N	—		—		—		—	
<i>Scenedesmus intermedius</i> var. <i>bicaudatus</i> HORTOB.	VI.	—		—		—		0,05		0,15	
	VII.	—		—		—		—		0,05	
	VIII.	—		—		—		—		0,1	
	IX.	—		—		—		0,1		—	
	X.	0,07		—		—		0,05		—	

Tabelle 2 (Fortsetzung) 2. táblázat (Folytatás)

Sammelstellen, Zeitpunkt Gyűjtőhelyek, időpont		M_0		K		G		A_1		E_s	
Artenverzeichnis Fajok felsorolása		i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25	i/l	Nr. 25
<i>Scenedesmus arcuatus</i> LEMM. forma UHERKOV.	VI.	—		—		0,05		—		—	+
	VII.	—		—		—		0,15	N	0,01	
	VIII.	—		0,3		—		0,05	N	—	N
	IX.	—	+	—		0,05		—		—	
	X.	—		—		—		—		—	+
<i>Scenedesmus quadricauda</i> (TURP.) BRÉB.	VI.	0,7		0,2	+	—	+	0,2	N	0,35	+
	VII.	—	N	0,15		—		0,25		0,05	+
	VIII.	0,31	N	0,9		0,05		0,2		0,45	
	IX.	—	N	0,02		0,15		0,35		0,47	+
	X.	0,4	+ N	0,15		0,12		0,1		0,2	N
<i>Selenastrum gracile</i> REINSCH	VI.	—		—	+	0,05	+	0,1	N	—	
	VIII.	—		—		—		0,05		—	
	IX.	—		—		—		—		—	+
	X.	—	+	—		—		—		—	
<i>Staurastrum gracile</i> RALFS	VI.	0,21		—	+	0,2		0,02	N	0,07	+ N
	VII.	0,05	+	0,35	+	0,85	+	1,0	+	0,45	+ N
	VIII.	0,01		0,01	+	0,65	+	0,7	+ N	1,35	+ N
	IX.	—		0,3	+	0,85	+	0,75	+ N	0,85	+ N
	X.	—		0,2	+	0,8	+	0,85	+	0,45	+
<i>Staurastrum paradoxum</i> MEYEN	VI.	0,11		—	+	0,2	+	—	+	0,02	
	VII.	—	+ N	0,05	+	0,2	+	—	+ N	0,2	+
	VIII.	0,31	+ N	—		0,8	+	0,75	+ N	0,1	+ N
	IX.	0,13	+ N	0,15	+	0,3	+	0,1	+ N	—	+ N
	X.	—	+	0,2	+	0,2	+	0,25	+	0,3	
<i>Stylosphaeridium stipitatum</i> GEITLER	VIII.	—		—		—	+	—		—	
	IX.	—		—		—		—	+	—	
	X.	—		—		—		—		—	+

* <i>Tetraëdron longispinum</i> (PERTY) HANSGIRG	VIII.	—	+	—		—		—		—	
<i>Tetraëdron minimum</i> (A. BRAUN) HANSGIRG	VI.	0,1		—		—		—		—	
<i>Tetraëdron trilobatum</i> (REINSCH) HANSG.	X.	—		—		—	+	—		—	
<i>Tetrastrum heteracanthum</i> (NORDSTEDT) CHOD.	VIII.	—	+	—		—		—		—	
<i>Tetrastrum staurogeniaeforme</i> (SCHROEDER) LEMM.	IX.	—		—		0,1		—		—	
	X.	—	N	0,05		—		—		—	
MYCOPHYTA											
<i>Dactylosporium</i> sp.	VI.	0,21		—	+	—	+	—		0,07	
	VII.	—		—		0,1		0,05		—	
	X.	—		0,15		—		—		—	

Die zur *Xanthophyceae*-Klasse dieses Stammes gehörige *Planktonema lauterborni* erreicht im Balaton das Maximum ihrer Populationsdichte zur Warmwasserzeit (TAMÁS 1954, 208); demnach ist ihre ziemlich hohe Individuenzahl in den Proben nur natürlich. Der epiphyte *Stipitococcus urceolatus* bzw. sein Vorkommen in größerer Populationsdichte in den Proben hängt von der Häufigkeit der zu einer Anheftung geeigneten Wirtspflanzen (*Coelosphaerium*, *Gomphosphaeria*, *Microcystis*, *Asterionella*, *Attheya*, *Pediastrum*) als auch von der entsprechenden Temperatur (etwa 20 °C) des Wassers ab (vgl. TAMÁS 1962, 270).

Von den Vertretern der Klasse *Chrysophyceae* erreicht *Dinobryon divergens* im Juli in der Bucht von Keszthely eine — im Vergleich zu den Ergebnissen der früheren Jahre (TAMÁS 1965a) — auffallend hohe Individuenzahl von 39 750 pro Liter und im Abschnitt zwischen Szigliget und Balatonmária eine solche von 22 250 pro Liter. Ein epibiontes Vorkommen von *Cephalothamnion cyclopus* war in den Netzfilterproben häufig auf Planktonkrebsen zu beobachten (vgl. KOL 1938; SEBESTYÉN 1951).

Salpingoeca frequentissima fand sich in *Coelosphaerium*- und *Dictyosphaerium*-Kolonien in den Netzfilterproben (vgl. HORTOBÁGYI 1942, 66).

Laut der von Juni bis Oktober geschöpften Proben wechselte das prozentuelle Vorkommen der Arten dieses Stammes stellenweise zwischen 18 und 99,4%. Der Stamm erreichte 51% der gesamten Algenartenzahl.

Vom Standpunkte der Häufigkeit seines Vorkommens nimmt der *Chlorophyten*-Stamm die zweite Stelle ein. Die überwiegende Mehrzahl der hierher gehörigen 57 Arten fällt in die Ordnung der *Chlorococcales*. Diese erreichen das Maximum ihrer Populationsdichte zur Warmwasserzeit (Wassertemperatur in den Monaten Juli—August über 20 °C). Ihre Populationsdichte ist stellenweise recht bedeutend (Tab. 2).

Von den pelagischen Arten ist in den geschöpften Proben die Individuenzahl von *Ankistrodesmus*, *Dictyosphaerium pulchellum*, *Oocystis*, *Scenedemus* stellenweise bedeutend. Von den *Desmidiaceen* erreichte *Closterium aciculare* in den Sommerproben des Segmentes Balatonalmádi—Balatonvilágos die höchsten Werte. *Staurastrum gracile* und *S. paradoxum* kamen ebenfalls häufig vor.

Stellenweise konnten wir die epibionte Grünalge *Rhopalosolen sebestyénae* von den Zooplankton-Individuen von *Diaphanosoma* und *Daphnia* aufzeichnen (vgl. SEBESTYÉN 1951, 162; FOTT 1958, 350; TAMÁS 1965a, 233). Die epiphyte Grünalge *Stylosphaeridium stipitatum* kam zur Warmwasserzeit je nach Vorhandensein und Häufigkeit ihrer Wirtspflanzen in den Proben vor (vgl. TAMÁS 1962, 268; 1965a, 233). —

Das prozentuelle Vorkommen der Arten des Stammes wechselte an den Sammelstellen von Juli bis Oktober nach dem Inhalte der geschöpften Proben zwischen 0,3—21%. Der Stamm machte 34% der gesamten Algenartenzahl aus.

In dem der Reihenfolge nach nächsten Stamm der *Cyanophyten* kamen 17 Arten in sämtlichen Proben vor. Jene pelagischen Arten, die im allgemeinen ihre maximale Anzahl zur Zeit des warmen Wassers erreichen, wie z. B. *Aphanizomenon flos-aquae* var. *klebahnii* und *Lyngbya* kamen auch jetzt wiederum in den geschöpften Proben, den Untersuchungsergebnissen des vorigen Jahres ähnlich (TAMÁS 1954, 1965a), in hoher Individuenzahl vor (Tab. 2). *Aphanocapsa delicatissima*, *Aphanothece clathrata* var. *brevis*, *Coelosphaerium kützingerianum*, *Gomphosphaeria lacustris* und *Microcystis flos-aquae* fanden sich stellenweise ebenfalls in hoher Individuenzahl pro Liter.

Das perzentuelle Vorkommen der Stammesarten wechselte zwischen den Monaten Juni—Oktober nach dem Inhalte der geschöpften Proben je Sammelstelle zwischen 0,1—40%. Der Stamm machte 10,2% der gesamten Algenartenzahl aus.

Der Häufigkeit seines Vorkommens nach folgt nunmehr der Stamm der *Euglenophyten*, dessen 14 Arten in sämtlichen Proben enthalten sind. In Anbetracht der in den geschöpften Proben gefundenen niedrigen Werte kann ihr Vorkommen als sporadisch bezeichnet werden. Mit den vertikalen Daten der *Euglena*-Arten beabsichtige ich mich in einer anderen Studie eingehender zu beschäftigen.

Die als Epibionten der Planktonkrebse und Rotatorien bekannten *Colacium cyclopicola*, *Colacium simplex* und *Colacium vesiculosum* (TAMÁS 1964a, 248; 1965a, 234; 1966b) kamen in den Netzfilterproben häufig vor.

Das perzentuelle Vorkommen des Stammes wechselte in der Zeit zwischen Juni und Oktober in den geschöpften Proben zwischen 0,09—4,1%. Der Stamm betrug 8,4% der gesamten Algenartenzahl.

Von zwei Klassen des *Pyrrophyten*-Stammes fanden sich 7 Vertreter (*Cryptophyceae* 2, *Dinophyceae* 5) in allen Proben. *Ceratium hirundella* kam im August zwischen Ságpusztá und Balatonszemes mit 49 500 pro Liter, zwischen Szigliget und Balatonmária im September mit 46 320 pro Liter vor (vgl. SEBESTYÉN 1953, 66; 1959, 270; TAMÁS 1965a, 234 und Tab. 2). Über die vertikalen Zahlenangaben von *Ceratium hirundinella*, *Diplopsalis acuta* und *Gonyaulax apiculata* möchte ich mich an dieser Stelle nicht ausbreiten.

Das perzentuelle Vorkommen der Arten des Stammes wechselte zwischen Juni und Oktober auf Grund der geschöpften Proben je nach Sammelstelle zwischen 0 und 63%. Der Stamm betrug 4,2% der gesamten Algenartenzahl.

Der *Mycophyten*-Stamm war durch *Dactylosporium* sp. (BARNETT 1960) vertreten und kam zeitweise an allen Sammelstellen, jedoch in sehr geringer Individuenzahl vor (vgl. TAMÁS 1965a, 234; 1966a 196). Das perzentuelle Vorkommen des Stammes wechselte auf Grund der geschöpften Proben von Juni bis Oktober stellenweise zwischen 0—0,2% und betrug 1% der gesamten Algenartenzahl.

An Algenarten war in den 5 Sammelstellen von Juni bis Oktober sowohl an Artenzahl (54—93) als an Individuenzahl (54 920—4 204 340 pro Liter) die Bucht von Keszthely am reichsten. Am ärmsten an Arten zeigte sich der Abschnitt Ságpusztá—Balatonszemes im Juli (47), die Oktoberprobe von Balatonalmádi—Balatonvilágos enthielt 28 030 Individuen pro Liter.

Von Juni bis Oktober fand sich an sämtlichen Sammelstellen *Lyngbya circumcreta*, *Lyngbya limnetica*, *Ceratium hirundinella* und *Dictyosphaerium pulchellum*.

Die höchsten Arten-, Individuen- und Prozentzahl erreichte der *Chrysophyten*-Stamm. Dieser kam in den Proben der Bucht von Keszthely zu 90—99,4%, an der Sammelstelle zwischen Szigliget—Balatonmária zu 54,4—97% vor. Eine derartige Juli-Massenvegetation war bei der hierher gehörigen Art *Dinobryon divergens* im Balaton bisher unbekannt. Aus der ausländischen Fachliteratur (HUBER-PESTALOZZI 1941, 227) wissen wir, daß diese Art ständige oder zumindest häufige Bewohnerin eutropher oder eutrophisierender Seen ist (PRESCOTT 1960, 30). Die Art findet sich in allen drei Segmenten des südwestlichen Balaton, als auch im nordöstlichen Teile an den Sammelstellen zwischen Balatonfüred—Zamárdi vor dem Biologischen Forschungsinstitut

Tihany; ein maximales Vorkommen zeigt sich jedoch nur in der Bucht von Keszthely.

Die in die *Bacillariophyceae*-Klasse des *Chrysophyten*-Stammes gehörige *Asterionella formosa*, *Melosira granulata* und deren Variation verursachten im August an allen drei Segmenten des südwestlichen Seeteiles eine Wasserverfärbung mit einer Millionen betragenden Individuenzahl pro Liter. Diese Erscheinung ist auch aus der ausländischen Literatur bekannt (LUND 1959, 1964; LUND et al. 1963). Zum Entstehen einer derartigen Massenentwicklung der Vegetation von *Asterionella-Melosira* war es notwendig, daß der Kieselsäuregehalt des Wassers sich in den Frühjahrs- und Sommeranfangs-Monaten stark vermehre. Ohne eine solche Vermehrung des Kieselsäuregehaltes hätte sich eine derartige Massenvegetation pelagischer Kieselalgen nicht entwickeln können. Diese Massenentwicklung veränderte auch die Farbe des Wassers zu einer bräunlich-gelblichen Schattierung. Die Millionenmasse von Kieselalgen verbreitete auf dem offenen Wasser des Sees einen starken Fischgeruch. Die außerordentliche Population der Mikroorganismen trübte auch die Durchsichtigkeit des Wassers (s. die Daten über Durchsichtigkeit in Tab. 1 an den Sammelstellen der Segmente M, K, und G.).

Neben der ungeheuren Population der drei pelagischen Kieselalgen fanden sich Vertreter sonstiger Algenstämme bloß in recht geringer Individuen- und Artenzahl in den Proben der oben erwähnten südwestlichen Sammelstellen (Tab. 2). Die durch *Asterionella-Melosira* verursachte Wasserverfärbung wirkte auch auf das Anzahlverhältnis der an der oberen Schichte der Schlammproben lebenden und abgestorbenen Algen ein (vgl. TAMÁS 1966a, 197, 201, 203, 207).

Die hohe 63% erreichende Prozentzahl des *Pyrrophyten*-Stammes in der Augustprobe des Segmentes Ságpusztá—Balatonszemes war der hohen Individuenzahl der warmes Wasser bevorzugenden *Ceratium hirundinella* zu verdanken. Der Bestand von *Ceratium hirundinella* zeigt im Plankton des Balaton in den letzten 20 Jahren eine ansteigende Tendenz.

Aus den Septemberproben der Sammelstellen zwischen der Bucht von Keszthely und Szigliget—Balatonmária haben wir eine verstreute Wasserblüte von *Aphanizomenon-Microcystis* aufgezeichnet. Diese wirkte ungünstig auf die an der Schlammoberfläche lebende Kieselalgengemeinschaft ein. Die abgestorbene Zellenmasse überdeckte an der Oberfläche des Schlammes die dort lebenden Kieselalgen mit einer bläulich-grünen Schicht. Im Jahre 1965 kam es zu keiner größeren Wasserblüte, da die bedeutenderen Schwankungen der Wassertemperatur als auch die häufig aufgetretenen Sturmwinde eine den früheren Jahren ähnliche Entwicklung der *Aphanizomenon-Microcystis*-Gemeinschaft (TAMÁS 1965b) nicht zuließen.

Aus den Algengemeinschaften der längs der Tiefenlängsachse gesammelten Proben haben wir für das offene Wasser des Balaton folgende charakteristische Arten aufgezeichnet:

1. euriterme Arten,
2. warme stenoterme pelagische Arten,
3. tychoplanktische Kieselalgen,
4. ufernahe, jedoch tiefes Wasser bevorzugende Arten,
5. epipelagische Arten,
6. aus dem Zala-Fluß und aus den in den See mündenden Bächen und Berekwässern stammende Arten.

Das Vorkommen von *Anabaena spiroides* Mallomonas-Arten, *Actinastrum hantzschii*, *Eudorina elegans*, *Gloecoccus schroeteri*, *Gonium pectorale*, *Hofmania lauterborni*, *Scenedesmus acuminatus*, *Tetraëdron minimum*, *Tetrastrum heteracanthum* war auf die Bucht von Keszthely und auf deren unmittelbare Umgebung beschränkt. Auffallend war das Fehlen von *Euglena klebsii*, *Closterium aciculare*, *Scenedesmus balatonicus* in den Proben der Keszthelyer Bucht.

Im Laufe unserer Untersuchungen haben wir aus dem Balaton bisher noch nicht mitgeteilte 4 Arten (*Cryptomonas pusilla*, *Mallomonas elongata*, *Cosmarium depressum* und *Tetraëdron longispinum*) in Tab. 2 mit einem »*« bezeichnet.

Wir haben an der Sammelstelle zwischen Balatonalmádi und Balatonvilágos und in der Nähe des Ufers bei Balatonaliga im Oktober eine (conjugierende) Gruppenbildung von *Closterium aciculare* beobachtet.

In Tab. 2 haben wir jene *Scenedesmus*-Art, welche wir in unseren früheren Studien verschieden bezeichneten (*Scenedesmus baculiformis* CHOD., TAMÁS 1959, 362; — *S. ovalternus* var. *hortobágyii* UHERKOV., TAMÁS 1964a, 270; 1965a, 245; 1965b, 98) als *Scenedesmus arcuatus* LEMM. forma UHERKOV. benannt (UHERKOVICH 1966, 136 pag. Abbildung 153—155). Die erweiterte taxonomische Bezeichnung »*Scenedesmus arcuatus* LEMM. forma UHERKOV.« soll darauf hinweisen, daß der betreffende Organismus der Form nach von der Art als Typus verschieden, selbständig erscheint. Heute stehen uns bereits reichlich Daten zu einer präziseren Abgrenzung und Benennung der Form zur Verfügung, woran wir demnächst in einer kürzer gefaßten Abhandlung zurückkommen werden.

Die fortschreitende Anreicherung des Balatonwassers an Nähr- und Wirkstoffen hat eine von Jahr zu Jahr steigende Produktion der pflanzlichen Mikroorganismen zur Folge.

Aus der in den letzteren Jahren häufiger wiederkehrenden Wasserverfärbung (TAMÁS 1958) und Wasserblüte (TAMÁS 1965b) können wir auf das Maß der Eutrophisierung schließen (vgl. FOTT 1959, 401—407; THOMAS 1962). In der Eutrophisierung ist die Bucht von Keszthely weiter fortgeschritten so wie auch die nordöstlichen Teile des Balatonsees oder auch die sich der Halbinsel von Tihany vorgelagerten offenen Wasserteile.

Die im Vorangehenden erwähnte Menge von *Dinobryon divergens*, weiterhin die Massentwicklung von *Asterionella-Melosira* und *Ceratium hirundinella* bilden einen nützlichen und vorzüglichen organischen Nährstoff für die Planktonkrebse und sonstige Fischnahrung bildende Organismen (vgl. PRESCOTT 1960, 30). Die in den letzteren Jahren sich in geringerem oder größerem Maße gegen Sommersende wiederholenden *Aphanizomenon-Microcystis*-Wasserblüten verunreinigen das Seewasser. Diese Blaualgenarten können mit den im Laufe ihrer Lebensvorgänge erzeugten Stoffwechselprodukten auf die übrigen Lebewesen eine toxische Wirkung ausüben (PRESCOTT 1948, 1960; SHELUBSKY 1951b; GORHAM 1965).

Im Laufe unserer Untersuchungen haben wir aus dem offenen Wasser des Sees für β -mezzosaprobe-Gewässer charakteristische Indikator-Organismen (*Aphanizomenon flos-aquae*, *Microcystis*, *Ceratium*, *Dinobryon*, *Navicula*, *Nitzschia*, *Ankistrodesmus*, *Crucigenia*, *Dictosphaerium*, *Pediastrum*, *Scenedesmus*, *Euglena* usw.) aufgezeichnet (FOTT 1959, 448—450).

Tabelle 3

Verteilung des Balatonplanktons nach Artenzahl der Algenstämme, nach Individuen-
gesammelten

A Balaton planktonjának algatörzsenkénti fajszám, egyedszám/liter

Sammelstellen, Zeitpunkt Gyűjtőhelyek, időpont		M_0			K		
Algenstämme Algacsoportok		Arten faj	i/l	%	Arten faj	i/l	%
<i>Cyanophyta</i> (17)	VI.	5	1,27	1,4	9	4,55	3,5
	VII.	6	1,2	1	8	2,0	1
	VIII.	11	2,73	0,01	10	6,35	1
	IX.	7	1,13	1	9	4,4	3,5
	X.	7	1,35	3	11	9,1	12,3
<i>Euglenophyta</i> (14)	VI.	9	0,92	1	3	0,35	0,3
	VII.	5	0,1	0	5	0	0
	VIII.	5	0,41	0,09	8	3,74	0
	IX.	7	0,4	0	7	1,07	1
	X.	7	0,66	1	9	1,6	2,1
<i>Pyrrophyta</i> (7)	VI.	2	0,22	0,2	2	0,33	0,2
	VII.	2	0,72	1	2	1,83	1
	VIII.	3	8,06	0,2	3	16,57	1
	IX.	3	4,95	3	3	46,55	37,1
	X.	2	0,05	0	2	0,03	0,4
<i>Chrysophyta</i> (85)	VI.	47	78,59	92	22	106,83	83
	VII.	33	113,0	97	24	197,42	96
	VIII.	34	4178,02	99,4	13	1149,27	97
	IX.	26	180,03	95	14	68,15	54,4
	X.	40	49,52	90	23	55,11	74,5
<i>Chlorophyta</i> (57)	VI.	29	4,45	5,2	21	16,52	13
	VII.	16	1,7	1	10	4,60	2
	VIII.	24	15,12	0,3	17	9,07	1
	IX.	16	1,28	1	16	5,04	4
	X.	21	3,34	6	20	7,78	10,5
<i>Mycophyta</i> (1)	VI.	1	0,21	0,2	1	0	0
	VII.	—	0	0	—	0	0
	VIII.	1	0	0	—	0	0
	IX.	—	0	0	—	0	0
	X.	—	0	0	1	0,15	0,2
Zusammen Összesen (181)	VI.	93	85,66	100	58	128,58	100
	VII.	62	116,72	100	49	205,85	100
	VIII.	78	4204,34	100	51	1185,0	100
	IX.	59	187,79	100	49	125,21	100
	X.	77	54,92	100	66	73,77	100

— 3. táblázat

zähl pro Liter und nach perzentuellen Vorkommen auf Grund der im Jahre 1965 Proben

és százalékos megoszlása az 1965. évi gyűjtések alapján

<i>G</i>			<i>A₁</i>			<i>E_e</i>		
Arten faj	<i>i/l</i>	%	Arten faj	<i>i/l</i>	%	Arten faj	<i>i/l</i>	%
10	13,05	11,3	10	14,45	12	6	9,45	15
9	3,95	3	11	53,3	38	9	34,15	31
9	4,7	6	9	12,95	12	9	23,1	27
9	19,75	25	11	21,75	35,3	11	27,44	40
7	17,0	39	9	9,65	27	10	9,41	33,6
2	0,05	0	9	1,6	1	5	0,42	1
5	0,1	0	9	1,1	1	6	0,85	1
6	0,4	0,5	10	0,86	1	4	0,17	0
5	1,16	1	10	1,86	3	4	0,43	0
6	1,36	3	10	1,48	4	6	0,45	2
2	0,8	0,7	4	1,17	1	3	1,7	3
3	16,06	13	4	4,37	3	4	13,94	13
3	49,66	62,5	3	11,36	10,4	3	21,27	24
3	33,29	42	3	5,9	9,6	3	12,24	18
3	1,35	3	2	0,71	2	3	0,95	3,4
27	88,99	77	34	92,72	74	26	40,67	66,5
13	103,03	81	34	67,99	50	34	46,94	42
16	14,20	18	35	69,93	64	26	25,91	28
20	18,72	23	29	20,38	33,1	33	21,40	31
16	17,60	40	26	18,56	52	25	13,44	48
23	12,55	11	29	15,34	12	25	8,84	14,4
16	4,02	3	21	11,08	8	30	14,43	13
20	10,01	13	30	13,68	12,6	27	18,41	21
21	7,25	9	23	11,72	19	23	7,53	11
23	6,71	15	20	5,46	15	24	3,78	13
1	0	0	—	0	0	1	0,07	0,1
1	0,1	0	1	0,05	0	—	0	0
—	0	0	—	0	0	—	0	0
—	0	0	—	0	0	—	0	0
—	0	0	—	0	0	—	0	0
65	115,44	100	86	125,28	100	66	61,15	100
47	127,26	100	80	137,89	100	83	110,31	100
54	78,97	100	87	108,78	100	69	88,86	100
58	80,17	100	76	61,61	100	74	69,04	100
55	44,02	100	67	35,86	100	68	28,03	100

Zusammenfassung

Autorin nahm in der Zeit von Juni 1965 bis Oktober desselben Jahres einmal monatlich in 5 Quersegmenten der Tiefenlängsachse des Balatonsees geschöpfte Proben und Netzfilterproben-Sammlungen vor (Netzgewebe Nr. 6 und 25).

An 3 Stellen des südwestlichen Seeteiles und 2 Punkten des nordöstlichen Seeteiles wurden die aus 4 verschiedenen Tiefen geschöpften 97 Proben an Ort und Stelle mit Jodjodkalium behandelt, sodann im Laboratorium mittels eines UTERMÖHLSchen Planktonmikroskopes abgezählt. Die 76 Netzfilterproben wurden teils in lebendem, teils in 2%iger Formalinlösung konserviertem Zustande untersucht.

Im Laufe der Phytoplankton-Untersuchungen wurden aus den geschöpften und Netzfilterproben 165 Arten, 14 Variationen und 2 Formen bestimmt. Aus diesen waren 4 Arten (in Tab. 2 mit einem »*« bezeichnet) aus dem Balaton bisher unbekannt.

Die Arten gehören systematologisch zu 5 großen Algen- und einem Pilzstamm; nach Häufigkeitsordnung sind es die folgenden: *Chrysophyten* 85, *Chlorophyten* 57, *Cyanophyten* 17, *Euglenophyten* 14, *Pyrrophyten* 7 und *Mycochyten* 1.

Von Juni bis Oktober war unter den 5 Sammelstellen die Bucht von Keszthely mit einer Artenzahl von 59—93 und einer Individuenzahl von 54 920—4 204 340 pro Liter am reichsten. Am ärmsten an Artenzahl zeigte sich die Sammelstelle zwischen Ságpusztá—Balatonszemes im Juli (47), und an Individuenzahl am ärmsten die Oktoberprobe der Sammelstelle Balatonalmádi—Balatonvilágos (mit 28 030 pro Liter).

An allen Sammelstellen waren in den Proben von Juni bis Oktober *Lyngbya circumcreta*, *L. limnetica*, *Ceratium hirundinella* und *Dictyosphaerium pulchellum* vertreten.

Die höchste Arten-, Individuen- und Prozentzahl erreichte der *Chrysophyten*-Stamm (Tab. 3). Diese Gruppe kam in den Proben der Bucht von Keszthely mit 90—99,4% und an der Sammelstelle (K) zwischen Szigliget—Balatonmária mit 54,4—97% vor. Eine derartig große Massenvegetation der hierher gehörigen *Dinobryon divergens* war bisher aus dem Balaton unbekannt. Im Monat August verursachten die in die *Bacillariophyceae*-Klasse des *Chrysophyten* Stammes gehörigen *Asterionella formosa*, *Melosira granulata* und *Melosira granulata* var. *angustissima* eine sich auf alle drei Segmente (M, K, G) des südwestlichen Seeteiles erstreckende Wasserverfärbung. Die Millionen ausmachende Individuenzahl von *Asterionella-Melosira* bewirkte in der Bucht von Keszthely und an der Sammelstelle zwischen Szigliget—Balatonmária eine gelbliche Wasserverfärbung. Neben diesen drei in großer Populationsdichte vorkommenden pelagischen Kieselalgen kamen Vertreter sonstiger Algenstämme nur in geringer Arten- und Individuenzahl in den Augustproben der zwei südlichsten Sammelstellen (M und K) vor (Tab. 2). Die durch *Asterionella-Melosira* verursachte Wasserverfärbung beeinflusste stark das Zahlenverhältnis der auf der oberen Schichte der Schlammproben lebenden und abgestorbenen Algen.

Die hohe Prozentzahl von 63% des *Pyrrophyten*stammes in der geschöpften Augustprobe zwischen Ságpusztá—Balatonszemes ist auf die hohe Individuenzahl von *Ceratium hirundinella* zurückzuführen.

Autorin hatte auch aus den Septemberproben des Abschnittes zwischen der Bucht von Keszthely und Szigliget—Balatonmária eine zerstreute Wasserblüte von *Aphanizomenon-Microcystis* aufgezeichnet. Diese wirkte ungünstig auf die an der Oberfläche des Schlammes lebenden Kieselalgengemeinschaften.

In den längs der Tiefenlängsachse gesammelten Proben gefundenen Algengemeinschaften kamen für das offene Wasser des Balaton charakteristisch folgende Arten vor: 1. euriterme, 2. warme, stenotermische pelagische Algen, 3. tychoplanktische Kieselalgen, 4. ufernahe, jedoch tiefes Wasser bevorzugende Arten, 5. epipelagische Arten und 6. aus dem Zala-Fluß und aus den in den Balaton mündenden Bächen, Berekwässern und sonstigen Wasserläufen stammende Arten.

Aus den in den letzten Jahren sich wiederholt ergebenden Erscheinungen der Wasserverfärbung und der Wasserblüte läßt sich ein Schluß auf das Maß der Eutrophisierung des Sees ziehen. Die Bucht von Keszthely und deren nächste Umgebung ist in dieser Beziehung weiter fortgeschritten als das Nordost-Becken.

Die Massenentwicklungen von *Dinobryon*—*Ceratium*—*Asterionella*—*Melosira* bedeuten einen nützlichen und guten organischen Nährstoff für die Planktonkrebse und sonstigen Fischnahrungs-Organismen. Demgegenüber zeigt sich die gegen Sommersende auftretende *Aphanizomenon-Microcystis* Wasserblüte bzw. deren Stoffwechselproduktion wegen ihrer toxischen Wirkung schädlich.

Autorin hatte im Laufe ihrer Untersuchungen Gelegenheit, viele für β -mezzosaprobe Gewässer charakteristische Indikator-Organismen aufzuzeichnen.

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HORIZONTÁLIS PLANKTONVIZSGÁLATOK A BALATONON V. A TÓ FITOPLANKTONJÁRÓL AZ 1965. ÉVI MERÍTETT MINTÁK ÉS HÁLÓ- SZÜREDÉK ALAPJÁN

Tamás Gizella

Összefoglalás

Szerző 1965 júniustól — októberig havonta egyszer a tó mélységi hossztengegyének öt harántszelvényén végzett merített és hálószüredék (No 6. és 25. hálósövet) minta gyűjtéseket.

A tó DNY-i részének 3, az ÉK-i részének pedig 2 pontján négy szintből merített 97 mintát a helyszínen jódjódkáliummal kezelte, majd a laboratóriumban UTERMÖHL planktonmikroszkóppal számlálta. A 76 hálószüredék mintát részben élő, részben pedig 2%-os formalinnal konzervált állapotban vizsgálta.

A fitoplankton vizsgálatok során a merített és a hálószüredék mintákból 165 fajt 14 változatot és 2 formát határozott meg. Ebből a számadatból 4 faj (a 2. táblázaton * jelölés) eddig a Balatonból ismeretlen volt.

Rendszertanilag öt nagy alga- és egy gombatörzsbe tartoznak a fajok, gyakorisági sorrendben a következők: *Chrysophyta* 85, *Chlorophyta* 57, *Cyanophyta* 17, *Euglenophyta* 14, *Pyrrophyta* 7, *Mycophyta* 1.

Júniustól — októberig az 5 gyűjtőhely közül fajszámban (59—93) és egyedszámban (54 920 — 4 204 340/liter) a Keszthelyi-öböl volt a leggazdagabb. Fajszámban a legszegényebb a Ságpuszta—Balatonszemes közötti gyűjtőhely júliusi (47), egyedszámban pedig a Balatonalmádi—Balatonvilágos októberi mintája (28030/liter) volt.

Valamennyi gyűjtőhelyen júniustól — októberig szerepelt a *Lyngbya circumereta*, *L. limnetica*, *Ceratium hirundinella* és a *Dictyosphaerium pulchellum*.

A legmagasabb faj-, egyed- és százelékszámot a *Chrysophyta* törzs érte el (l. 3. táblázat). Ez a törzs a Keszthelyi-öböl mintáiban 90—99,4%-kal, a Szigliget—Balatonmária közötti (K) gyűjtőhelyen pedig 54,4—97%-kal szerepelt. Az ide tartozó *Dinobryon divergens* ilyen nagy méretű tömegvegetációja a Balatonból eddig nem volt ismert. Augusztus hónapban a tó DNY-i részének mindhárom (M, K, G) szelvényére kiterjedő vízszíneződést idézett elő a *Chrysophyta* törzs *Bacillariophyceae* osztályába tartozó *Asterionella formosa*, *Melosira granulata* és *M. granulata* var. *angustissima*. Az *Asterionella* — *Melosira* milliós egyedszáma a Keszthelyi-öbölben és a Szigliget—Balatonmária közötti gyűjtőhelyen sárgás vízszíneződésben nyilvánult meg. E nagy népességű három pelagikus kovamoszat mellett más algatörzsek képviselői csak nagyon csekély faj- és egyedszámban fordultak elő a két legdélibb (M és K) gyűjtőhely augusztusi mintáiban (l. 2. táblázat adatait). Az *Asterionella* — *Melosira* vízszíneződés hatással volt az iszapminták felületi rétegén élő és elpusztult algák számarányára.

A *Pyrrophyta* törzs 63%-át Ságpuszta—Balatonszemes augusztusi merített mintájában a *Ceratium hirundinella* magas egyedszáma idézte elő.

Szerző *Aphanizomenon* — *Microcystis* szórt vízvirágzást jegyzett fel a Keszthelyi-öböl és Szigliget—Balatonmária közötti gyűjtőhely szeptemberi mintáiból. Ez a jelenség az iszap felületén élő kovamoszat együttesre kedvezőtlen hatással volt.

A mélységi hossztenyegre mentén gyűjtött minták algaflórájában a Balaton nyíltvizére jellemző fajok szerepeltek: 1. euriterm, 2. meleg stenoterm pelagikus algák, 3. tychoplanktikus kovamoszatok, 4. partközeli, de mélyvizet kedvelők, 5. epipelagikus fajok, 6. a Zala folyóból és a tóba ömlő patakokból, berekvizékből származók.

Az utóbbi években ismétlődő vízszíneződés és vízvirágzás jelenségeiből lehet következtetni az eutrófizálódás mértékére. A Keszthelyi-öböl és környéke ebben előbbre haladt, mint az ÉK-i medence.

A *Dinobryon* — *Ceratium* — *Asterionella* — *Melosira* tömegkifejlődés hasznos és jó szerves anyag táplálék a planktonrákoknak és egyéb haltáplálék szervezeteknek. Ezzel ellentétben a nyár végi *Aphanizomenon* — *Microcystis* vízvirágzás anyagszere-termékének mérgező hatásával káros.

Szerző a vizsgálatok során nagy számban jegyzett fel β -mezoszaprób vizekre jellemző indikátor szervezeteket.

ГОРИЗОНТАЛЬНОЕ ИССЛЕДОВАНИЕ ПЛАНКТОНА БАЛАТОНА V. О ФИТОПЛАНКТОНЕ ОЗЕРА ПО ОБРАЗЦУ САЧКА И ПОГРУЖЕННОЙ ПРОБЫ

Гизелла Тамаш

Автор приводит данные об анализе образцов сачка и погруженной пробы (№ сетки 6 и 25), собранных в 5 разных пунктах по глубинной оси озера раз в месяц, с июня по октябрь 1965 года.

97 образцов погруженной пробы, собранных в 3 местах северо-восточной части озера и в 2 местах юго-западной части озера на 4 залеганиях, обработали на месте йодистым калием, затем в лабораторных условиях производили расчеты посредством Уттермонн планктонного микроскопа. 76 образцов сачка были изучены отчасти в живой и отчасти в зафиксированном 2%-ным формалинном виде.

В ходе исследования образцов было определено 165 видов, 14 разновидностей и 2 вариации. Из них 4 вида (см. таблицу № 2, *) были впервые обнаружены в Балатоне.

Обнаруженные виды систематически относятся к 5 классам водорослей и одному классу грибов по следующему ряду: Chrysophyta 85 Chlorophyta 57, Cyanophyta 17, Euglenophyta 14, Pyrrophyta 7, Mycophyta 1.

По численности (54 920—4 204 340/литр) и числу (59—93) видов из 5 мест обитания самым богатым был Кестхейский залив. По числу видов самым бедным был образец, собранный в Шагпуста—Балатонсемеш в июле, (47), а по численности вида образец, собранный в Балатоналмади—Балатонвилагош в октябре (28 030/литр).

Во всех местах обитания за указанный период времени всегда обнаруживаются: *Lyngbya circumcreta*, *L. limnetica*, *Ceratium hirundinella*, *Dictyosphaerium pulchellum*.

Самого высокого содержания достигла группа Chrysophyta (таблицы 1 и 3). Эта группа составила в образцах Кестхейского залива 90—99,4% — а в Сиглигет—Балатоналмади (место К) 54,4—97%. Такое массовое появление *Dinobryon divergens* новое для Балатона. В августе в трех местах (М, К, Г) юго-западной части озера значительное окрашивание воды вызывалось представителями типа Chrysophyta относящихся к классу Bacillariophyceae, а именно *Asterionella formosa*, *Melosira granulata*, *M. granulata* var. *angustissima*. Вследствие миллионной численности *Asterionella* и *Melosira* вода в Кестхейском заливе и Сиглигет—Балатонмária окрашивается в желтый цвет. Помимо этих пелагических кремневых водорослей другие водоросли обнаруживаются в низкой численности и числе в месте М и К в августе (таблицы 1 и 2). Окрашивание воды видоизменяло и число водорослей, живущих на поверхности ила и там же погибших.

63% типа Pyrrophyta в образце погруженной пробы, собранной в Шагпуста—Балатонсемеш в августе был составлен высоким числом *Ceratium hirundinella*.

В образце, собранном в сентябре в Кестхейском заливе и Сиглигет—Балатонмária, было отмечено частичное окрашивание воды с *Aphanizomenon-Microcystis*. Это явление видоизменяло коллекцию кремневых водорослей, живущих на поверхности ила, в неблагоприятном направлении.

В образцах, собранных по глубинной и вертикальной оси озера, были обнаружены виды водорослей, характерных для открытой части Балатона: 1—эвтермные, 2—тепlostенотермные пелагические водоросли, 3—тихопланктические кремневые водоросли, 4—водоросли, характерные для прибреговой части, но предпочитающие глубокую воду, 5—эпипелагические виды, 6—виды, происходящие из реки Зала и других, впадающих в озеро рек.

По интенсивности окрашивания и «расцветания» воды, повторяющихся в последние годы, можно сделать вывод о мере эвтрофикации, которая сильнее в Кестхейском заливе, чем в северо-восточном бассейне.

Dynobryon-Ceratium-Asterionella-Melosira являются хорошим органическим питательным веществом для планктонных раков и другим кормом для рыб. В отличие от этого *Aphanizomenon-Microcystis*, появляющиеся в конце лета вредны, вследствие ядовитости обоих продуктов при обмене веществ.

Автор в ходе исследования нашел в большом количестве индикаторные организмы, характерные для β -мезосапробных вод.

QUANTITATIVE ALGOLOGISCHE UNTERSUCHUNGEN IM BODEN-SCHLAMM DES BALATON AUF GRUND DER SAMMLUNGEN DES JAHRES 1966

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Vorliegende Studie schließt sich den früher erschienenen Werken an, welche Angaben über das Mikrophytenbentos des Balaton enthalten (ausführliches Schrifttum siehe in der Studie von TAMÁS 1966).

Diese Studie bildet die Fortsetzung der quantitativen algologischen Untersuchungen (Individuenzahl pro dm^2) von Schlammproben, welche wir im Jahre 1965 an drei Segmenten des südwestlichen und an zwei Segmenten des nordöstlichen Seeteiles in der Zeit von Juni bis Oktober monatlich systematisch durchgeführt eingesammelt hatten.

Ort und Zeit der Sammlungen, Methodik der Aufarbeitung

Die Einsammlung der Schlammproben erfolgte im Jahre 1966 — in ähnlicher Weise wie im Vorjahre — am südwestlichen Teile des Sees an drei, am nördöstlichen Teile an zwei, auf die Längsachse des Seespiegels senkrechten Quersegmenten (SEBESTYÉN 1960). Die Schlammproben wurden an drei bestimmten Punkten der einzelnen Quersegmente (M, K, G, A, und E; *Abb. 1*) mittels eines modifizierten Schlammgreifers System CRAIB ausgehoben (ausführliche Beschreibung desselben bei PONYI, BIRÓ und P. ZÁNKAY, 1967). Wir ließen die Schlammproben 48 Stunden lang im Laboratorium sich absetzen. Aus den Proben haben wir aus fünfmal 1 cm^2 betragenden Schlammoberflächen sämtliche (lebende und abgestorbene) Algen aufgezeichnet und die auf diese Weise erhaltenen Daten auf 1 dm^2 umgerechnet. In *Tab. 2* und *3* sind die Mittelwerte angegeben, errechnet aus den aus 3 Punkten je eines Quersegmentes erhaltenen Daten.

Die Lage der Quersegmente ist in *Abb. 1* zu ersehen; die sonstigen Sammlungsdaten sind in *Tab. 1* enthalten (diese sind ebenfalls die Mittelwerte, die aus den aus drei Punkten je eines Quersegmentes erhaltenen Angaben errechnet wurden).

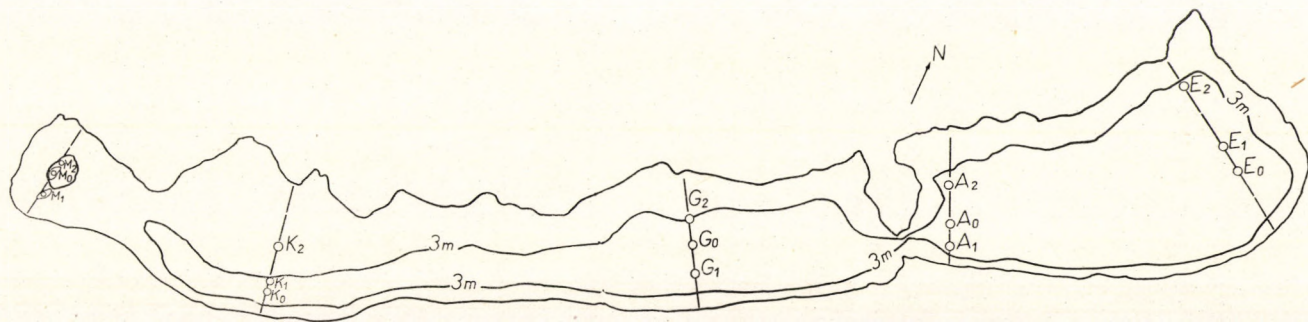


Abb. 1. Skizzenhafte See-Karte des Balaton, mit Bezeichnung der Probenentnahme-Stellen. M_1 = zwischen Gyenesdiás und der Mündung des Zala-Flusses, cca 4000 m vom Nordufer; M_0 = cca 2800 m vom Nordufer; M_2 = cca 2000 m vom Nordufer; K_0 = zwischen Szigliget und Balatonmária, cca 6800 m vom Nordufer; K_1 = cca 6000 m vom Nordufer; K_2 = cca 4000 m vom Nordufer; G_1 = zwischen Sággpuszta und Balatonszemes, cca 5500 m vom Nordufer; G_0 = cca 4000 m vom Nordufer; G_2 = cca 2500 m vom Nordufer; A_1 = zwischen Balatonfüred—Fenékfürdő und Zamárdi, cca 7000 m vom Nordufer; A_0 = cca 5800 m vom Nordufer; A_2 = cca 3300 m vom Nordufer; E_0 = zwischen Balatonalmádi und Balatonvilágos, cca 8600 m vom Nordufer; E_1 = cca 6400 m vom Nordufer; E_2 = cca 2300 m vom Nordufer

1. ábra. A Balaton vázlatos térképe a mintavételi helyek megjelölésével. M_1 = Gyenesdiás — Zala folyó torkolata, az északi parttól kb. 4000 m; M_0 = az északi parttól kb. 2800 m; M_2 = az északi parttól kb. 2000 m; K_0 = Szigliget—Balatonmária, az északi parttól kb. 6800 m; K_1 = az északi parttól kb. 6000 m; K_2 = az északi parttól kb. 4000 m; G_1 = Sággpuszta—Balatonszemes, az északi parttól kb. 5500 m; G_0 = az északi parttól kb. 4000 m; G_2 = az északi parttól kb. 2500 m; A_1 = Balatonfüred Fenékfürdő—Zamárdi, az északi parttól kb. 7000 m; A_0 = az északi parttól kb. 5800 m; A_2 = az északi parttól kb. 3300 m; E_0 = Balatonalmádi—Balatonvilágos, az északi parttól kb. 8600 m; E_1 = az északi parttól kb. 6400 m; E_2 = az északi parttól kb. 2300 m

Tabelle 1 — 1. táblázat

Ort und Zeitpunkt der Probenentnahme 1966 und andere Angaben

Az 1966. évi gyűjtések helye, ideje és egyéb adatai

Sammelstellen Gyűjtőhelyek	Zeitpunkt — Időpont	Wasser- temperatur Víz hőfok, °C	Lufttemperatur Levegő hőfok, °C	Wassertiefe Víz mélység, cm	Durchsichtigkeit * Átlátszóság, cm	Anmerkungen Megjegyzések
M	V. 17. 6—10 h	19	20	270	57	* <i>Aphanizomenon</i> — <i>Microcystis</i> zerstreute Wasserblüte
	VI. 14. 7—11 h	23	25	296	55	
	VII. 26. 7—10 „	19,5	19	297	61	
	* VIII. 23. 7—10 „	22	22	287	49	* <i>Aphanizomenon</i> — <i>Microcystis</i> szórt víz- virágzás
	* IX. 21. 8—11 „	17	20,3	274	36	
	X. 18. 6— 9 „	16	15,6	280	36	
	XI. 15. 6— 9 „	3,9	2,5	241	45	
K	V. 17. 10—12 h	19	21,6	375	86	* <i>Aphanizomenon</i> — <i>Micro-</i> <i>cystis</i> zerstreute Wasserblüte
	VI. 14. 11—13 „	23,2	27,3	369	70	
	VII. 26. 10—12 „	20	20	383	52	
	* VIII. 23. 10—12 „	22,6	25	395	55	* <i>Aphanizomenon</i> — <i>Microcystis</i> szórt víz- virágzás
	* IX. 21. 11—13 „	17,4	21,8	374	48	
	X. 18. 9—12 „	16	16	359	35	
	XI. 15. 10—12 „	5	5,1	368	45	
G	V. 17. 16—18 h	19,4	21	413	77	
	VI. 14. 16—19 „	23	25	432	82	
	VII. 26. 15—17 „	20	20,6	423	56	
	VIII. 23. 15—17 „	23	23	425	58	
	IX. 21. 16—18 „	18,8	19,8	412	82	
	X. 18. 15—17 „	16	18	404	78	
	XI. 15. 15—17 „	6	6,5	409	67	
A	V. 18. 9—12 h	21	23,3	369	72	Wenig Planktonorganismen!
	VI. 15. 9—12 „	22	24	399	55	
	VII. 27. 9—12 „	21,2	24	392	49	Kevés plankton!
	VIII. 24. 9—12 „	22	26	362	53	
	IX. 22. 9—12 „	18,3	21,1	388	88	
	X. 19. 9—11 „	17	19,3	375	92	
	XI. 16. 9—11 „	6	7 2	394	81	
E	V. 18. 15—18 h	20	21,2	449	151	o Während der Sammlungen herrschte stürmischer Nord- wind und Regen o Gyűjtés közben viha- ros északi szél, eső
	o VI. 15. 17—19 „	22	22,6	408	89	
	VII. 27. 15—18 „	22	26,2	454	65	
	VIII. 24. 15—17 „	22	21,3	433	48	
	IX. 22. 15—17 „	18	20,8	433	90	
	X. 19. 14—17 „	17	20,3	413	90	
	XI. 16. 14—16 „	6	9,2	423	95	

Zeichenerklärung — Jelmagyarázat

* Die Werte beziehen sich auf Messungen mit der SECCHI-Scheibe — Mérések SECCHI-koronggal

Untersuchungsergebnisse

Die aus 105 Schlammproben der 15 Sammelstellen bestimmten Algenarten gehören — mit dem Pilz zusammen — in die nachstehend aufgezählten 6 systematischen Stämme, in der Reihe nach Häufigkeit ihres Vorkommens geordnet:

	Art	Varietät
<i>Chrysophyten</i>	60	3
<i>Cholorophyten</i>	24	3
<i>Cyanophyten</i>	13	—
<i>Euglophyten</i>	8	—
<i>Pyrrophyten</i>	1	—
<i>Mycophyten</i>	1	—
Zusammen	107	6

Die Arten aller drei Klassen (*Xanthophyceae* 2, *Chrysophyceae* 1, *Bacillariophyceae* 60) des *Chrysophyten*-Stammes waren vertreten. Von den 32 Arten der schlammbewohnenden *Bacillariophyceae*-Klasse erreichten einige stellenweise — ähnlich wie im vorigen Jahre — bedeutende Individuenzahlen: *Amphora ovalis*, *A. ovalis* var. *pediculus*, *Diploneis elliptica*, *D. puella*, *Fragilaria pinnata*, *Navicula cryptocephala*, *Nitzschia amphibia*, *N. sigmoidea* usw. Von den aus dem offenen Wasser des Sees wohlbekannten 15 pelagischen Arten kamen *Cyclotella bodanica*, *C. ocellata*, *Melosira granulata*, *M. granulata* var. *angustissima*, *Nitzschia acicularis* stellenweise in großer Individuenzahl in den Schlammproben vor. Von den 13 epiphyten Arten waren *Cocconeis placentula* Cymbellen, *Epithemien*, *Gomphonema olivaceum*, *Rhoicosphenia curvata*, *Rhopalodia gibba* und *Synedra parasitica* nur sporadisch anzutreffen.

Das perzentuell quantitative Vorkommen (Individuenzahl pro dm²) des *Chrysophyten*-Stammes wechselte in der Zeit von Mai bis November stellenweise zwischen 4 und 99%. Der Stamm erreichte 55% der gesamten Algenartenzahl.

Nach Häufigkeit der Artenzahl geordnet steht der Stamm der *Chlorophyten* an zweiter Stelle. In der Mehrzahl gehören die Arten in die Ordnung der *Chlorococcales*. Die pro dm² angetroffene Individuenzahl der in den Schlammproben bloß sporadisch vorkommenden Arten ist unbedeutend. (Tab. 2).

Das perzentuell quantitative Vorkommen (Individuenzahl pro dm²) des *Chlorophyten*-Stammes wechselte in der Zeit von Mai bis November stellenweise zwischen 0 und 3%. Der Stamm erreichte 24% der gesamten Algenartenzahl.

Nach Häufigkeitsanordnung der Artenzahl folgt als nächster der Stamm der *Cyanophyten*. Unter den in Tab. 2 angeführten 13 Arten kommen die pelagischen Arten *Lyngbya circumcreta* und *L. limnetica* fast in sämtlichen Proben, stellenweise sogar in bedeutender Populationsdichte vor.

Das perzentuell quantitative Vorkommen des *Cyanophyten*-Stammes wechselte in der Zeit von Mai bis November stellenweise von 0 bis 6%. Der Stamm erreichte 11% der gesamten Algenartenzahl.

Die 8 Vertreter des Stammes der *Euglenophyten* fanden sich sporadisch in niedriger Individuenzahl in den Schlammproben (Tab. 2). Das perzentuell

Tabelle 2 — 2. táblázat

Quantitative Mikrophytobentos-Untersuchungen aus dem Eprofundal des Balaton-Sees auf Grund der Sammlungen des Jahres 1966 ($i/\text{dm}^2 = \text{Individuenzahl pro } \text{dm}^2 \times 1000$)

A Balaton nyíltvízi fenékiszapmintáinak mennyiségi algológiai adatai az 1966. évi gyűjtések alapján ($i/\text{dm}^2 = \text{egyedszám}/\text{dm}^2 \times 1000$)

Sammelstellen und Zeitpunkt des Vorkommens Gyűjtőhelyek, időpont		M		K		G		A		E	
Artenverzeichnis Fajok felsorolása		a	b	a	b	a	b	a	b	a	b
CYANOPHYTA											
<i>Aphanizomenon flos-aquae</i> var. <i>klebahnii</i> ELENK.	V.	0,1	—	0,1	—	—	—	—	—	0,1	—
	VI.	—	—	—	—	—	0,1	—	—	—	—
	VII.	—	0,1	—	0,2	—	0,1	—	0,1	—	—
	VIII.	—	—	—	0,1	—	0,1	—	—	—	—
	IX.	—	—	—	0,1	0,1	0,1	0,1	0,5	0,2	0,1
	X.	—	0,2	—	0,1	0,1	—	—	—	—	—
	XI.	—	0,1	—	0,1	—	0,1	—	—	—	—
<i>Aphanocapsa delicatissima</i> W. et G. S. WEST	V.	—	—	—	—	—	—	—	—	0,1	—
<i>Chroococcus limneticus</i> LEMM.	V.	—	—	—	—	—	—	—	—	0,1	—
	VII.	—	—	0,1	—	—	—	—	—	—	—
<i>Chroococcus turgidus</i> (Kütz.) NAEG.	VI.	0,1	—	—	—	—	—	—	—	—	—
<i>Coelosphaerium kützingianum</i> NAEG.	V.	—	—	—	—	0,1	—	—	—	0,1	—
	VI.	—	—	0,1	—	—	—	—	—	—	—
	VII.	0,1	—	0,1	—	0,1	—	0,1	—	0,1	—
	VIII.	—	—	—	—	—	—	—	—	0,1	—
	IX.	—	—	0,1	—	0,1	—	0,1	—	0,3	—
	X.	—	—	0,1	—	—	—	0,1	—	0,1	—
	XI.	—	—	0,1	—	—	—	0,1	—	0,1	—
<i>Gomphosphaeria lacustris</i> CHOD.	VI.	—	—	0,1	—	—	—	—	—	—	—
	X.	—	—	—	—	0,1	—	—	—	—	—
	XI.	—	—	—	—	0,1	—	—	—	—	—
<i>Lyngbya circumcreta</i> G. S. WEST	V.	0,1	0,2	0,1	0,3	0,3	0,1	1,1	0,5	2,7	1,7
	VI.	0,1	0,2	0,3	0,5	0,5	1,3	1,4	1,9	0,5	3,6
	VII.	0,1	0,1	0,2	0,4	0,6	1,5	0,8	1,6	0,6	3,0
	VIII.	0,1	0,1	0,2	0,4	0,6	1,2	1,0	2,0	1,2	3,5
	IX.	0,2	0,1	0,4	0,4	2,4	2,3	1,8	3,7	1,6	4,9
	X.	0,1	0,1	0,1	0,2	0,3	1,7	1,5	3,2	2,2	3,6
	XI.	0,2	0,1	0,2	0,2	0,3	0,7	0,6	0,9	0,2	0,2
<i>Lyngbya limnetica</i> LEMM.	V.	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,4	0,3
	VI.	—	—	0,5	0,1	0,1	0,1	0,1	0,1	—	0,1
	VII.	—	—	0,1	0,1	0,1	0,1	0,1	—	0,1	—
	VIII.	0,1	—	—	—	0,1	—	0,1	—	0,1	—
	IX.	—	—	0,1	—	0,1	0,1	0,3	—	—	0,1
	X.	—	—	—	—	—	0,1	0,1	—	0,1	—

Tabelle 2 (Fortsetzung) — 2. táblázat (folytatás)

Sammelstellen und Zeitpunkt des Vorkommens Gyűjtőhelyek, időpont		M		K		G		A		E	
Artenverzeichnis Fajok felsorolása		a	b	a	b	a	b	a	b	a	b
<i>Merismopedia glauca</i> (EHR.) NAEG.	VI.	—	—	—	—	0,1	0,1	—	—	—	—
	VII.	0,1	—	—	—	—	—	—	—	—	—
<i>Microcystis flos-aquae</i> (WITTR.) KIRCHN.	V.	—	—	—	—	—	—	—	—	—	0,1
	VI.	0,1	0,1	0,1	—	0,1	—	—	—	—	—
	VII.	0,1	—	—	—	0,1	—	0,1	—	—	—
	IX.	0,1	—	—	—	—	—	—	0,1	—	—
<i>Oscillatoria</i> sp.	V.	—	—	0,1	—	—	—	—	—	—	—
	VI.	—	—	0,1	—	—	—	—	—	—	—
	VII.	—	—	0,1	—	—	—	—	—	—	—
	VIII.	—	—	—	—	0,1	—	—	—	—	—
<i>Phormidium</i> sp.	VII.	0,1	—	—	—	—	—	—	—	—	—
	IX.	0,1	—	—	—	—	—	—	—	—	—
<i>Pseudanabaena catenata</i> LAUT.	V.	0,1	—	0,1	—	0,1	—	0,1	—	—	—
	VI.	0,1	—	—	—	0,1	—	0,1	—	—	—
	VII.	0,2	—	—	—	—	—	—	—	—	—
	VIII.	0,1	—	—	—	0,1	—	0,1	—	0,1	—
	IX.	—	—	—	—	—	—	0,1	—	—	—
	X.	—	—	—	—	0,1	—	0,3	—	—	—
	XI.	—	—	—	—	—	—	0,1	—	—	—
EUGLENOPHYTA											
<i>Euglena acus</i> EHR.	V.	—	—	—	—	—	—	—	—	0,1	—
<i>Euglena ehrenbergii</i> KLEBS	V.	—	—	—	—	0,1	—	—	—	—	—
	VII.	—	—	—	0,1	—	—	—	—	—	—
	VIII.	—	—	—	—	—	—	0,1	—	—	—
	X.	—	—	—	—	0,1	—	—	—	—	—
<i>Euglena klebsii</i> (LEMM.) MAINX	V.	—	—	—	—	0,1	—	—	—	0,1	—
	IX.	—	—	—	—	—	—	0,1	—	—	—
<i>Euglena limnophila</i> var. <i>minor</i> DREZ.	V.	—	—	0,1	—	—	—	—	—	—	—
	IX.	0,1	—	—	—	—	—	—	—	—	—
<i>Euglena oxyurus</i> SCHMARDT	V.	—	—	0,1	—	0,1	—	—	—	0,1	—
	VII.	—	—	0,1	—	—	—	—	—	—	—
<i>Phacus acuminatus</i> STOKES	V.	—	—	0,1	—	—	—	—	—	—	—
	VII.	—	—	0,1	—	—	—	—	—	—	—
	IX.	—	—	0,1	—	—	—	—	—	—	—
<i>Phacus tortuosus</i> ROLL	V.	—	—	—	—	0,1	—	—	—	0,1	—
<i>Trachelomonas</i> sp.	IX.	—	—	—	—	—	0,1	—	—	—	—

Tabelle 2 (Fortsetzung) — 2. táblázat (folytatás)

Sammelstellen und Zeitpunkt des Vorkommens Gyűjtőhelyek, időpont		M		K		G		A		E	
Artenverzeichnis Fajok felsorolása		a	b	a	b	a	b	a	b	a	b
PYRROPHYTA											
<i>Peridineae</i>											
<i>Ceratium hirundinella</i> (O. F. MÜLL.)	V.	—	—	—	—	—	0,1	—	—	—	—
SCHRANK	IX.	—	—	—	—	—	—	—	—	0,1	—
(ZYSTEN)	X.	—	—	0,1	—	—	—	—	—	—	—
	XI.	—	—	0,1	—	—	—	—	—	—	—
CHRYSTOPHYTA											
<i>Xanthophyceae</i>											
<i>Botryococcus braunii</i> KÜTZ.	VII.	—	—	—	—	0,1	—	—	—	—	—
<i>Planktonema lauterborni</i> SCHMIDLE											
	V.	0,1	—	0,1	0,1	0,1	—	0,1	—	0,2	—
	VI.	—	—	0,3	—	0,1	—	—	—	0,1	—
	VII.	0,1	—	—	—	—	—	—	—	—	—
	IX.	—	—	—	—	—	—	—	—	0,1	—
<i>Chrysophyceae</i>											
<i>Synura uvella</i> EHR.	X.	0,1	—	—	—	—	—	—	—	—	—
	XI.	0,1	—	—	—	—	—	—	—	—	—
<i>Bacillariophyceae</i>											
<i>Be Amphora ovalis</i> KÜTZ.	V.	2,2	0,7	3,3	0,8	1,0	0,9	4,5	3,8	2,5	0,6
	VI.	0,5	1,8	0,6	2,5	3,1	2,6	3,1	2,0	0,4	0,7
	VII.	0,3	0,8	2,5	2,6	0,5	2,5	0,4	3,4	1,2	0,9
	VIII.	0,5	0,6	2,9	1,3	1,4	3,5	0,3	3,1	1,5	1,9
	IX.	0,5	1,8	2,0	1,4	1,8	3,3	1,2	3,9	2,2	1,1
	X.	—	1,0	0,7	1,4	0,3	2,6	0,6	2,7	0,1	0,9
	XI.	0,6	1,2	1,3	0,9	0,6	2,0	0,9	0,7	0,4	—
<i>Be Amphora ovalis</i> var. <i>pediculus</i> KÜTZ.	V.	8,4	0,9	11,8	1,3	4,6	2,6	4,9	1,3	4,6	0,9
	VI.	0,5	0,7	0,5	1,1	2,6	2,1	2,1	1,8	0,2	0,1
	VII.	0,3	0,4	0,6	0,3	0,4	0,9	0,1	0,8	0,9	0,4
	VIII.	0,3	0,1	1,8	0,6	0,2	1,5	—	1,0	0,7	0,6
	IX.	0,3	1,1	0,3	1,1	0,7	1,8	0,3	2,1	0,6	0,3
	X.	0,1	0,3	0,3	0,9	0,1	1,0	0,1	1,0	0,1	0,5
	XI.	0,1	0,3	0,5	0,5	0,4	1,3	0,4	0,3	—	—
<i>Pl Asterionella</i> <i>formosa</i> HASSAL	V.	—	0,1	—	—	—	—	—	—	—	—
<i>Pl Attheya zachariasii</i> J. BRUN.	V.	—	—	0,1	—	—	—	—	—	—	—
	VII.	—	—	0,1	—	—	—	—	—	0,1	—
<i>Be Caloneis schumanniana</i> var. <i>biconstricta</i> GRUN.	V.	0,1	0,1	0,1	—	—	0,1	0,2	0,4	0,2	0,1
	VI.	0,1	0,1	0,2	0,1	0,1	0,1	0,1	0,3	0,1	0,1
	VII.	—	—	—	—	0,1	0,1	—	0,2	0,1	0,1
	VIII.	0,1	0,1	—	—	0,1	0,1	—	0,3	—	0,1
	IX.	0,1	0,1	—	0,1	—	0,1	—	0,2	—	0,2
	X.	—	—	0,1	0,1	—	0,1	—	0,2	—	0,1
	XI.	—	—	—	0,1	—	0,2	—	0,3	—	—

Tabelle 2 (Fortsetzung) — 2. táblázat (folytatás)

Sammelstellen und Zeitpunkt des Vorkommens Gyűjtőhelyek, időpont		M		K		G		A		E	
Artenverzeichnis Fajok felsorolása		a	b	a	b	a	b	a	b	a	b
Ep <i>Cymbella cymbi-</i> <i>formis</i> (KÜTZ.) V. HEURCK	V.	—	—	0,1	—	0,1	—	—	—	—	—
	VII.	—	—	—	0,1	—	0,1	—	—	—	—
Ep <i>Cymbella ehren-</i> <i>bergii</i> KÜTZ.	V.	—	—	—	—	—	—	0,1	—	—	—
	VI.	—	—	—	—	—	—	—	—	—	0,1
	VII.	—	—	—	0,1	—	—	—	—	—	—
Ep <i>Cymbella lanceo-</i> <i>lata</i> (EHR.) V. HEURCK	V.	—	—	—	—	—	—	0,1	0,1	—	—
	VI.	—	0,1	—	—	—	—	—	0,1	—	—
	VII.	—	—	—	—	—	—	—	0,1	—	—
	VIII.	—	0,1	—	—	—	—	—	—	—	—
	IX.	—	—	—	—	—	—	—	0,1	—	—
Ep <i>Cymbella prostra-</i> <i>ta</i> (BERK.) CLEVE	V.	—	0,1	—	—	—	—	0,1	—	0,1	—
	VI.	—	0,1	—	0,1	—	—	—	—	—	—
Be <i>Diploneis domb-</i> <i>littensis</i> (GRUN.) CLEVE	V.	—	—	—	—	—	0,1	—	0,1	0,1	—
	VI.	—	0,1	—	—	0,1	0,1	—	0,5	0,1	0,1
	VII.	—	—	—	0,1	0,1	—	0,1	0,1	—	—
	VIII.	—	—	—	—	—	—	—	0,1	0,1	0,2
	IX.	—	—	—	0,1	—	—	—	—	—	—
	X.	—	0,1	—	—	—	—	—	—	—	—
Be <i>Diploneis elliptica</i> (KÜTZ.) CLEVE	XI.	—	0,1	—	—	—	—	—	—	—	—
	V.	1,8	0,1	0,2	0,1	0,4	0,5	4,1	1,4	1,8	1,3
	VI.	0,4	0,3	0,2	0,3	2,9	0,6	4,0	3,3	1,7	0,9
	VII.	0,1	0,1	0,1	0,2	0,5	0,3	4,7	2,3	2,2	1,4
	VIII.	0,1	0,1	0,4	0,1	6,3	0,8	2,8	3,1	7,0	3,6
	IX.	0,1	0,5	0,5	0,1	0,9	0,3	2,6	2,3	2,0	1,5
Be <i>Diploneis puella</i> (SCHUM.) CLEVE	X.	—	0,1	—	0,1	0,2	0,1	0,7	1,9	0,9	2,0
	XI.	0,1	0,2	—	0,1	0,6	0,4	0,8	1,7	—	0,5
	V.	2,3	—	—	—	2,1	0,6	2,7	1,0	2,8	1,4
	VI.	0,3	0,1	0,2	0,3	3,6	1,1	3,4	3,2	0,4	1,1
	VII.	—	—	0,3	0,3	4,7	0,9	3,3	2,5	2,7	2,4
	VIII.	0,1	0,1	0,2	0,1	10,7	1,5	1,4	3,9	14,7	5,0
Ep <i>Epithemia hynd-</i> <i>manni</i> W. SMITH	IX.	0,1	0,4	0,3	0,2	2,3	1,1	2,0	2,4	1,8	2,5
	X.	—	0,1	—	0,1	0,1	0,8	0,7	1,2	1,0	2,0
	XI.	—	—	—	0,1	0,1	0,3	0,4	1,1	—	0,2
	V.	—	0,1	—	—	—	—	—	—	—	—
	IX.	—	—	—	—	—	—	—	0,1	—	—
Ep <i>Epithemia inter-</i> <i>media</i> FRICKE	X.	—	—	—	—	—	0,1	—	—	—	—
	V.	—	0,1	—	—	—	—	—	—	—	—
Ep <i>Epithemia sorex</i> KÜTZ.	VI.	—	—	—	—	—	—	—	—	—	0,1
	V.	—	0,1	—	0,1	—	—	0,1	0,1	—	0,1
	VI.	—	—	—	—	—	0,1	—	0,1	—	—
	VII.	—	—	—	0,1	—	—	—	0,1	—	—
	VIII.	—	0,1	—	—	—	0,1	—	0,1	—	—
	X.	—	0,1	—	—	—	—	—	—	—	—
Ep <i>Epithemia sorex</i> KÜTZ.	XI.	—	0,1	—	—	—	—	—	—	—	—
	V.	—	0,1	—	—	—	—	—	—	—	—

Tabelle 2 (Fortsetzung) — 2. táblázat (folytatás)

Sammelstellen und Zeitpunkt des Vorkommens Gyűjtőhelyek, időpont		M		K		G		A		E	
Artenverzeichnis Fajok felsorolása		a	b	a	b	a	b	a	b	a	b
Pl <i>Fragilaria constru- ens</i> (EHR.) GRUN.	V.	3,3	5,9	2,0	5,0	0,8	0,1	1,7	7,8	—	0,7
	VI.	0,3	5,3	2,2	4,3	0,5	1,1	8,3	7,6	—	0,1
	VII.	0,3	8,7	0,5	9,9	0,4	1,9	9,2	5,8	—	0,9
	VIII.	0,6	5,6	0,2	7,1	0,2	5,2	8,5	3,7	2,5	2,3
	IX.	5,6	8,2	1,5	5,6	0,2	3,5	7,2	8,7	—	0,8
	X.	1,5	9,7	0,5	6,6	2,8	6,1	11,8	7,9	0,7	0,2
	XI.	1,2	5,1	2,5	6,4	1,0	3,6	5,0	3,5	0,5	4,6
Be <i>Fragilaria pinnata</i> EHR.	V.	0,9	10,6	1,4	7,8	0,6	1,9	2,8	8,2	0,7	1,6
	VI.	0,6	3,3	0,9	1,9	1,3	4,0	6,6	6,1	1,3	0,9
	VII.	0,2	4,9	0,6	4,7	0,2	3,6	6,1	4,1	1,5	2,0
	VIII.	0,1	3,1	0,7	3,9	2,0	0,9	4,9	—	1,2	—
	IX.	0,2	3,5	0,9	1,0	0,4	1,0	5,4	2,5	—	0,7
	X.	9,0	1,8	0,7	1,2	2,0	0,7	5,1	3,8	1,5	—
	XI.	1,5	1,0	1,5	1,2	1,0	1,5	2,0	2,5	0,5	1,5
Ep. <i>Gomphonema olivaceum</i> (LYNGB. KÜTZ.	VI.	—	—	—	—	—	—	—	0,1	—	—
Pl <i>Gyrosigma attenu- tum</i> (KÜTZ.) RABH.	V.	—	—	—	0,1	—	—	—	0,1	—	—
	VI.	—	—	—	—	—	—	—	0,1	—	—
	VII.	—	—	—	0,1	—	0,1	—	0,1	—	0,1
	VIII.	—	—	—	—	—	—	0,3	0,1	0,1	—
	IX.	—	—	—	—	—	—	—	0,1	—	0,1
	X.	—	0,1	—	—	—	—	—	0,1	—	—
	XI.	—	—	—	—	—	—	—	0,2	—	—
Pl <i>Gyrosigma distor- tum</i> var. <i>parkeri</i> HARRIS	V.	1,2	0,1	0,1	—	0,1	—	9,9	0,4	3,3	0,3
	VI.	0,1	—	0,1	0,1	0,1	0,1	1,3	0,6	0,4	0,2
	VII.	—	—	—	0,1	—	—	—	0,1	0,1	—
	VIII.	—	—	0,1	—	0,1	—	—	0,1	0,1	—
	IX.	—	0,1	0,1	0,1	0,1	—	0,1	0,1	0,1	0,3
	X.	—	—	—	—	0,1	—	0,1	0,1	0,1	0,1
	XI.	0,1	—	—	0,1	—	—	0,2	—	—	—
Pl <i>Gyrosigma kütz- ingi</i> (GRUN.) CLEVE	V.	2,4	0,2	0,2	—	2,9	0,6	7,0	0,8	2,4	0,3
	VI.	0,3	0,1	0,1	0,1	0,1	0,3	0,7	1,4	0,5	1,0
	VII.	0,3	0,1	0,1	0,1	—	0,3	0,2	0,6	2,1	0,7
	VIII.	0,8	0,1	0,1	—	0,2	0,2	0,5	0,5	1,6	0,4
	IX.	1,1	0,3	0,1	0,1	0,1	0,1	0,2	2,1	0,4	0,6
	X.	0,1	0,2	—	0,1	0,1	0,3	0,2	1,0	0,9	0,2
	XI.	0,2	1,0	0,1	0,2	0,1	0,6	0,2	0,6	0,1	0,2
Be <i>Gyrosigma prolon- gatum</i> (W. SMITH) CLEVE	V.	—	0,1	—	—	—	—	—	—	—	—
	IX.	0,1	—	—	—	—	—	—	—	—	—
	XI.	0,1	0,1	—	—	—	—	—	—	—	—
Pl <i>Melosira granu- lata</i> (EHR.) RALFS	V.	5,8	14,7	2,1	2,5	—	0,9	0,5	2,4	0,8	5,4
	VI.	3,8	11,2	4,9	6,8	—	0,7	—	3,0	0,7	1,7
	VII.	15,8	16,8	3,0	7,7	—	1,7	2,0	3,9	2,6	1,4
	VIII.	3,7	8,0	—	6,3	—	1,7	1,5	1,7	0,2	4,8

Tabelle 2 (Fortsetzung) — 2. táblázat (folytatás)

Sammelstellen und Zeitpunkt des Vorkommens Gyűjtőhelyek, időpont		M		K		G		A		E	
Artenverzeichnis Fajok felsorolása		a	b	a	b	a	b	a	b	a	b
Pl <i>Melosira granulata</i> (EHR.) RALFS	IX.	7,7	16,4	0,5	4,6	0,2	1,3	5,1	4,3	4,1	3,4
	X.	7,7	19,5	3,3	2,8	1,5	1,7	2,1	6,1	1,5	4,4
	XI.	1,2	11,1	4,1	3,3	1,5	1,5	1,5	4,6	—	—
Pl <i>Melosira granulata</i> var. <i>angustissima</i> O. MÜLL.	V.	12,7	15,2	5,5	5,3	0,1	0,1	—	0,2	0,2	0,2
	VI.	10,5	11,9	5,7	6,9	0,6	0,6	—	0,2	—	—
	VII.	9,1	10,2	5,1	8,3	—	0,4	—	0,1	—	—
	VIII.	4,1	7,8	0,5	5,0	—	3,2	1,5	0,5	1,2	1,7
	IX.	21,9	25,0	4,1	10,8	0,2	1,0	—	3,8	0,2	1,8
	X.	17,7	19,1	2,2	5,4	0,5	0,5	0,7	0,7	0,2	1,5
	XI.	2,0	12,6	8,7	7,7	0,5	1,0	2,5	6,7	0,5	—
Be <i>Navicula costulata</i> GRUN.	V.	0,1	0,1	—	—	—	—	—	0,1	—	—
	VI.	—	0,1	—	—	—	0,1	0,1	0,3	0,1	0,2
	VII.	0,1	0,1	—	—	—	—	0,1	0,1	—	0,1
	VIII.	—	—	—	—	—	—	—	0,1	—	—
	XI.	—	—	—	—	—	—	—	0,2	—	—
Be <i>Navicula cryptocephala</i> KÜTZ.	V.	2,9	0,4	2,8	0,1	0,6	0,8	0,7	0,1	1,7	0,3
	VI.	2,9	0,4	3,9	0,3	1,3	0,6	2,3	1,0	0,2	0,1
	VII.	2,2	0,1	1,3	0,2	0,9	0,2	2,1	0,2	6,7	0,5
	VIII.	1,8	0,2	4,8	0,3	5,3	0,4	1,3	0,8	5,3	0,6
	IX.	8,7	0,7	4,2	0,4	2,0	0,2	1,9	0,3	1,1	—
	X.	2,2	0,3	0,3	0,1	1,1	—	2,4	0,1	1,0	0,2
	XI.	1,0	0,3	0,1	0,2	0,6	—	0,7	0,4	—	0,2
Be <i>Navicula gracilis</i> EHR.	V.	0,1	0,1	—	—	0,2	0,2	—	0,1	—	—
	VI.	0,1	—	—	—	—	—	—	0,1	—	—
	VII.	0,1	—	—	—	—	—	—	—	—	—
	X.	0,3	0,2	—	—	—	—	—	—	—	—
	XI.	—	0,1	—	—	—	—	—	—	—	—
Be <i>Navicula hungarica</i> var. <i>capitata</i> (EHR.) CLEVE	V.	0,1	—	—	0,2	0,1	0,2	—	0,1	0,2	0,1
	VI.	0,1	0,1	—	0,1	—	0,2	—	0,1	—	—
	VII.	0,3	0,1	0,1	0,1	0,1	0,1	0,1	0,3	0,1	—
	VIII.	0,1	—	—	0,1	—	0,1	—	0,1	—	0,1
	IX.	—	—	—	—	—	—	—	0,1	0,1	0,1
	X.	—	—	—	0,1	—	—	—	0,1	—	0,1
	XI.	—	—	—	0,1	—	—	—	—	—	—
Be <i>Navicula placentalis</i> (EHR.) GRUN.	V.	2,7	0,1	—	0,1	—	0,5	0,2	0,2	0,6	0,2
	VI.	0,5	0,1	0,4	0,1	0,2	0,1	0,5	0,2	0,2	0,1
	VII.	0,3	0,1	0,4	0,1	0,4	0,5	0,2	0,4	0,8	0,2
	VIII.	0,3	0,1	0,3	0,1	0,8	0,2	0,2	0,5	1,8	0,8
	IX.	1,5	0,4	0,1	—	0,4	0,1	0,3	0,4	0,1	0,1
	X.	0,1	0,1	—	—	0,1	0,3	0,1	0,1	0,1	0,1
	XI.	0,3	0,3	—	0,1	0,2	—	0,1	0,3	0,1	—
Be <i>Navicula pupula</i> KÜTZ.	V.	—	0,1	—	—	—	0,1	—	0,1	—	0,1
	VI.	—	—	—	—	—	0,1	—	0,1	—	0,1
	VII.	—	—	—	—	—	0,1	—	—	—	—
	X.	—	—	—	—	—	—	—	0,1	—	0,1

Tabelle 2 (Fortsetzung) -- 2. táblázat (folytatás)

Sammelstellen und Zeitpunkt des Vorkommens Gyűjtőhelyek, időpont		M		K		G		A		E	
Artenverzeichnis Fajok felsorolása		a	b	a	b	a	b	a	b	a	b
Be <i>Navicula reinhardtii</i> GRUN.	V.	—	—	—	—	—	—	0,1	0,1	—	—
	VI.	—	0,1	—	—	—	—	—	—	—	0,1
	VII.	—	0,1	—	—	0,1	—	—	—	—	—
Be <i>Navicula scutelloides</i> W. SMITH	V.	—	—	—	—	—	—	—	0,1	—	—
	VII.	—	—	—	—	—	—	—	0,1	—	—
Be <i>Navicula tusculta</i> (EHR.) GRUN.	VI.	—	—	—	—	—	0,1	—	0,1	—	0,1
Be <i>Neidium dubium</i> (EHR.) CLEVE	V.	—	—	—	—	—	—	0,1	0,1	—	0,1
	VI.	—	—	—	0,1	—	—	—	—	—	0,1
	VII.	—	0,1	—	—	—	0,1	—	—	—	0,1
	VIII.	—	—	—	—	—	—	—	0,1	—	0,3
	IX.	—	—	—	—	—	0,1	—	0,4	—	—
	X.	—	0,1	—	—	—	0,1	—	—	0,1	0,1
	XI.	—	0,1	—	—	—	—	—	—	—	0,1
Pl <i>Nitzschia acicularis</i> W. SMITH	V.	0,1	0,1	0,1	0,1	0,1	6,8	0,8	5,3	3,4	3,2
	VI.	—	—	0,3	0,3	0,5	5,5	0,9	7,9	0,1	4,4
	VII.	0,1	—	0,1	0,1	0,1	1,3	—	0,7	0,5	1,1
	VIII.	0,1	—	0,2	—	0,6	0,7	—	1,1	5,0	0,8
	IX.	0,2	—	0,2	0,1	0,4	1,0	0,3	0,5	0,9	0,3
	X.	—	—	0,1	0,2	—	0,3	0,2	0,4	0,8	0,6
	XI.	0,1	—	0,1	0,1	—	0,3	0,3	0,4	0,1	—
Be <i>Nitzschia amphibia</i> GRUN.	V.	2,3	0,5	6,2	0,3	1,4	3,9	4,0	2,3	14,5	3,9
	VI.	4,0	0,6	4,9	1,2	2,3	3,5	2,2	3,6	0,8	1,8
	VII.	2,8	0,7	1,6	0,3	0,9	0,7	0,6	0,8	2,6	0,8
	VIII.	1,1	0,2	1,9	0,4	5,2	0,4	2,3	0,9	8,8	0,8
	IX.	1,8	0,4	4,0	0,2	4,8	1,0	1,6	0,9	3,4	1,6
	X.	0,5	0,4	1,5	0,4	1,4	2,1	1,3	1,9	0,8	0,6
	XI.	1,2	1,0	0,7	0,3	1,1	1,2	0,7	0,9	0,3	0,3
Be <i>Nitzschia hungarica</i> GRUN.	V.	0,5	—	—	—	—	0,1	0,1	—	—	—
Be <i>Nitzschia sigmoidea</i> (EHR.) W. SMITH	V.	1,9	0,7	0,9	0,1	0,5	1,4	4,2	3,9	8,9	3,0
	VI.	2,1	0,3	2,1	0,4	1,5	0,9	2,7	5,1	1,1	3,1
	VII.	0,9	0,3	0,5	0,1	1,1	1,4	0,6	2,2	2,0	1,5
	VIII.	0,3	0,1	0,1	0,4	1,4	0,3	0,1	1,7	4,9	1,5
	IX.	0,9	0,6	1,9	0,4	1,7	1,7	0,9	2,6	1,6	0,3
	X.	0,4	0,3	0,5	0,1	0,5	1,1	1,7	2,9	0,3	1,9
	XI.	0,9	0,6	0,3	0,1	0,7	1,8	0,5	1,8	0,4	0,2
Be <i>Nitzschia tryblionella</i> var. <i>debilis</i> (ARNOTT) A. MAYER	V.	0,1	—	0,1	0,1	0,1	0,2	0,1	0,1	0,1	0,1
	VI.	—	0,1	0,1	0,3	0,1	0,3	—	0,1	—	—
	VII.	—	0,1	0,2	0,2	—	0,1	0,1	0,3	—	0,2
	VIII.	—	—	—	0,1	—	0,1	0,1	0,1	—	0,4
	IX.	0,1	0,1	—	0,1	0,1	0,1	—	0,5	—	0,2
	X.	—	—	—	0,1	—	0,1	—	0,2	—	0,1
	XI.	—	—	—	—	—	0,2	—	0,4	—	0,2

Tabelle 2 (Fortsetzung) — 2. táblázat (folytatás)

Sammelstellen und Zeitpunkt des Vorkommens Gyűjtőhelyek, időpont		M		K		G		A		E	
Artenverzeichnis Fajok felsorolása		a	b	a	b	a	b	a	b	a	b
Be <i>Opephora martyi</i> HÉRIBAUD	V.	—	0,1	—	0,1	—	0,1	—	0,1	—	—
	VI.	—	0,1	—	—	—	0,1	—	0,1	—	—
	VII.	—	0,1	—	0,1	—	0,1	—	0,1	—	—
	VIII.	—	—	—	—	—	—	—	0,1	—	—
	IX.	—	—	—	—	—	0,1	—	—	—	—
Be <i>Pinnularia</i> sp.	V.	—	0,1	—	—	—	—	0,1	—	—	—
	VI.	—	0,1	0,1	—	—	—	0,1	—	0,1	0,1
	VII.	0,1	0,1	0,1	0,1	0,1	0,1	—	0,1	0,1	—
	VIII.	—	0,1	—	—	—	—	0,1	—	—	—
	X.	—	—	—	—	—	—	—	—	0,1	—
	XI.	—	0,1	—	—	—	—	—	—	—	—
Ep <i>Rhoicosphenia</i> <i>curvata</i> (Kütz.) GRUN	V.	—	0,1	—	—	—	0,1	—	—	—	—
	VI.	—	0,1	—	—	—	—	—	—	—	—
Ep <i>Rhopalodia gibba</i> (EHR.) O. MÜLL.	V.	—	—	—	—	—	—	—	0,1	—	—
	VI.	—	—	—	0,1	—	—	—	—	—	—
	VII.	—	0,1	—	—	—	—	—	—	—	—
Be <i>Stauroneis smithii</i> var. <i>incisa</i> PANT.	VI.	—	—	—	—	—	—	—	0,1	—	—
Pl <i>Stenopterobia</i> <i>pelagica</i> HUST.	V.	0,2	0,1	0,1	0,1	—	0,1	0,1	—	0,3	0,1
	VI.	0,3	0,1	0,4	0,2	0,1	0,1	0,1	0,1	0,1	0,1
	VII.	0,1	—	0,1	—	0,1	0,1	0,2	0,2	0,1	0,1
	VIII.	—	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
	IX.	0,1	—	0,7	0,1	0,1	—	0,1	0,1	—	—
	X.	0,1	—	0,1	—	0,1	—	0,1	0,1	0,1	—
	XI.	0,1	—	0,1	—	0,1	—	0,1	0,3	0,2	—
Be <i>Surirella bise-</i> <i>riata</i> BRÉB.	VII.	0,1	—	—	—	—	—	—	—	0,1	—
	VIII.	—	0,1	—	—	—	—	—	—	—	—
	X.	—	—	—	—	—	—	—	0,1	—	—
	XI.	—	0,1	—	—	—	—	—	—	—	—
Be <i>Surirella elegans</i> EHR.	VI.	—	—	—	—	0,1	0,1	—	0,1	—	—
	VII.	—	—	—	—	—	—	—	0,1	—	—
	VIII.	—	—	—	—	—	—	—	0,1	—	—
	IX.	—	—	—	—	—	—	—	0,2	—	—
Be <i>Surirella robusta</i> var. <i>splendida</i> (EHR.) V. HEURCK	V.	0,1	—	—	0,1	0,1	0,1	0,5	0,5	0,1	0,4
	VI.	0,1	0,1	0,2	—	0,2	0,1	0,6	1,0	0,4	0,5
	VII.	0,2	0,1	0,1	—	0,1	—	0,1	0,7	0,5	0,3
	VIII.	0,1	0,1	0,1	0,1	0,1	0,1	0,5	0,7	0,8	0,8
	IX.	0,1	0,1	0,1	0,1	—	0,1	0,3	0,9	0,1	0,3
	X.	—	0,1	—	—	—	0,1	0,4	0,9	—	0,1
	XI.	0,1	0,1	—	0,1	—	0,3	0,3	0,5	—	0,2

Tabelle 2 (Fortsetzung) — 2. táblázat (folytatás)

Sammelstellen und Zeitpunkt des Vorkommens Gyűjtőhelyek, időpont		M		K		G		A		E	
Artenverzeichnis Fajok felsorolása		a	b	a	b	a	b	a	b	a	b
<i>Closterium polystictum</i> NYGAARD	V.	—	—	—	—	—	—	—	—	0,1	—
<i>Closterium</i> sp.	IX.	—	—	0,1	—	—	—	0,1	—	0,1	—
<i>Coelastrum micropo-</i> <i>rum</i> NAEG.	VI.	0,1	—	—	—	—	—	—	—	—	—
<i>Crucigenia quadrata</i> var. <i>octogona</i> SCHMIDLE	V.	—	—	—	—	0,1	—	0,3	—	0,2	—
	VI.	—	—	0,1	—	0,3	—	0,2	—	0,2	0,1
	VII.	—	—	0,1	—	—	—	—	—	—	—
	VIII.	—	—	0,1	—	—	—	—	—	—	—
	IX.	—	—	—	—	0,2	—	—	—	—	—
	X.	—	—	0,1	—	—	—	—	—	—	—
	XI.	—	—	0,1	—	—	—	—	—	—	—
<i>Dictyosphaerium</i> <i>pulchellum</i> WOOD.	V.	—	—	—	—	0,1	—	0,1	—	—	—
	VI.	—	—	0,2	—	—	—	0,1	—	—	—
	VII.	0,1	—	—	—	0,1	—	0,1	—	0,1	—
	VIII.	—	—	—	—	—	—	0,1	—	0,1	—
	IX.	—	—	—	—	—	—	0,1	—	0,1	—
	X.	—	—	—	—	—	—	—	—	0,1	—
<i>Kirchneriella obesa</i> (W. WEST) SCHMIDLE	V.	—	—	—	—	—	—	—	—	0,1	—
	VI.	—	—	—	—	0,1	—	—	—	0,1	—
	VII.	0,1	—	—	—	—	—	—	—	—	—
<i>Oocystis solitaria</i> W. WITTR.	V.	0,1	—	—	—	0,1	—	—	—	0,1	—
	VI.	—	—	—	—	0,1	—	0,1	—	0,1	—
	VII.	—	—	—	—	0,1	—	—	—	—	—
	IX.	—	—	0,1	—	—	—	—	—	—	—
<i>Oocystis submarina</i> LAGERH.	V.	—	—	—	—	0,1	—	—	—	0,1	—
<i>Pediastrum boryanum</i> (TURP.) MENEGH.	V.	—	—	—	0,1	—	0,1	—	—	—	0,1
	VI.	—	0,1	—	0,1	—	0,1	0,1	—	—	—
	VII.	—	—	—	0,1	—	0,1	—	0,1	—	0,1
	IX.	—	0,1	—	0,1	—	0,1	—	0,1	—	—
	X.	—	—	—	—	—	0,1	—	—	—	0,1
	XI.	—	0,1	—	—	—	—	—	—	—	—
<i>Pediastrum clathra-</i> <i>tum</i> (SCHROET.) LEMM.	V.	—	0,8	—	0,1	—	0,1	—	—	—	0,1
	VI.	—	—	—	0,1	—	0,2	—	0,1	—	0,1
	VII.	—	0,1	0,1	0,1	—	0,1	—	0,3	0,1	0,1
	VIII.	—	—	—	—	—	0,1	—	—	—	0,1
	IX.	—	0,1	—	0,1	—	0,1	—	0,1	0,1	0,1
	X.	—	0,1	—	—	—	0,1	—	0,1	—	0,1
	XI.	—	0,1	—	0,1	—	0,1	—	0,1	—	0,1

Tabelle 2 (Fortsetzung) — 2. táblázat (folytatás)

Sammeistellen und Zeitpunkt des Vorkommens Gyűjtőhelyek, időpont		M		K		G		A		E	
Artenverzeichnis Fajok felsorolása		a	b	a	b	a	b	a	b	a	b
<i>Pediastrum duplex</i> var. <i>reticulatum</i> LAGERH.	V.	—	—	—	—	—	—	—	—	0,1	—
	VI.	0,1	—	0,1	—	—	—	0,1	—	0,1	—
	VII.	—	—	—	—	—	—	—	0,1	—	0,1
	IX.	—	—	—	—	—	—	0,1	—	—	—
	X.	—	—	—	—	—	0,1	—	0,1	—	—
	XI.	—	—	—	—	—	0,1	—	0,1	—	—
<i>Pediastrum simplex</i> RALFS	V.	—	—	—	0,1	—	—	—	—	—	—
	IX.	—	—	—	—	0,1	—	—	—	—	—
	XI.	—	0,1	—	—	—	—	—	—	—	—
<i>Scenedesmus balatonicus</i> HORTOB.	VI.	—	—	—	—	—	—	—	—	—	0,1
<i>Scenedesmus bicaudatus</i> var. <i>brevicaudatus</i> HORTOB.	X.	—	—	0,1	—	—	—	—	—	—	—
<i>Scenedesmus ecornis</i> (RALFS) CHOD.	VI.	—	—	—	—	0,1	—	—	—	—	—
	VIII.	—	—	—	—	—	—	—	—	0,1	—
	IX.	—	—	—	—	0,1	—	0,1	—	0,2	—
	X.	—	—	—	—	0,1	—	—	—	—	—
<i>Scenedesmus intermedius</i> var. <i>acaudatus</i> HORTOB.	V.	0,1	—	—	—	—	—	—	—	—	—
	VII.	—	—	—	—	—	0,1	—	—	—	—
<i>Scenedesmus quadricauda</i> (TURP.) BRÉB.	V.	0,2	—	0,2	—	0,1	0,1	0,1	0,1	0,1	0,1
	VI.	0,1	0,1	0,1	0,1	0,1	0,1	0,1	—	0,2	0,1
	VII.	0,1	—	0,1	—	0,1	0,1	—	—	0,1	—
	VIII.	0,1	—	0,1	—	0,2	—	—	—	0,1	—
	IX.	0,1	—	0,3	—	0,1	0,1	—	—	0,1	—
	X.	0,3	—	0,1	0,1	0,1	—	—	—	0,1	—
	XI.	0,1	—	0,1	—	0,1	—	0,1	—	0,1	—
<i>Scenedesmus spinosus</i> CHOD.	V.	—	—	—	—	0,1	—	—	—	—	—
<i>Staurastrum gracile</i> RALFS	V.	—	—	—	—	—	0,1	—	—	—	0,1
	VI.	—	—	—	0,1	—	—	—	—	—	0,1
	VII.	—	0,1	—	—	0,1	0,1	—	0,1	0,1	0,1
	VIII.	—	—	—	—	—	—	—	0,1	—	0,1
	IX.	—	0,1	0,1	—	0,1	0,1	0,1	0,1	0,1	0,1
	X.	—	—	0,1	0,1	—	0,1	—	0,1	—	—
	XI.	—	—	0,1	0,1	—	0,1	—	0,2	—	—
<i>Staurastrum paradoxum</i> MEYEN	VII.	—	—	—	—	—	—	—	—	0,1	—
	IX.	—	—	0,1	—	0,1	—	—	0,1	0,1	0,1
	X.	—	—	0,1	—	—	—	—	—	—	—
	XI.	—	—	0,1	—	—	—	—	—	—	—

Tabelle 2 (Fortsetzung) — 2. táblázat (folytatás)

Sammelstellen und Zeitpunkt des Vorkommens Gyűjtőhelyek, időpont		M		K		G		A		E	
Artenverzeichnis Fajok felsorolása		a	b	a	b	a	b	a	b	a	b
<i>Tetrastrum staurogeniaeforme</i> (SCHROEDER) LEMM.	VI.	—	0,1	—	—	—	—	—	—	—	—
	VIII.	0,1	—	—	—	—	—	—	—	—	—
MYCOPHYTA <i>Dactylosporium</i> sp.	VI.	—	—	—	—	0,1	—	0,1	—	—	—
	VII.	0,1	—	—	—	—	—	—	—	—	—
	VIII.	0,1	—	—	—	—	—	—	—	—	—
	X.	0,1	—	—	—	—	—	—	—	0,1	—

Zeichenerklärung: Pl = Planktondiatomeen; Ep = Epiphyten; Be = Benthosdiatomeen; V—XI = Monate; a = lebende Algen; b = abgestorbene Algen.

quantitative Vorkommen des Stammes wechselte in der Zeit von Mai bis November bloß von 0 bis 0,5%. Der Stamm erreichte 8% der gesamten Algenartenzahl.

Der Stamm der *Pyrrophyten* ist allein durch die einzige Art der *Dynophyceae*-Klasse, durch *Ceratium hirundinella* (in Cistenform) sporadisch vertreten. Das perzentuell quantitative Vorkommen der Art ist unbedeutend. Der Stamm erreichte bloß 1% der gesamten Algenartenzahl.

Ebenso sporadisch und in unbedeutenden Mengen fand sich in den Schlammproben auch *Dactylosporium* als einzige Art des *Mycophyten*-Stammes. Dieser Stamm erreichte ebenfalls bloß 1% der gesamten Algenartenzahl.

Von den fünf Quersegmenten war an Algenarten die Schlammprobe von Mai zwischen Balatonalmádi und Balatonvilágos mit 47 Arten am reichsten und am ärmsten zeigte sich die Schlammprobe von November aus demselben Segment mit 15 Algenarten.

Das Vorkommen der Arten *Synura uvella*, *Asterionella formosa* und *Gyrodinium prolougatum* beschränkte sich auch in diesem Jahre auf die Bucht von Keszthely und bekräftigte somit die Daten der Plankton- und Schlammproben-Untersuchungen der früheren Jahre (vgl. TAMÁS 1965, p. 242—243; und 1967, p. 203, 207).

Aus den algologischen Ergebnissen der Schlammproben des Jahres 1966 erhellt, daß *Melosira granulata* und *M. granulata* var. *angustissima* in der Bucht von Keszthely bereits seit dem Monat Mai eine große Individuenzahl (lebende und auch abgestorbene Exemplare) erreicht hatten. Die Individuenzahl der lebenden Algen fiel im November plötzlich stark zurück, während die der abgestorbenen fast auf das Achtfache der lebenden angewachsen war. Hinsichtlich der *Melosira*-Arten gleichen die Verhältnisse im Segment Szigliget—Balatonmária denen der Verhältnisse in der Bucht von Keszthely, nur mit bescheidenen Individuenzahlen pro dm². In diesem Jahre erreichten die *Melosiren* in der Keszthelyer Bucht und ihrer Umgebung nur ein Drittel der September-Population des Jahres 1965.

Tabelle 3

Zusammenfassende quantitative Mikrophytobentos-Untersuchungen aus dem Eprofundal
zahl pro

A Balaton nyíltvízi fenékiszapmintáinak összesített mennyiségi algológiai adatai

Sammelstellen	Monate	Artenzahl	Lebende Kiesel- algen — i/dm^2	Proz. — i/dm^2	Artenzahl	Abgestorbene Kieselalgen — i/dm^2	Proz. — i/dm^2
<i>M</i>	V.	27	52,9	98	33	58,2	98
	VI.	24	28,3	98	31	51,5	99
	VII.	24	34,3	96	25	51,6	99
	VIII.	20	14,7	95	24	35,0	99
	IX.	21	51,8	99	20	77,1	99
	X.	15	42,6	98	23	68,5	99
	XI.	18	11,0	95	22	42,3	95
<i>K</i>	V.	22	38,2	97	27	30,7	97
	VI.	26	29,8	93	26	44,1	98
	VII.	21	17,6	93	28	45,0	97
	VIII.	21	15,2	97	20	38,7	98
	IX.	21	22,7	92	24	41,7	98
	X.	13	10,4	90	18	30,0	98
	XI.	13	20,1	96	20	27,2	98
<i>G</i>	V.	21	16,8	89	33	29,3	95
	VI.	26	22,7	91	33	39,0	95
	VII.	23	11,3	87	29	25,1	92
	VIII.	18	35,3	97	23	31,4	96
	IX.	18	16,5	83	24	26,7	90
	X.	16	11,0	90	23	32,0	94
	XI.	14	8,5	92	19	19,8	95
<i>A</i>	V.	31	53,7	97	38	49,0	98
	VI.	24	42,7	94	40	60,2	97
	VII.	20	30,4	96	36	37,1	94
	VIII.	20	27,3	95	32	29,7	93
	IX.	20	30,2	90	32	45,4	91
	X.	19	28,6	93	31	40,3	92
	XI.	19	17,1	95	26	33,8	96
<i>E</i>	V.	27	50,7	89	31	34,0	93
	VI.	26	10,6	87	33	24,4	85
	VII.	26	27,9	96	26	19,2	96
	VIII.	23	50,4	96	26	33,4	90
	IX.	19	19,1	85	24	20,9	79
	X.	18	10,5	78	26	20,7	84
	XI.	11	3,2	86	14	9,5	97

3. táblázat

des Balaton-Sees auf Grund der Sammlungen des Jahres 1966 — $i/\text{dm}^2 = \text{Individuen-}\text{dm}^2 \times 1000$

az 1966. évi gyűjtések alapján — $i/\text{dm}^2 = \text{egyedszám}/\text{dm}^2 \times 1000$

Das Zahlenverhältnis zwischen lebenden und abgestorbenen Kieselalgen	Artenzahl	Lebende Algen — i/dm^2	Proz. — i/dm^2	Artenzahl	Abgestorbene Algen — i/dm^2	Proz. — i/dm^2	Das Zahlenverhältnis zwischen lebenden und abgestorbenen Algen
1 : 1,1	8	0,9	2	3	1,1	2	1 : 1,1
1 : 1,8	7	0,7	2	5	0,6	1	1 : 1,1
1 : 1,5	12	1,3	4	4	0,4	1	3,2 : 1
1 : 2,3	7	0,7	5	1	0,1	1	7 : 1
1 : 1,4	6	0,7	1	4	0,4	1	1,7 : 1
1 : 1,6	5	0,7	2	3	0,4	1	1,7 : 1
1 : 3,8	4	0,6	5	5	0,5	5	1,2 : 1
1,2 : 1	11	1,2	3	6	0,8	3	1,5 : 1
1 : 1,4	12	2,1	7	6	1,0	2	2,1 : 1
1 : 2,5	11	1,2	7	6	1,0	3	1,2 : 1
1 : 2,5	3	0,4	3	2	0,5	2	1 : 1,2
1 : 1,8	11	1,8	8	4	0,7	2	2,5 : 1
1 : 2,8	10	1,1	10	4	0,5	2	2,2 : 1
1 : 1,3	8	0,9	4	4	0,5	2	1,8 : 1
1 : 1,7	18	2,0	11	7	1,7	5	1,2 : 1
1 : 1,6	16	2,2	9	7	2,0	5	1,1 : 1
1 : 2,2	11	1,6	13	8	2,2	8	1 : 1,3
1,1 : 1	5	1,1	3	3	1,4	4	1 : 1,2
1 : 1,6	11	3,5	17	8	3,0	10	1,1 : 1
1 : 2,9	10	1,2	10	5	2,1	6	1 : 1,7
1 : 2,3	4	0,7	8	5	1,1	5	1 : 1,5
1 : 1	13	1,6	3	4	1,1	2	1,5 : 1
1 : 1,4	11	2,5	6	3	2,1	3	1,1 : 1
1 : 1,2	6	1,3	4	6	2,3	6	1 : 1,7
1 : 1	5	1,4	5	2	2,1	7	1 : 1,5
1 : 1,5	13	3,2	10	7	4,7	9	1 : 1,4
1 : 1,4	4	2,0	7	4	3,5	8	1 : 1,7
1 : 1,9	4	0,9	5	4	1,3	4	1 : 1,4
1,5 : 1	20	6,5	11	8	2,6	7	2,5 : 1
1 : 2,3	10	1,6	13	7	4,2	15	1 : 2,6
1,4 : 1	8	1,3	4	5	0,7	4	1,7 : 1
1,5 : 1	6	2,2	4	3	3,7	10	1 : 1,6
1 : 1	14	3,3	15	6	5,4	21	1 : 1,6
1 : 1,9	8	2,9	22	3	3,8	16	1 : 1,3
1 : 2,9	4	0,5	14	2	0,3	3	1,6 : 1

Aus den zusammenfassenden Daten der *Tabelle 3* ist zu entnehmen, daß die Individuenzahl der lebenden Kieselalgen in der Mai-Probe des Segmentes Balatonfüred—Zamárdi den höchsten Wert (53 700 pro dm²) erreicht hatte; den niedrigsten Wert ergab die November-Probe des Segmentes Balatonalmádi—Balatonvilágos mit 3 200 pro dm².

Stellen- und zeitweise zeigt sich das Zahlenverhältnis der lebenden und abgestorbenen Kieselalgen in den Schlammproben gleichmäßiger im Vergleich zu den Daten des Jahres 1965. Auffallend große Abweichungen waren keine anzutreffen. Das Verhältnis der lebenden zu den abgestorbenen Kieselalgen ist oft 1 : 1 und nur in einem einzigen Falle trafen wir auf ein Verhältnis von 1 : 3,8 (*Tab. 3*).

Die Differenz der Zahlenverhältnisse zwischen den zu anderen Algenstämmen gehörigen lebenden und abgestorbenen Algen ist — von einigen kleineren Abweichungen abgesehen — ziemlich gering.

Zusammenfassung

Autorin sammelte in der Zeit von Mai 1966 bis November desselben Jahres — ebenso wie im vorhergehenden Jahre 1965 — Schlammproben und führte die gleichen Untersuchungen bzw. die quantitative Aufarbeitung der gesammelten Algen durch. Die Entnahme der Proben erfolgte im südwestlichen Seeteile in drei und im nordöstlichen Seeteile in zwei Quersegmenten. Die Schlammproben wurden in je einem Quersegment (M, K, G, A, E) (*Abb. 1*) mittels eines modifizierten Schlammgreifers CRAIB aus 3 bestimmten Punkten an die Oberfläche herausgehoben. Im Laboratorium wurden nach einer 48stündigen Sedimentierung alle lebenden und abgestorbenen Algen aus einer fünfmal 1 cm² betragenden Schlammproben-Oberfläche aufgezeichnet und die erhaltenen Daten auf 1 dm² umgerechnet.

Die 107 Algenarten und 6 Varietäten, welche aus den 15 Sammelstellen gehobenen 105 Schlammproben bestimmt wurden, gehören samt dem Pilz zu 6 großen systematischen Stämmen, welche nach der Häufigkeit ihres Vorkommens angeführt die folgenden sind: *Chrysophyten* (63), *Chlorophyten* (27), *Cyanophyten* (13), *Euglenophyten* (8), *Pyrrophyten* (1) und *Mycophyten* (1).

Unter den 5 Quersegmenten ist die Maiprobe des Segmentes Balatonalmádi—Balatonvilágos an Algenarten am reichsten mit 47, am ärmsten dagegen die Novemberprobe desselben Segmentes mit 15 Arten (*Tab. 2* und *3*).

In der Bucht von Keszthely erreichten *Melosira granulata* und ihre Varietät *M. granulata* var. *angustissima* bereits seit dem Monat Mai eine große Individuenzahl (lebende und auch abgestorbene), deren Anzahl jedoch im November plötzlich stark zurückfiel, dagegen vermehrte sich die Anzahl der abgestorbenen fast auf das Achtfache der lebenden. Die *Melosiren* erreichten in der Bucht von Keszthely in diesem Jahre bloß ein Drittel der September-Population des Jahres 1965.

Die Individuenzahl der lebenden Kieselalgen ist in der Maiprobe des Segmentes Balatonfüred—Zamárdi am größten, hingegen wurde die niedrigste Individuenzahl in der Novemberprobe des Segmentes Balatonalmádi—Balatonvilágos aufgezeichnet.

Stellen- und zeitweise ist das Verhältnis der in den Schlammproben vorgefundenen lebenden und abgestorbenen Kieselalgen als auch das Verhältnis bei den zu anderen Stämmen gehörigen Algen im Vergleich zu den Daten des Jahres 1965 gleichmäßiger.

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MENNYISÉGI ALGOLÓGIAI VIZSGÁLATOK A BALATON FENÉKISZAPJÁN AZ 1966. ÉVI GYŰJTÉSEK ALAPJÁN

Tamás Gizella

Összefoglalás

Szerző 1966. év májustól — novemberig — az 1965. évi iszapmintavételek gyűjtéséhez és mennyiségi algológiai feldolgozásához hasonlóan — végzett vizsgálatokat. A tó DNY-i részének három, az ÉK-i részének pedig két harántszelvényén történtek a mintavételek. Egy-egy harántszelvény (M, K, G, A, E) három kijelölt pontjáról (l. 1. ábra) a módosított CRAIB-féle iszapvevővel hozták felszínre a mintákat. A laboratóriumban 48 órai ülepedés után ötször 1 cm² iszapfelület valamennyi (élő és elpusztult) algáját feljegyezte, és az így kapott adatokat 1 dm² iszapfelületre számította át.

A 15 gyűjtőhely 105 iszapmintájából meghatározott 107 faj és 6 változat a gombával együtt 6 nagy rendszertani törzsbe tartozik, gyakorisági sorrendben: *Chrysophyta* 63, *Chlorophyta* 27, *Cyanophyta* 13, *Euglenophyta* 8, *Pyrrophyta* 1, *Mycophyta* 1.

Az 5 harántszelvény közül algafajokban a leggazdagabb a Balatonalmádi—Balatonvilágos közötti májusi (47), a legszegényebb pedig ugyanezen szelvény novemberi (15) iszapmintája volt (l. 2. és 3. táblázat adatait).

A Keszthelyi-öbölben a *Melosira granulata* és változata már májustól magas egyedszámot ért el (élők és elpusztultak is), majd november hónapra számuk hirtelen csökkent, az elpusztultak száma pedig az élőknél csaknem nyolcszorosára növekedett. Ebben az évben az 1965. évi szeptemberi népességnek csak az egyharmadát érték el a *Melosirák* a Keszthelyi-öbölben és környékén.

Az élő kovamoszatok egyedszáma a Balatonfüred—Zamárdi szelvény májusi mintájában a legmagasabb, a legalacsonyabb értéket pedig a Balatonalmádi—Balatonvilágos novemberi mintában jegyezte fel.

Helyenként és időnként az iszapmintákban jelenlevő élő és elpusztult kovamoszatok és más algatörzsbe tartozó moszatok aránya — az 1965. évi adatokhoz hasonlítva — egyenletesebb.

КОЛИЧЕСТВЕННЫЕ ИССЛЕДОВАНИЯ ВОДОРосЛЕЙ ИЛА БАЛАТОНА НА ОСНОВЕ МАТЕРИАЛА СОБРАННОГО В 1966 ГОДУ

Гизелла Тамаш

Образцы ила были собраны с мая по ноябрь 1966 года, которые были обработаны подобно материалу 1965 года. В трех пунктах северо-восточной части и в двух пунктах юго-западной части озера были собраны образцы ила на разной глубине залегания. Материал поднимали на поверхность (в пунктах М, К, G, А, Е) по методу Сватв (рис. 1.). В лаборатории после 48 часового осаждения были описаны все водоросли (и живущие и погибшие) на 5×1 см² поверхности ила, а затем был проведен пересчет на 1 дм² поверхности ила.

В 105 образцах, собранных в 15 местах, было найдено 107 видов, 6 разновидностей (вместе с грибами), которые относились к 6 большим систематическим группам: Chrysophyta 63, Chlorophyta 27, Cyanophyta 13, Euglenophyta 8, Pyrrophyta 1, Micophyta 1.

Самым богатым образцом по водорослям является образец, собранный в мае (47) между Балатоналмади—Балатонвилагош, а самым бедным—образец, собранный в ноябре (15) в том же месте (таблицы 2 и 3).

Численность *Melosira granulata* и его разновидностей в Кестхейском заливе уже в мае высокая (и живых и погибших), а в ноябре внезапно падает, и число погибших превосходит количество живых почти в 8 раз. В этом году число *Melosira* в Кестхейском заливе и окрестности составило только 1/3 количества 1965 года.

Число живых кремневых водорослей было самое высокое в образце, собранном в мае в Балатонфюред—Замарди, а самое низкое — в образце, собранном в ноябре в Балатоналмади—Балатонвилагош.

Местами и временами пропорция живых и погибших кремневых и других водорослей в образце ила была более равномерна чем в образцах 1965 года.

**HORIZONTAL PLANKTON INVESTIGATIONS IN LAKE BALATON. VI.
A STUDY OF THE OPEN WATER ROTATORIA OF LAKE BALATON,
BASED ON COLLECTINGS IN 1965**

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The excessive dying of fish in Lake Balaton in the spring of 1965 again called attention to the importance of studying the biological conditions of the lake. For the sake of acquiring informations on the character and direction of changes enacted in the life of the lake, the Hydrobiological Section of the Biological Research Institute of the Hungarian Academy of Sciences organized systematic collecting trips covering the entire body of water. The primary aim of the study provides for a cognition of the qualitative and quantitative conditions of the diverse aquatic organisms, and its subsequent use in establishing changes occurring in the respective communities.

A number of authors (DADAY 1884, 1897, NÁDAY 1914, ENTZ, KOTTÁSZ and SEBESTYÉN 1937, ENTZ and SEBESTYÉN 1946, SEBESTYÉN, TÖRÖK and VARGA 1951, SEBESTYÉN 1953, 1958, 1960) discussed Rotatoria living in the open water of Lake Balaton, their quantitative changes and role in the plankton. It seems, at the first glance, that the Rotatoria represent one of the most intensely studied and best known group of animals of Lake Balaton. The high specific number shown from the plankton also seems to substantiate this assumption. DADAY (1897) lists ten species inhabiting the open water of the lake. NÁDAY (1914) increased this number to 24, mentioning, however, that there are a number of not typically open water animals also among these species and forms. As a result of VARGA's work (1932, 1935—36, SEBESTYÉN, TÖRÖK and VARGA 1951), the number of species known from the plankton reached 58. In spite of the fact, however, that the above-mentioned treatises had summarized research results obtained during years, indeed decades, they still offer but a mosaic-like picture of Lake Balaton. SEBESTYÉN (1960) had accordingly emphasized the necessity, and also the concomitant difficulties of horizontal investigations, to be done simultaneously. Until recently, lacking suitable transportation facilities and other requirements, it was not possible to gather, approximately simultaneously, animal materials from the entire area of Lake Balaton which would have rendered a comprehensive picture of the conditions prevailing in the open water of the lake. The project of the complex investigation of Lake Balaton, launched in 1965 and steadily continuing as planned, has its very importance in resolving, by better financial and personnel conditions as well as their enhanced organization, also the horizontal investigations required.

The aim of the present undertaking was to establish, by the working up of qualitative plankton samples, the Rotatoria fauna and its percentual composition characteristic for the open water of Lake Balaton.

Location, date, and method of collectings

Samples were taken, from June till October, 1965, in transversal sections perpendicular to the longitudinal axis of the surface of the lake (*Fig. 1*) (cf. SEBESTYÉN 1960) at three points in the south-western, and two points in the north-eastern parts of Lake Balaton. The designation of the localities of collecting is given according to SEBESTYÉN:

M_0 = Gyenesdiás — the mouth of the river Zala

K = Szigliget—Balatonmária

G = Ságpuszta—Balatonszemes

A_1 = Balatonfüred, Fenékfürdő—Zamárdi-alsó.

(About 500 m in front of the Biological Research Institute of the Hungarian Academy of Sciences, Tihany).

E_e = Balatonalmádi—Balatonvilágos

The time of the day of the collectings was selected with a view to provide also for evening and night samples from the two extreme localities of the lake (M_0 and E_e) as well as the waters, hitherto the most intensely studied ones, in front of the institute. Data referring to these samples, together with some remarks, are submitted in *Table 1*.

Samples were taken by a No. 25 plankton-net by subsurface dredging (at a depth of about 1 m) from a row-boat for 7–10 minutes around the point of collecting; the material gathered was conserved in formalin. Concurrently, also quantitative samples were taken, to be worked up at a later time. The investigation of the Rotatoria was made by a relative quantitative method, by counting 600–700 individuals per sample (SEBESTYÉN 1953). Strongly shrunken, intransparent, and thus hardly identifiable, specimens (*Synchaeta*, *Brachonius sessilis*, *Asplanchna*, etc.) were individually cleared up by sodium hypochlorite on separate slides, and then identified.

The dominant species have been established by relating the species to each other as well as to the total number of Rotatoria counted in the samples.

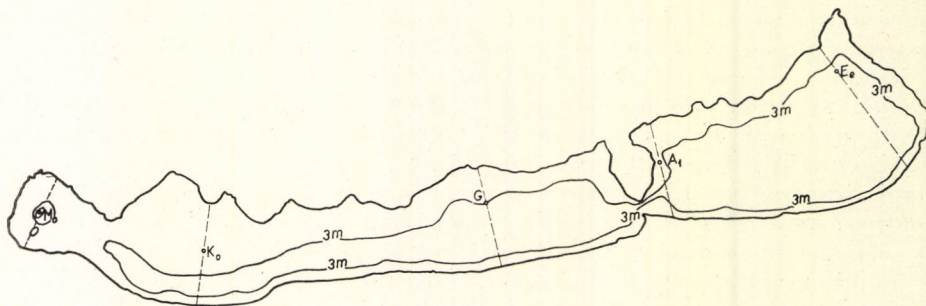


Fig. 1. Location of collecting sites in Lake Balaton

1. ábra. Gyűjtőhelyek megjelölése a Balatonon

For a better survey of their percentual occurrence, the percentage values referring to the dominant species in *Table 2* were also plotted on graphs (*Figs 2—6*). In the case of sections with also nocturnal collections available, values higher than those of the diurnal ones were considered. For the section M_0 , the *Synchaeta* species have not been separated for illustration; the species showing the higher percentage value was invariably shown.

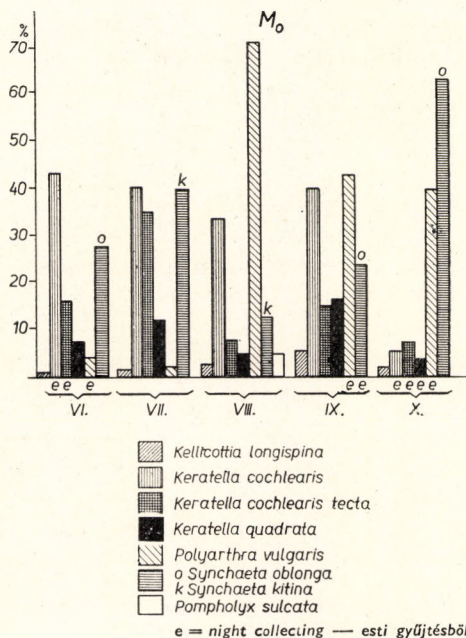


Fig. 2. Percentual occurrence of dominant species in the Keszthely-bay (M_0)

2. ábra. Domináns fajok %-os előfordulása a Keszthelyi-öbölben (M_0)

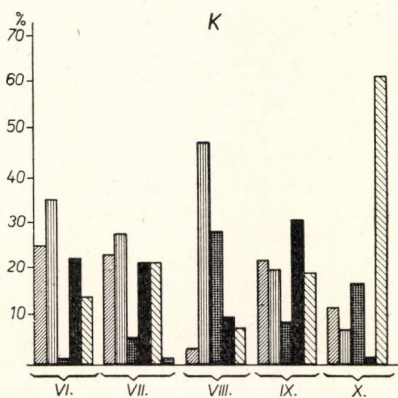


Fig. 3. Percentual occurrence of dominant species in section K (Szigliget—Balatonmária)

3. ábra. Domináns fajok %-os előfordulása a K szelvényben (Szigliget—Balatonmária)

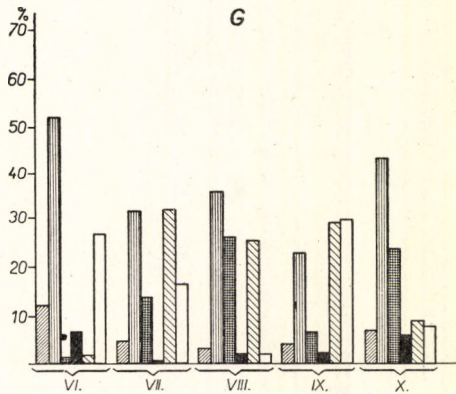


Fig. 4. Percentual occurrence of dominant species in section G (Ságpusztá—Balatonszemes)

4. ábra. Domináns fajok %-os előfordulása a G szelvényben (Ságpusztá—Balatonszemes)

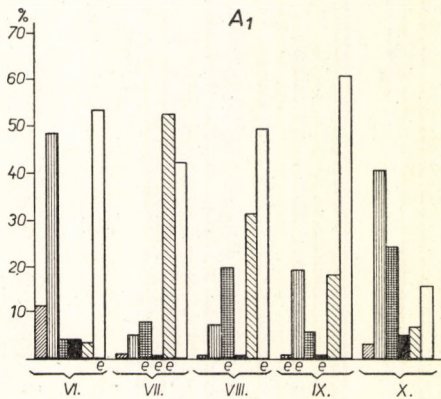


Fig. 5. Percentual occurrence of dominant species in the water fronting the Biological Research Institute (A_1)

5. ábra. Domináns fajok %-os előfordulása a Biológiai Intézet előtti vízterületen (A_1)

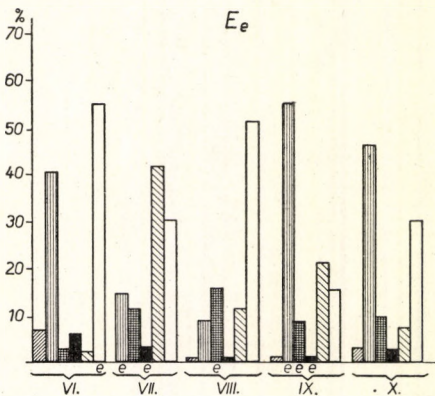


Fig. 6. Percentual occurrence of dominant species in section E_e (Balatonalmádi—Balatonvilágos)

6. ábra. Domináns fajok %-os előfordulása az E_e szelvényben (Balatonalmádi—Balatonvilágos)

Taxonomical and morphological remarks

Anuraeopsis fissa GOSSE? (Plate 1). A rather widely ranging species, but still offering difficulties for identification. In literature known by us, we have found reference nowhere to the fact that the body of *Anuraeopsis fissa*, as in the case of the specimens originating from Lake Balaton, would lie on an extremely thin, sinuously margined membrane. We have examined about 70, mainly egg-bearing specimens, and found only four in which the rectangular membrane was not to be observed. The species being a true open water form, the membrane might possibly have an importance in assisting floating, or subserving the protection of the eggs. Since we worked with strongly shrunken individuals, the dimensions (60–80 μ without the basic membrane) could not be considered. On the basis of the external habits and characters important in identification, we consider the species as *A. fissa*, but detailed morphological and anatomical investigations on live animals are needed. VARGA (1937) classifies it as a warm, stenothermic species, justified also by its occurrence from July until September (Table 2).

Brachionus sessilis was first found by SEBESTYÉN in the Balaton; VARGA described it (1951) as a new species epizoid on the Cladoceran *Diaphanosoma brachyurum*. The specimens examined by us completely agreed morphologically with VARGA's description and figures, though, in many cases, the animals had shrunken to such an extent that the chitinous structure at the cephalic aperture and the mastax could only be recognized after clearing up of the specimen. It is recorded here merely as an interesting note that we have found only two individuals attached to Crustaceans. All other exemplars have been

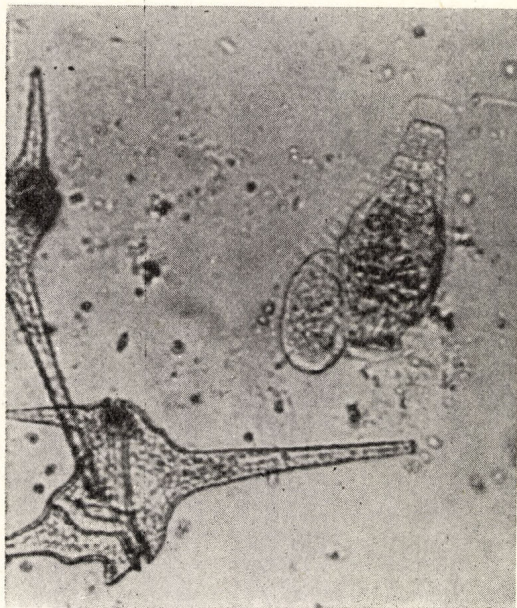


Plate 1. *Anuraeopsis fissa* GOSSE? greatly contracted
1. kép. *Anuraeopsis fissa* GOSSE? zsugorodott példány

Table 1 — 1. táblázat

Number and Section of samples Minták		Date and hour of collecting Gyűjtés		Water tem- perature Víz hőfok,	Trans- parency* Átlátszóság,*	Remarks** Megjegyzés**
sorszáma	szelvénye	időpontja	óra	°C	cm	
No. 1002	M ₀	VI. 8.	21	—	—	extremely meagre material — igen kevés anyag
No. 1006		VI. 9.	7	18	45	many bivalve-larvae — sok kagyló-lárva
No. 1034		VI. 30.	21	—	—	disattached epiphytes — leszakadt epifiták
No. 1038		VII. 1.	7	22	80	
No. 1075		VIII. 2.	21	—	—	masses of <i>Melosiras</i> — tömeges <i>Melosira</i> -k
No. 1079		VIII. 3.	7	20	39	<i>Melosira</i> discolouration of water — <i>Melosira</i> vízszíneződés
No. 1114		IX. 6.	21	—	—	sporadic algal bloom of <i>Microcystis-Aphanizomenon</i> — <i>Microcystis-Aphanizomenon</i> szórt vízvirágzás
No. 1118		IX. 7.	8	18	62	
No. 1154		X. 12.	19	—	—	diatoms living on reed-grass crust. — hinárbevonatban élő kovamoszatok
No. 1158		X. 13.	7	13	114	<i>Melosiras</i> — <i>Melosira</i> -k
No. 1010	K	VI. 9.	12	19.5	36	many <i>Ceratium</i> — sok <i>Ceratium</i>
No. 1042		VII. 1.	9	24	40	masses of <i>Microcystis</i> — tömeges <i>Microcystis</i>
No. 1083		VIII. 3.	9	20	35	<i>Melosira</i> discolouration of water — <i>Melosira</i> vízszíneződés
No. 1122		IX. 7.	10	19	51	<i>Microcystis-Aphanizomenon</i> — <i>Microcystis-Aphanizomenon</i>
No. 1162		X. 13.	11	13	66	<i>Colacium</i> species on <i>Cyclops</i> specimens — <i>Colacium</i> -ok <i>Cyclops</i> -okon
No. 1014	G	VI. 9.	16	20	42	many <i>Ceratium</i> — sok <i>Ceratium</i>
No. 1050		VII. 1.	16	32	92	many <i>Ceratium</i> — sok <i>Ceratium</i>
No. 1089		VIII. 3.	16	25	56	masses of <i>Ceratium</i> , <i>Melosira</i> discolouration of water — tömeges <i>Ceratium</i> , <i>Melosira</i> vízszíneződés

No. 1129	G	IX. 7.	16	24	50	masses of <i>Ceratium</i> — tömeges <i>Ceratium</i>
No. 1169		X. 13.	16	15	96	many <i>Ceratium</i> — sok <i>Ceratium</i>
No. 1016	A ₁	VI. 10.	16	18.5	50	bivalve larvae, many <i>Ceratium</i> — kagylólárvák, sok <i>Ceratium</i>
No. 1020		VI. 10.	22	—	—	many <i>Ceratium</i> — sok <i>Ceratium</i>
No. 1054		VII. 2.	15	24	92	many <i>Ceratium</i> , <i>Microcystis</i> groups — sok <i>Ceratium</i> , <i>Microcystis</i> csoportok
No. 1065		VII. 2.	24	—	—	many <i>Ceratium</i> — sok <i>Ceratium</i>
No. 1093		VIII. 4.	15	26	51	many <i>Ceratium</i> , <i>Melosiras</i> — sok <i>Ceratium</i> , <i>Melosira</i> -k
No. 1104		VIII. 4.	23	—	—	many <i>Ceratium</i> — sok <i>Ceratium</i>
No. 1133		IX. 8.	15	24	86	<i>Ceratiums</i> , many <i>Microcystis</i> — <i>Ceratium</i> -ok, sok <i>Microcystis</i>
No. 1144		IX. 8.	21	—	—	masses of <i>Ceratium</i> , many bivalve larvae — tömeges <i>Ceratium</i> , kagylólárvák
No. 1173		X. 14.	15	18	120	bivalve larvae — kagylólárvák
No. 1024	E _e	VI. 10.	18	19.5	64	many bivalve larvae, <i>Ceratium</i> , <i>Melosira</i> — sok kagylólárva, <i>Ceratium</i> , <i>Melosira</i>
No. 1026		VI. 10.	20	—	—	many <i>Ceratium</i> — sok <i>Ceratium</i>
No. 1058		VII. 2.	18	23	66	many <i>Ceratium</i> — sok <i>Ceratium</i>
No. 1063		VII. 2.	22	—	—	many <i>Ceratium</i> — sok <i>Ceratium</i>
No. 1100		VIII. 4.	18	21	64	many <i>Ceratium</i> , <i>Melosiras</i> — sok <i>Ceratium</i> , <i>Melosira</i> -k
No. 1102		VIII. 4.	22	—	—	masses of <i>Ceratium</i> — tömeges <i>Ceratium</i>
No. 1140		IX. 8.	19	20	—	bivalve larvae — kagylólárvák
No. 1142		IX. 8.	21	—	—	
No. 1180		X. 14.	18	14	—	

* = Measured by SECCHI-disk — SECCHI-koronggal mérve.

** = Algological data were included on the basis of oral communications by Dr. G. TAMÁS — Az algológiai adatokat Dr. TAMÁS GIZELLA szóbeli közlése alapján vettük be a táblázatba.

Table 2 — 2. táblázat

Species — Fajok	Period — idő	Locality — Gyűjtőhelyek													
		M_0				K		G		A_1				E_0	
		evening — este		morning reggel		db*	%	db*	%	afternoon délután		evening — este		afternoon délután	
		db*	%	db*	%					db*	%	db*	%	db*	%
<i>Anuraeopsis fissa</i> (GOSSE)?	VI. VII. VIII. IX. X.			2	0.29	1	0.16	8	1.21	1	0.15	3	0.43	17	2.70
								4	0.52	1	0.16	9	1.38	3	0.47
										1	0.14	1	0.17	5	0.81
<i>Ascomorpha ecaudis</i> * PERTY	VI. VII. VIII. IX. X.			4	0.62										
<i>Asplanchna priodonta</i> GOSSE	VI. VII. VIII. IX. X.							2	0.30	11	1.79	8	1.22		
<i>Brachionus angularis</i> GOSSE	VI. VII. VIII. IX. X.	77 34	14.23 5.34	19 4 5 1	2.91 0.64 0.72 0.15	1 1	0.16 0.16	2	0.30	1	0.16	1	0.15		
<i>Brachionus sessilis</i> VARGA	VI. VII. VIII. IX. X.					1 9	0.16 1.43	15 1	2.27 0.13	1 1 42	0.15 0.15 6.85	2 17	0.29 2.60	50	7.95
														89	13.26

* db = number of animals

<i>Cephalodella catellina</i> (O. F. MÜLL.)	VI. VII. VIII. IX. X.	2	0.33									1	0.15				
<i>Cephalodella gibba</i> (EHRBG.)	VI. VII. VIII. IX. X.	1	0.16														
<i>Colurella adriatica</i> EHRBG.	VI. VII. VIII. IX. X.			1	0.15												
<i>Colurella colurus</i> (EHRBG.)	VI. VII. VIII. IX. X.													7	1.12	1	0.16
<i>Filinia longiseta</i> (EHRBG.)	VI. VII. VIII. IX. X.	8	1.48	10 2	1.54 0.29												
<i>Kellicottia longispina</i> (KELLICOTT)	VI. VII. VIII. IX. X.	27 3 1	0.37 0.48 0.16	7 10 17 40 11	1.08 1.62 2.46 6.22 1.75	148 143 17 135 76	24.67 23.03 2.70 21.50 12.54	78 29 26 36 52	12.19 4.54 3.93 4.71 7.44	72 4 4 3 20	11.18 0.61 0.65 0.41 3.14	15 2 1 6	2.37 0.29 0.15 1.01	47 1 5 5 22	7.03 0.16 0.79 0.80 3.34	24 4	3.46 0.65
<i>Keratella cochlearis</i> <i>cochlearis</i> (GOSSE)	VI. VII. VIII. IX. X.	233 258 39 40 34	43.07 40.50 6.01 6.12 5.58	212 35 237 258 7	32.72 5.68 34.30 40.12 1.11	210 170 296 123 43	35.00 27.37 47.14 19.58 -7.09	335 201 237 178 305	52.34 31.50 35.85 23.27 43.63	310 37 76 99 258	48.13 5.69 12.40 13.50 40.57	214 28 59 115	33.86 4.70 9.03 19.36	272 84 60 320 302	40.65 13.21 9.54 51.12 45.83	237 95 46 340	34.20 15.05 6.85 55.10

Table 2 (contimeld) — 2. táblázat (folytatás)

Species — Fajok	Period — idő	Locality — Gyűjtőhelyek															
		M ₀				K		G		A ₁				E ₀			
		evening — este		morning reggel		db*	%	db*	%	afternoon délután		evening — este		afternoon délután		evening — este	
		db*	%	db*	%					db*	%	db*	%	db*	%	db*	%
<i>Keratella cochlearis hispida</i> (LAUTERBORN.)	VI. VII. VIII. IX. X.							3	0.47							1	0.14
<i>Keratella cochlearis macracantha</i> LAUTERBORN	VI. VII. VIII. IX. X.	24 3	4.43 0.48	20 4	3.09 0.62	17	2.84										
<i>Keratella cochlearis macracantha</i> f. <i>micracantha</i> LAUTERBORN	VI. VII. VIII. IX. X.	19	2.98					4	0.56	1 4 1 1 3	0.15 0.61 0.16 0.14 0.47	1 1	0.14 0.17	2 1	0.32 0.15	1	0.16
<i>Keratella cochlearis tecta</i> (GOSSE)	VI. VII. VIII. IX. X.	86 223 8 5 45	15.90 35.00 1.23 0.76 7.39	54 50 55 95 20	8.34 8.12 7.96 14.77 3.17	3 27 175 54 101	1.50 4.35 27.86 8.60 16.67	7 88 173 56 167	1.09 13.79 26.17 7.31 23.89	27 31 85 45 156	4.19 4.77 13.87 6.14 24.53	21 54 130 31	3.32 7.84 19.91 5.22	21 76 77 53 64	3.14 11.95 12.24 8.46 9.71	14 74 112 56	2.02 11.73 16.69 9.08
<i>Keratella quadrata</i> (O. F. MÜLL.)	VI. VII. VIII. IX. X.	32 77 12 42 22	5.91 12.08 1.85 6.43 3.62	50 47 36 107 17	7.72 7.63 5.21 16.64 2.70	134 129 60 192 10	22.33 20.77 9.55 30.57 1.65	42 4 13 19 46	6.56 0.63 1.97 2.49 6.58	28 4 4 1 31	4.34 0.61 0.65 0.14 4.87	24	3.79	45 11 3 2 16	6.73 1.73 0.47 0.32 2.43	25 23 3	3.61 3.64 0.48

* db = number of animals

<i>Keratella valga</i> (EHRBG.)	VI. VII. VIII. IX. X.	2	0.32								1	0.15			
<i>Lecane luna</i> (O. F. MÜLL.)	VI. VII. VIII. IX. X.						1	0.15							
<i>Lepadella patella</i> (O. F. MÜLL.)	VI. VII. VIII. IX. X.						1	0.15					1	0.16	
<i>Mytilina ventralis</i> (EHRBG.)	VI. VII. VIII. IX. X.								3	0.49					
<i>Notholca squamula</i> (O. F. MÜLL.)	VI. VII. VIII. IX. X.	3									1				
<i>Notholca striata</i> (O. F. MÜLL.)	VI. VII. VIII. IX. X.		0.55									0.15			
		1	0.16												
<i>Polyarthra major</i> BURCKHARDT	VI. VII. VIII. IX. X.	11 113 16 2	2.03 17.41 2.45 0.33	50 8 4	7.22 1.16 0.63										

Table 2 (continued) — 2. táblázat (folytatás)

Species — Fajok	Period — idő	Locality — Gyűjtőhelyek															
		M ₀				K		G		A ₁				E ₀			
		evening — este		morning reggel		db*	%	db*	%	afternoon délután		evening — este		afternoon délután		evening — este	
		db*	%	db*	%					db*	%	db*	%	db*	%	db*	%
<i>Polyarthra vulgaris</i> CARLIN	VI. VII. VIII. IX. X.	20 12 464 280 244	3.70 1.88 71.49 42.88 40.07	10 2 119 32 76	1.54 0.32 17.22 4.97 12.06	81 132 45 120 370	13.50 21.26 7.16 19.10 61.06	9 206 168 225 66	1.40 32.29 25.41 29.41 9.44	21 282 194 135 45	3.25 43.39 31.65 18.42 7.07	9 359 85 65	1.42 52.18 13.02 10.94	16 270 78 135 50	2.39 42.45 12.40 21.56 7.59	13 244 76 111	1.88 38.67 11.32 17.99
<i>Pompholyx complanata</i> GOSSE	VI. VII. VIII. IX. X.	9 7	1.66 1.07	4 14	0.62 2.18	10	1.61	 1	 0.14	 9	 1.41	 5	 0.76	 6	 0.91		
<i>Pompholyx sulcata</i> HUDSON	VI. VII. VIII. IX. X.	22 1	4.07 0.16	 35	 5.05	1 6	0.16 0.99	169 106 13 232 57	26.40 16.61 1.97 30.33 8.15	178 274 184 443 102	27.64 42.15 30.02 60.43 16.04	336 238 322 350	53.16 34.58 49.31 58.92	256 193 321 99 198	38.26 30.35 51.03 15.81 30.04	329 191 332 93	54.69 30.27 49.48 15.07
<i>Synchaeta kitina</i> ROUSSELET	VI. VII. VIII. IX. X.	 98 71	 15.01 11.66	30 245 85 5 99	4.63 39.77 12.30 0.78 15.72	5	0.81										
<i>Synchaeta oblonga</i> EHRBG.	VI. VII. VIII. IX. X.	4 13 157 184	0.74 2.01 24.04 30.21	180 221 45 72 396	27.78 35.87 6.51 11.20 62.86	1	0.16				7 1.10						

* db = number of animals

<i>Testudinella mucronata</i> (GOSSE)	VI.	5	0.78							6	0.93	7	1.10	12	1.79		
	VII.																
	VIII.																
	IX.							1	0.15	5	0.81	16	2.45	16	2.54	10	1.49
	X.	1	0.16					14	1.83	5	0.68	21	3.53			3	0.48
								2	0.28	2	0.31						
<i>Testudinella parva</i> (TERNETZ)	VI.	8	1.48														
	VII.																
	VIII.																
	IX.																
	X.																
<i>Testudinella patina</i> (HERMANN)	VI.	2	0.37	1	0.15												
	VII.																
	VIII.																
	IX.	6	0.92	6	0.93												
	X.																
<i>Testudinella patina</i> <i>trilobata</i> ANDERSON et SEPHARD	VI.																
	VII.																
	VIII.																
	IX.	1	0.15														
	X.																
<i>Trichocerca bidens</i> (LUCKS)	VI.																
	VII.																
	VIII.																
	IX.														1	0.16	
	X.																
<i>Trichocerca pusilla</i> (JENNINGS)	VI.			1	0.16	3	0.45										
	VII.																
	VIII.			27	3.91	14	2.23										
	IX.			4	0.62	2	0.32										
	X.																
<i>Trichocerca rattus</i> (O. F. MÜLL.)	VI.			1	0.16					1	0.15	1	0.15				
	VII.																
	VIII.			8	1.16	11	1.75			2	0.33						
	IX.			1	0.15												
	X.	1	0.16														

Table 2. (continued) — 2 táblázat (folytatás)

Species — Fajok	Period — idő	Locality — Gyűjtőhelyek															
		M_0				K		G		A_1				E_0			
		evening — este		morning reggel		db*	%	db*	%	afternoon délután		evening — este		afternoon délután		evening — este	
		db*	%	db*	%					db*	%	db*	%	db*	%	db*	%
<i>Trichocerca stylata</i> (GOSSE)	VI. VII. VIII. IX. X.			10	1.45												
<i>Trichotria pocillum</i> (O. F. MÜLL.)	VI. VII. VIII. IX. X.							1	0.15								

* db = number of animals

** Note: It was found experiments on living animals that the *Anuraeopsis fissa* GOSSE described with a question mark were strongly contracted speci mens of *Collotheca balatonica* VARGA

** Megjegyzés: Élő állatokon történt vizsgálatok alapján megállapítottuk, hogy az *Anuraeopsis fissa* GOSSE kérdőjelesen leírt faj *Collotheca balatonica* VARGA erősen zsugorodott példányai.

free-swimming. This striking phenomenon may have several explanations. Our specimens may possibly have separated from their hosts owing to the process of preservation, or to some other mechanical cause (the repeated shaking of the samples). On the other hand, VARGA also worked with preserved materials, and he never made reference to non-epizoic forms. One might also assume that the species had vastly proliferated in recent years, since we have found it in the entire Balaton, with the exception of the Keszthely-bay. It is not improbable that, similarly to other *Brachionius* species, it also may change habits, and thus might prefer a free-swimming existence instead of being carried by *Diaphanosoma* forms.

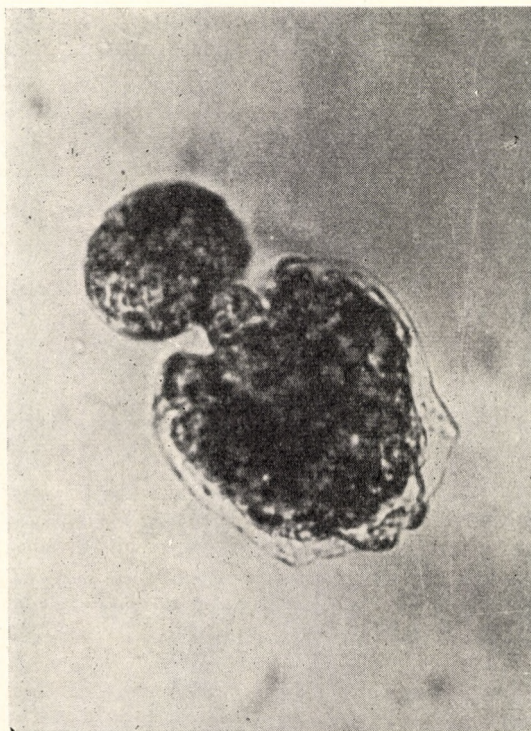


Plate 2. Ventral side of *Brachionus sessilis* VARGA

2. kép. *Brachionus sessilis* VARGA hasoldala

Of *Synchaeta kitina* ROUSSELET and *S. oblonga* EHRLG., DONNER (1959) writes, as the first sentence of his work, as follows: "Die Synchaeta-Arten sind nur mit Vorsicht zu bestimmen." This remark, shedding some light on problems of identifying live animals, is emphatically true for specimens preserved in formalin. As is to be seen in both Table 2 and Fig. 2, the two *Synchaeta* species became increasingly abundant in the Keszthely-beach, during the entire course of our investigations. In October, *S. oblonga* was the leading species, its individual number exceeding 60%. This high number of specimens made the study of the taxonomical and morphological problems of the *Synchaeta* species mandatory.

In surveying our samples, specimens shrunken to various degrees appeared in the field of sight of our microscopes. Features characteristic for shrinkage-free *Synchaeta* were discovered only in the rarest of cases. After the treatment by sodium-hypochlorite, effecting the wellnigh complete dissolution of the animal's body, their generic relegation could be made only on the basis of the liberated mastaxes. Identification as to species were made solely on the basis of the configuration of the mastax, on the consideration that, owing to shrinkage, the dimensions given in literature cannot be applied to our animals. Nor could, for the above circumstance, be the data referring to the shape of the body and its colour considered. In his work on *Synchaeta oblonga*, DONNER (1959) summarizes the conclusions found in PEYLER's (1957) paper treating this problem. According to these authors, in deciding the specific allocation of the *Synchaeta* one should not ascribe any importance to the shape of the animal (a fundamental feature in most handbooks and keys, e.g. BRAUER 1912, RYLOV 1935, VOIGT 1957), since there might occur considerable differences even between individuals of the same population. The same holds with respect to size and other characteristics. Diagnostic significance can be attributed only to the protrusion of the head (shrunken in our samples), the location of the lateral tentacles (observable only on live material), and the differences appearing in the structure of the mastaxes. On the results of the analysis of these mastaxes and a discussion of their variation, obtained during our study of the *Synchaeta*, a future paper is proposed to be submitted.

Horizontal distribution of the species and some other remarks

The great extension of Lake Balaton, its water surface, the almost disjointed state of the lake into two basins connected by the narrow strait of Tihany, the shoreline variegated by small inlets and bays, the variety of substrate and depth, as well as the influences exerted by culture, are factors which may extensively promote the horizontal articulation of the plankton of the lake. If it were only for these factors, the distribution of the plankton would be excessive in various points of the lake. However, there are also moments known which, acting oppositely to the preceding factors, decrease the possibilities of the horizontal articulation (SEBESTYÉN 1960). The most important of these is wind, which, according to substrate and depth, disturbs water at a smaller or greater rate and produces water currents. This is also the cause why differences between the planktons of sections far removed from one another may become obscure. The resultant of the oppositely acting factors will change seasonally, and this is observable also in the qualitative composition of the Rotatoria plankton investigated in our project.

As is to be seen from the table, the species listed may, on the basis of their occurrence, be subdivided into four groups:

- a) occurring in all five sections;
- b) inhabiting the NE basin, or represented there by essentially higher individual numbers than in other areas;
- c) inhabiting the SW part of the lake;
- d) species collected in some few specimens in one or the other of the sections.

a) Species characteristic for the entire water body of Lake Balaton, and appearing in great individual numbers, were *Kellicottia longispina*, *Keratella cochlearis*, *K. cochlearis* var. *tecta*, *K. quadrata*, and *Polyarthra vulgaris*. As dominant species, they occurred in all localities and in every season. *Anuraeopsis fissa* and *Pompholyx complanata* were represented by small individual numbers in all sections. However, the occurrence of *A. fissa* was not uniform in the five sections (62 exemplars in sections $E_e + A_1 + G$, but three specimens only in sections $K + M_0$), while *Pompholyx complanata* showed a more uniform distribution. *Pompholyx sulcata* was also found in all sections, but whereas it appeared as a dominant species, and in many cases became the leading one (in sections E_e , A_1 , and G) at all times, its occurrence in the other two sections was insignificant.

b) There was no species found whose occurrence were characteristic for exclusively the NE basin of the lake, but we have identified some which occurred both in the sections of the NE basin and section G of the SE basin (*Asplanchna priodonta*, *Keratella c. hispida*). *Testudinella mucronata* might also be relegated to this group, its majority having been collected in these sections, but some specimens found also in section M . *Brachionus sessilis*, frequent in sections A and E , advances through section G to even K , though in rather small numbers in this latter one.

c) The Keszthely-bay, as is to be expected owing to its environmental conditions (topographic situation, the nearness of the confluence of the river Zala, strong cultural effects), considerably differs, with respect to the Rotatoria fauna, from all other investigated sections of Lake Balaton. Species occurring only here are *Ascomorpha ecaudis*, *Cephalodella gibba*, *Colurella adriatica*, *Filinia longiseta*, *Polyarthra major*, *Testudinella parva*, *patina*, *patina trilobata*, and *Trichocerca stylata*. Also those species belong here which have been found in other sections, too, but whose frequency of occurrence is more conspicuous in the Keszthely-bay. They are, e.g. *Brachionius angularis*, *Keratella cochlearis macracantha*, *Synchaeta kitina* and *oblonga*, *Trichocerca pusilla* and *rattus*. These latter also represent the species common with section K .

The Rotatoria listed on the basis of one specimen each, thus *Cephalodella catellina* and *gibba*, the *Colurella* species, *Lecane luna*, *Lepadella patella*, *Mytilina ventralis*, the *Notholca* species, and *Trichotria poecillum*, were represented by so small individual numbers that one has to have recourse, with respect to their appearance and role in the plankton, to literature data only. All *Cephalodella* species are rather common; they prefer aquatic plant habitats, and are also members of the psammon of Lake Balaton (VARGA 1939). The *Notholca* species are planktonic, but preferring cold water their absence in our collections is easily explainable. VARGA (1939) mentions *Mytilina ventralis* as a rare member of the plankton of the Lake Balaton, collected above the surface of the mud and among debris. The *Colurella*, *Lecane*, and *Lepadella* species are not typical constituents of the plankton, hence their occurrence in our samples are merely incidental.

Concerning the species showing small individual numbers in the Rotatoria plankton of the Keszthely-bay, it can be established that they all prefer eutrophic waters, plants, detritus, and mud surface.

By illustrating on graphs the changes of the percentual occurrences of the dominant species, it will be found that, in the case of sections E_e and A_1 , the ratio as related to one another of the species is largely equal (Figs 5, 6).

This statement holds for every data of collectings, except for September, when in section E_e *Pompholyx sulcata* is eclipsed by the high values of *Keratella cochlearis*, whereas the situation is just the opposite in section A₁. The Rotatoria community of section G is qualitatively identical with that of the preceding two sections (Fig. 4). The ratio of the dominant species to one another is also similar to the conditions prevailing in sections E_e and A₁, especially in June and October. In the summer season, the percentual composition of the Rotatoria community shifts towards the predominance of *Keratella cochlearis*. On this basis, section G might be considered as belonging to the NE part of the lake.

By its dominant Rotatoria, section K forms a self-standing unit. Only those species are to be found here in greater numbers which occur in all five sections of Lake Balaton. *Pompholyx sulcata*, appearing often as a leading species in the three preceding sections, was found in the sample collected in October, but we have not plotted it on Fig. 3 owing to its value below one per cent. Also insignificant amounts of the frequently leading species of the Keszthely-bay, *Synchaeta kitina* and *oblonga*, were found in the section now under discussion. The proportions of the dominant species give also a completely different picture against that of the other sections, though there is an undoubted resemblance to the Rotatoria community of the Keszthely-bay.

The Rotatoria plankton of this latter area — as was pointed out above — differs from that of the other sections. The characteristic species are the *Synchaeta* taxa, of which *oblonga* excels by its higher individual numbers in the spring and autumn months, while *kitina* predominates during the summer. Concerning the occurrence of *Synchaeta oblonga*, VARGA (1932) writes that "it can be regularly found, with the exception of the warmer season".

On the basis of Table 2 and Figs 2—6, it is quite obvious that, with respect to the horizontal occurrence of the Rotatoria, Lake Balaton is not a uniform body of water, but can be divided into three parts, namely sections E_e, then A₁ and G, finally K and M₀. Thus the Rotatoria plankton of the NE basin might be considered as uniform, with a similar plankton community, developing during the spring and autumn storms and stronger movements of water, also in section G. During the summer, when water currents are presumably weaker, differences develop in the interrelationship of the species in section G. However, the dominant species agree with those of the NE basin. The so-called transitional area is to be looked for, according to the investigations made in 1965, between sections G and K.

The articulation of the Rotatoria plankton according to the above sections is clearly shown by *Kellicottia longispina* (Figs 2—6, column 1), and *Keratella quadrata* (idem, column 4). Except for September, *Kellicottia* attains values about 2—3% in section M₀. While its percentual occurrence is high in every season in section K, its sudden decrease in section G becomes even more pronounced in the northeastern direction. In sections A₁ and E_e, its presence in the summer months can hardly be illustrated at all. *Keratella quadrata* exhibits a picture similar to the preceding one, with the difference of appearing in a rather significant percentage in the Keszthely-bay. It seems that during the entire period of collectings, the environmental conditions given by section K were the most favourable for its requirements, together with *K. longispina*.

This grouping of the examined sections of Lake Balaton, on the basis of the qualitative survey of the Rotatoria plankton, is rather unexpected, even

though SEBESTYÉN (1960) found, with respect to another constituent of the plankton, that "the values of section F of the SW portion come within the amplitude of the values received from the NE part of the lake" (section F = Balatonföldvár—Örvényes). It is interesting, however, that section G belongs to the NE part despite the great distance, while in sections K and M₀, rather close with respect to distances in km, there evolved distinct Rotatoria communities wherein the Rotatoria of the Szigliget-bay correspond with merely one or two species of section M₀. The cause may possibly lie in the considerable constriction of the lake between Balatongyörök and Balatonberény, as well as in the effects of the confluence of the river Zala failing to reach as far as section K.

Summary

The authors executed the qualitative investigation, by relative quantitative methods, of the 38 netted Rotatoria samples, collected at one site each of five sections perpendicular to the longitudinal axis of Lake Balaton in the months June—October, 1965. A total of 38 species, varieties, and forms have been identified, of which one species (*Anuraeopsis fissa*) proved to be new for the fauna of the Balaton.

It was established that, for the given survey period of the year 1965, the lake can be subdivided into three parts on the basis of the qualitative composition of the Rotatoria plankton (Table 2, Figs 2—6).

1. Sections E_e, A₁, and G. The characteristic species were: *Pompholyx sulcata*, *Anuraeopsis fissa*, *Asplanchna priodonta*, *Brachionus sessilis*, and *Testudinella mucronata*. The graphs indicating the percentual occurrence of the dominant species showed great similarity in sections E_e and A₁, whereas that of section G slightly differs from the preceding ones during the summer months.

2. The characteristic species of section K was *Kellicottia longispina*, excelling by rather high percentual values during the period of investigation (except for August). *Keratella quadrata* shows similar occurrence values, appearing with rather high percentage figures also in the Keszthely-bay. The specific composition stands nearer to that of the Keszthely-bay than those of the three preceding sections.

3. The Rotatoria fauna of the Keszthely-bay differs from those found in all other sections. The characteristic species were: *Synchaeta kitina* and *oblonga*, *Brachionus angularis*, *Keratella cochlearis macracantha*, *Polyarthra major*, and *Trichocerca* species. Several species, represented by one specimen each, have also been found here, taxa which cannot be regarded as typical constituents of the plankton. Those found here proved in the majority to favour eutrophic waters, plants and detritus.

The incidentality or constancy of the above distribution of the Rotatoria plankton will be determined by future investigations.

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HORIZONTÁLIS PLANKTONVIZSGÁLATOK A BALATONON, VI.
A BALATON NYÍLTVÍZI ROTATORIÁINAK VIZSGÁLATA
AZ 1965. ÉVI GYŰJTÉSEK ALAPJÁN

P.-Zánkai Nóra és Kertész György

Összefoglalás

A szerzők 1965 júniustól októberig a Balaton mélységi hossztengegyére merőleges 5 szelvényének 1—1 pontján begyűjtött 38 hálós minta Rotatoriáinak minőségi vizsgálatát végezték el relatív-quantitatív módszerrel. Összesen 38 fajt, ill. varietast és formát határoztak meg, melyek közül 1 faj (*Anuraeopsis fissa*) a Balaton területére új.

Szerzők megállapították, hogy az 1965-ös év adott vizsgálati időszakában a Rotatoria plankton minőségi összetétele szempontjából a Balaton 3 részre tagolható (1. 2. táblázat és 2—6. ábra).

1. E₂, A₁ és G szelvények. Jellemző fajaik: *Pompholyx sulcata*, *Anuraeopsis fissa*, *Asplanchna priodonta*, *Brachionus sessilis* és a *Testudinella mucronata* voltak. A domináns

fajok %-os előfordulását jelző grafikonok az E_e és A_1 szelvényben nagyfokú hasonlóságot mutattak, míg a nyári hónapokban a G szelvényé kissé eltér ezektől.

2. A K szelvény jellemző faja a *Kellicottia longispina*, amely az egész vizsgálati időszak alatt (VIII. hónap kivételével) magas %-kal tűnt ki. Hasonló előfordulását a *Keratella quadrata* is, mely azonban a Keszthelyi-öbölben is magas %-kal szerepelt. A fajok minőségi összetétele közelebb áll a Keszthelyi-öbölhöz, mint a másik 3 szelvényhez.

3. A Keszthelyi-öböl Rotatoria faunája eltér a többi gyűjtőhelyen találtaktól. Jellemző fajai: *Synchaeta kitina* és *oblonga*, *Brachionus angularis*, *Keratella cochlearis macracantha*, *Polyarthra major* és a *Trichocerca* fajok. E helyről több 1—1 példányban előkerült fajt határoztunk meg, melyek nem tekinthetők tipikus planktontagoknak. Az itt talált fajok jórészt eutróf vizeket, növényzetet és detrituszt kedvelők.

A Rotatoria plankton ilyen irányú eloszlásának esetlegességét vagy állandó jellegét a további vizsgálatok fogják eldönteni.

ГОРИЗОНТАЛЬНОЕ ИССЛЕДОВАНИЕ ПЛАНКТОНОВ БАЛАТОНА VI. ИЗУЧЕНИЕ В ОТКРЫТОЙ ВОДЕ БАЛАТОНА НА ОСНОВАНИИ АНАЛИЗА МАТЕРИАЛА, СОБРАННОГО В 1965 ГОДУ

Нора П.-Занкаи и Дьёрдь Кермес

Был проведен качественный анализ Rotatoria посредством относительно-количественного метода из 38 образцов сачка, собранного в одном пункте пяти залеганий по горизонтальной оси Балатона с июня по октябрь 1965 года. Всего было найдено 38 видов, разновидностей и форм, из которых один вид *Anuraeopsis fissa* был в первые обнаружен в Балатоне.

Было установлено, что во время исследования по качественному составу планктона Rotatoria Балатон разделяется на три части (таблица 2. рис. 2—6).

1. — Характерные виды места E_e , A_1 , G: *Pompholyx sulcata*, *Anuraeopsis fissa*, *Asplanchna priodonta*, *Brachionus sessilis*, *Testudinella mucronata*. Кривые нахождения доминантных видов в % сходны в местах E_e и A_1 , но в летнее время место G несколько отличается от предыдущих.

2. — Характерным видом места K является *Kellicottia longispina* который обнаруживается (за исключением августа) в самых высоких процентах. Часто также встречается *Keratella quadrata* но в отличие от предыдущего вида в большем количестве находится в Кестхейском заливе. Качественный состав ближе к характерному составу Кестхейского залива чем остальных трех мест.

3. — Фауна Rotatoria Кестхейского залива отличается от образцов, собранных в остальных местах. Характерные виды: *Synchaeta kitina*, *oblonga*, *Brachionus angularis*, *Keratella cochlearis macracantha*, *Polyarthra major* и *Trichocerca*.

В этом месте были найдены одиночные экземпляры определенных видов, которые не являются характерными для данного планктона. Большинство обнаруженных здесь видов характерно для эвтрофной воды, растений и детрита.

Описанное распределение планктона Rotatoria может быть временное или постоянное, но решить этот вопрос могут только дальнейшие исследования.

CHRONICLE

In 1966 two Departments functioned in the Institute.

The *Department of Experimental Zoology*, which due to the plan settled in the previous years performed comparative neurobiological investigations on invertebrates. In compliance with the principle of complexity, Lamelli-branches and Gastropods were investigated with physiological, morphological and biochemical methods.

The *Department of Hydrobiology* continued the regular plankton and benthos investigations, a program that was launched last year. The problems of nutrition biology and metabolism of water organism were subjected to further studies. Also this year several other institutions joined in the work.

Dr. OLGA SEBESTYÉN, retired head of the Hydrobiological Department worked on the theme "Lake history studies on microfossils of Lake Balaton sediments (Cladocera, Pediastrum)".

Results of the work performed in the two Departments were published partly in *Annal. Biol. Tihany*, Vol. 34, and partly in different Hungarian and foreign journals.

The Institute's permanent staff was in 1966 year 53 workers (total), divided as follows: 18 research workers, 20 technical assistants, 5 administrative and 10 other workers.

During this year the following changes took place in the scientific staff: ERNŐ SZABÓ (chemist) left for the Research Institute of Industrial Organic Chemistry on the 16th October, 1966.

LÁSZLÓ HIRIPI chemist on the 16th March, 1966 and

JÁNOS JÁRAI electroengineer on the 16th October 1966 were posted to the Department of Experimental Zoology, while JÁNOS OLÁH biologist-chemist was appointed to the Hydrobiological Department on the 1st November, 1966.

Travels abroad

Dr. JÁNOS SALÁNKI, Director, returned from England on the 6th March 1966, where he spent 6 months in the Department of Physiology and Biochemistry at the University of Southampton;

Dr. BÉLA ENTZ, Deputy Director, left on the 1st February, 1966 with a 3 year contract organized by TESCO to Ghana (Africa), where he took up work at the Hydrobiological Institute of Ghana Academy of Sciences.

Inland study trips

JÁNOS OLÁH spent 2 months in the Institute of Soil Research and Agrochemistry of Budapest.

ISTVÁN VARANKA stayed for 2 weeks in the Physiological Institute at the Medical University of Debrecen.

Visits of scientists from abroad and from Hungary

Also in 1966 several investigators from abroad and from Hungary worked for variable length of time in the Institute:

DR. H. KUZIEMSKI, Physiological Institute of the Medical Academy in Gdansk (Poland) finished his 6 months long study trip in April, 1966,

DR. H. PRAUSER and MRS. PRAUSER, Microbiological Institute of the Medical University, Jena (DDR), spent here 3 weeks in August,

DR. D. A. SAKHAROV, Zoomorphological Institute (Moscow) of the Academy of Sciences of the Soviet Union, spent 6 weeks here during April–May,

DR. M. SALAH, professor at the Hydrobiological Institute, Alexandria (U. A. K.) worked here the whole year through,

DR. TÖRÖK LÁSZLÓ, docent at the Institute of Histology and Embryology, BOTE, Budapest, stayed with us for 2 months,

DR. FELFÖLDY LAJOS from VIIUKI, Budapest, spent 6 weeks,

TÓTH LÁSZLÓ, from VIIUKI, Budapest, also 6 weeks,

DR. KERTÉSZ GYÖRGY, lecturer at the Zoosystematical Institute ELTE, Budapest, spent 2 weeks,

BOTHÁR ANNA, from the Station for Danube Research, Alsógöd, stayed for 2 weeks and

DR. SIMON LÁSZLÓ, from the Anatomical Institute, BOTE, Budapest, worked in the Institute for 2 weeks.

Besides the above-mentioned scientists several other investigators spent shorter periods in Tihany, and research workers from abroad and Hungary frequently paid visits at the Institute.

During the summer months 15 Hungarian and 3 university students from abroad joined the Institute's work for 3–4 weeks.

Meetings

Between the 9th–14th May, 1966, a "Symposium on Human Genetics" was held with 40 participants, partly with lecturers from abroad, in the organization of the Postgraduate Medical School.

The Hydrobiological Society organized a "Symposium on problems of organic matter determination in fresh waters" between the 25th–28th September. 48 scientists from abroad and 27 Hungarian specialists attended the lectures.

On the 16th of September the participants of the "International Muscle Symposium" (held at Budapest) paid a day's visit at the Institute and got acquainted with the work of the Department of Experimental Zoology.

Improvement in research facilities

Among the requisites, facilitating research work accessions in the instrumental stock and in the Library are remarkable.

During this year the following important equipments were procured:

Tesla BS 413 A type electron microscope
 LKB ultrotom III. type ultramicrotom
 Chrom III. UKZ type gas chromatograph
 Amplior II. (ALVAR) amplifier and oscilloscope
 Physiovar (ALVAR) stimulator
 Camera Chatomatic (ALVAR) photorecorder
 LH temperature controlled centrifuge
 DISA two-channeled electrometer amplifier
 EMG. TR-411 high frequency oscilloscope
 USB 2-S scintillation counter.

The value of these equipments in near to 3 million forints. Several other instruments were also obtained, their individual prices do not reach the amount of 50, 000 forints but the total sum of these acquisitions mounts up also to nearly half a million forints.

At the end of 1966 the Library registered 42,543 units. Altogether of about 600 different journals and publications arrived currently.

The yearbook of the Institute, *Annal. Biol. Tihany*, Vol. **33** (1966) was sent to 548 institutions all over the world; in exchange the Library received about 350 different journals and publications.

In 1966 renewals were finished, among them the morphological laboratories were renewed and a special laboratory was built for the electron microscopy. Four two-roomed, selfcontained and two bachelor's flats were built. The gardens around the Institute and the scientists' dwelling houses were rearranged, too. A tennis ground was established in cooperation with the Institute's staff.

In 1966 the complete renewal of the Institute's Hotel has begun, when finished 14 rooms with bath-rooms and central heating will be ready to accept our guests. The Institute's dining room, club room and kitchen as well as the porter's flat will be also renewed.

KRÓNIKA

Az Intézetben 1966-ban két osztály működött.

A *Kísérleti Állattani Osztály* a korábbi években kialakult tematikának megfelelően összehasonlító neurobiológiai kutatásokat végzett gerinctelen állatokon. A Lamellibranchiata és Gastropoda vizsgálatánál a komplexitás elvének megfelelően fiziológiai, morfológiai és biokémiai módszereket alkalmaztak.

A *Hidrobiológiai Osztály* tudományos munkáját az előző évben elkezdett rendszeres plankton és bentosz-kutatás, valamint egyes vízi szervezetek táplálkozásbiológiai és anyagserevizsgálata képezte. E kutatásokba több intézmény is bekapcsolódott.

Dr. SEBESTYÉN OLGA nyugalmazott osztályvezető továbbra is aktív tudományos tevékenységet fejtett ki az Intézetben. Munkáját a „Történeti tanulmányok balatoni üledékek mikrofossziliáin (Cladocera, Pediastrum)” c. téma keretében folytatta.

A két osztály tudományos munkáinak egy része az *Annal. Biol. Tihany* 34. kötetében, más része különböző hazai és külföldi folyóiratokban jelent meg. (Lásd: *Annal. Biol. Tihany* XXXIV., 286 oldal).

Az Intézet személyi állománya: 53 fő, ami a következőképpen oszlott meg: kutató: 18, kutatási segéderő: 20, adminisztratív: 5, egyéb: 10.

Az Intézet kutatói állományában az alábbi változások történtek:

SZABÓ ERNŐ tudományos munkatárs (vegyszer) 1966. VIII. 16-án a Szervesvegyipari Kutató Intézetbe távozott.

HIRIPI LÁSZLÓ tudományos segédmunkatárs (vegyszer) 1966. III. 16-án és

JÁRAI JÁNOS tudományos munkatárs (elektromérnök) október 16-án az Intézet Zoológiai Osztályára,

OLÁH JÁNOS tudományos segédmunkatárs (biológia-kémia szakos tanár) november 1-ével a Hidrobiológiai Osztályra került.

Külföldi utak:

DR. SALÁNKI JÁNOS igazgató 1966 március 6-án tért vissza Angliából, ahol 6 hónapot a Southamptoni Egyetem Élettani és Biokémiai Intézetében dolgozott.

DR. ENTZ BÉLA igazgatóhelyettes 1966. II. 1-én a Nemzetközi Műszaki Tudományos Együttműködési Iroda szervezésében (TESCO) 3 éves szerződéssel Ghanába utazott, ahol a Ghanai Akadémiai Hidrobiológiai Intézetben dolgozik.

Belföldi tanulmányutak:

OLÁH JÁNOS tudományos segédmunkatárs, a Talajtani és Agrokémiai Kutatóintézetben két hónapot,

VARANKA ISTVÁN tudományos segédmunkatárs a Debreceni Orvostudományi Egyetem Élettani Intézetében két hetet töltött.

Vendégkutatók: Az előző évekhez hasonlóan több külföldi és hazai kutató dolgozott az Intézetben.

DR. H. KUZIEWSKI — Orvosi Akadémia Gdanski Élettani Intézet (Lengyelország) munkatársa 6 hónapos tanulmányútját 1966 áprilisában fejezte be.

DR. H. PRAUSER és Mrs PRAUSER a Jenai Orvostudományi Egyetem Mikrobiológiai Intézetének munkatársai augusztusban 3 hetet,

DR. D. A. SAKHAROV — SZU Tudományos Akadémiája Moszkvai Állatmorfológiai Intézetének munkatársa április—május hónapban 6 hetet,

DR. M. SALAH Alexandriai Hidrobiológiai Intézet professzora egész éven át,

DR. TÖRÖK LÁSZLÓ BOTE Szövet- és Fejlődéstani Intézetének docense, 2 hónapot,

DR. FELFÖLDY LAJOS a Vízgazdálkodási Tudományos Kutatóintézet főmunkatársa 6 hetet,

TÓTH LÁSZLÓ a VITUKI munkatársa 6 hetet,

DR. MOLNÁR KÁLMÁN az MTA Állategészségügyi Kutatóintézetének munkatársa 3 hetet,

DR. KERTÉSZ GYÖRGY az ELTE Állatrendszertani Intézetének adjunktusa 2 hetet,

BOTHÁR ANNA a Dunakutató Állomás munkatársa 2 hetet,

DR. SIMON LÁSZLÓ a Budapesti Orvostudományi Egyetem Anatómiai Intézetének tanársegéde 2 hetet dolgozott az Intézetben.

A felsoroltakon kívül rövidebb időt még többen is töltöttek az Intézetben, valamint számos hazai és külföldi kutató látogatta meg az Intézetet.

A nyári hónapokban 15 hazai és 3 külföldi egyetemi hallgató kapcsolódott be az Intézet munkájába 3—4 hétre.

Rendezvények:

Május 9—21-ig 40 résztvevővel „Humángenetikai Szimpozion” került megrendezésre, részben külföldi előadókkal, az Orvostovábbképző Intézet szervezésében;

Szeptember 25—28 között „Szervesanyagmeghatározási szimpozionot” rendezett a Hidrológiai Társaság, amelyen 48 külföldi és 27 hazai szakember vett részt.

Szeptember 16-án a Budapesten rendezett Nemzetközi Izomszimpozion résztvevői 1 napos látogatást tettek az Intézetben, s megismerkedtek a Kísérleti Állattani Osztályon folyó kutatásokkal.

Kutatási feltételek fejlődése:

A tudományos kutatómunkát elősegítő eszközök közül említésre méltó a műszerpark és könyvtár növekedése.

Az év folyamán az alábbiakban felsorolt jelentősebb műszerek kerültek beszerzésre:

TESLA BS 413 A típusú elektronmikroszkóp
 LKB ultrotom III. típusú ultramikrotom
 CHROM III. UKZ típusú gázkromatográf
 Amplior II. (ALVAR) erősítőberendezés és oszcilloszkóp
 Physiovar (ALVAR) ingerlőkészülék
 Camera Cathomatic (ALVAR) fotoregisztráló készülék
 LH hűthető centrifuga
 DISA kétsatornás előerősítő
 Nagyfrekvenciás oszcilloszkóp (EMG; TR-440)
 USB 2-S szcintillációs számláló

A felsorolt műszerek értéke közel 3 millió forint. Ezen túlmenően több olyan műszer és kutatási eszköz került az Intézetbe, amelyek egyedenkénti értéke nem haladja meg az 50 000 forintot, de összértékük csaknem félmillió forint.

Az év végi összesítés alapján az intézeti könyvtár állománya 42.543 egység. Összesen kb. 600 különböző folyóirat és kiadvány jár, köztük 12 referáló.

Az intézeti évkönyv — *Annal. Biol. Tihany* — **33.** kötetét, 548 cím kapta meg, melyért csereként 320 kiadvány érkezett.

Az elmúlt évben több, az előző évben elkezdett építkezés fejeződött be. Így átadásra került 4 db kétszobás összkomfortos lakás, valamint két garzonlakás. Befejeződött az intézeti és kutató lakások körüli területek rendezése. A parképítés kapcsán a dolgozók közreműködésével elkészült egy tenispálya.

A morfológiai laboratóriumok átépítésre kerültek, és ennek során elektronmikroszkópos laboratóriumot alakítottak ki.

Elkezdődött a szállodaépület felújítása. A nagyarányú munka befejeztével 14 db fürdőszobás, központi fűtéssel ellátott szoba áll majd a vendégkutatók rendelkezésére. Újjáépítik továbbá az intézet konyháját, ebédlőjét, a portáslakást és a klubszobát.

List of papers published elsewhere as in Vol. 33 of our Annales

Az intézeti Évkönyv 33. kötetén kívül az 1966. év folyamán megjelent dolgozatok jegyzéke

- LÉVAI G., ZS.-NAGY I.: Effect of prolonged thyroxin and methylthiouracil treatment on the epiphyseal cartilage of young rats. — *Acta Morph. Hung.* **14**, 39—50.
- ZS.-NAGY I.: Simaizomregeneráció mechanizmusának szövettani és elektronmikroszkópos vizsgálata kísérleti körülmények között. — *Archiv. Anat. Hist. i Embr.* **51**, 21—32. (Leningrád) (oroszul).
- ZS.-NAGY I., BRODSKY, V. J., SALÁNKI, J.: Fluctuation of the nucleic acid in connection with the periodic activity of freshwater mussel (*Anodonta cygnea* L.). — *Acta Biol. Hung.* **17**, 43—49.
- PONYI J.: A rákok (Crustacea) emésztőrendszerének fehérjebontó enzimeiről. — *Állattani Közlemények* **53**, 115—122.
- S.-RÓZSA, K., PERÉNYI, L.: Chemical identification of the excitatory substance released in *Helix* heart during stimulation of the extracardial nerve. — *Comp. Biochem. Physiol.* **15**, 105—113.
- SALÁNKI, J.: Comparative studies on the regulation of the periodic activity in marine lamellibranchs. — *Comp. Biochem. Physiol.* **18**, 829—843.
- SALÁNKI, J., ZS.-NAGY, I.: Comparative histological investigations on marine Lamellibranch adductors in different functional conditions. — *Acta Biol. Hung.* **17**, 315—328.
- TAMÁS, G.: Mikroflora aus dem Periphyton der Landungsmolen der Donau zwischen Budapest und Mohács. — *Danubialia Hungarica XXVIII. Ann. Univ. Sc. Bp. Sect. Biol.* **8**, 345—356.
- TAMÁS G.: Epibiontok a tihanyi Belső-tóból. — *Bot. Közlem.* **53**, 7—10.

List of scientific lectures
Tudományos előadások jegyzéke

- B. BARANYI I., SALÁNKI J.: A folyami kagyló (*Anodonta cygnea*) központi idegrendszerének citológiai vizsgálata. — VII. Biol. Vándorgyűlés, Pécs. V. 19—21.
- FARKAS T.: Zsírmozgósítás halakban. — Biol. Vándorgyűlés, Pécs. V. 19—21.
- FARKAS T.: Katekolaminok és zsírmozgósítás alacsonyabbrendű gerincesekben. — MÉT VI. 30—VII. 2. Pécs.
- HERODEK S.: A digliceridek és trigliceridek anyagcseréjének vizsgálata 1-C^{14} palmitinsavval inkubált zsírszövetben. — MÉT VI. 30—VII. 2. Pécs.
- HERODEK S.: Die Verteilung der $1\text{-}^{14}\text{C}$ Palmitinsäure in die verschiedenen Lipide des Fettgewebes während in vitro Inkubation. — Nemzetközi Zsíradéktudományi Társaság Kongresszusa, Budapest.
- HIRIPI L., VARANKA I., SALÁNKI J.: Kolineszteráze aktivitás összehasonlító vizsgálata *Anodonta cygnea* L. idegrendszerében és egyéb szöveteiben. — MÉT VI. 30—VII. 2. Pécs.
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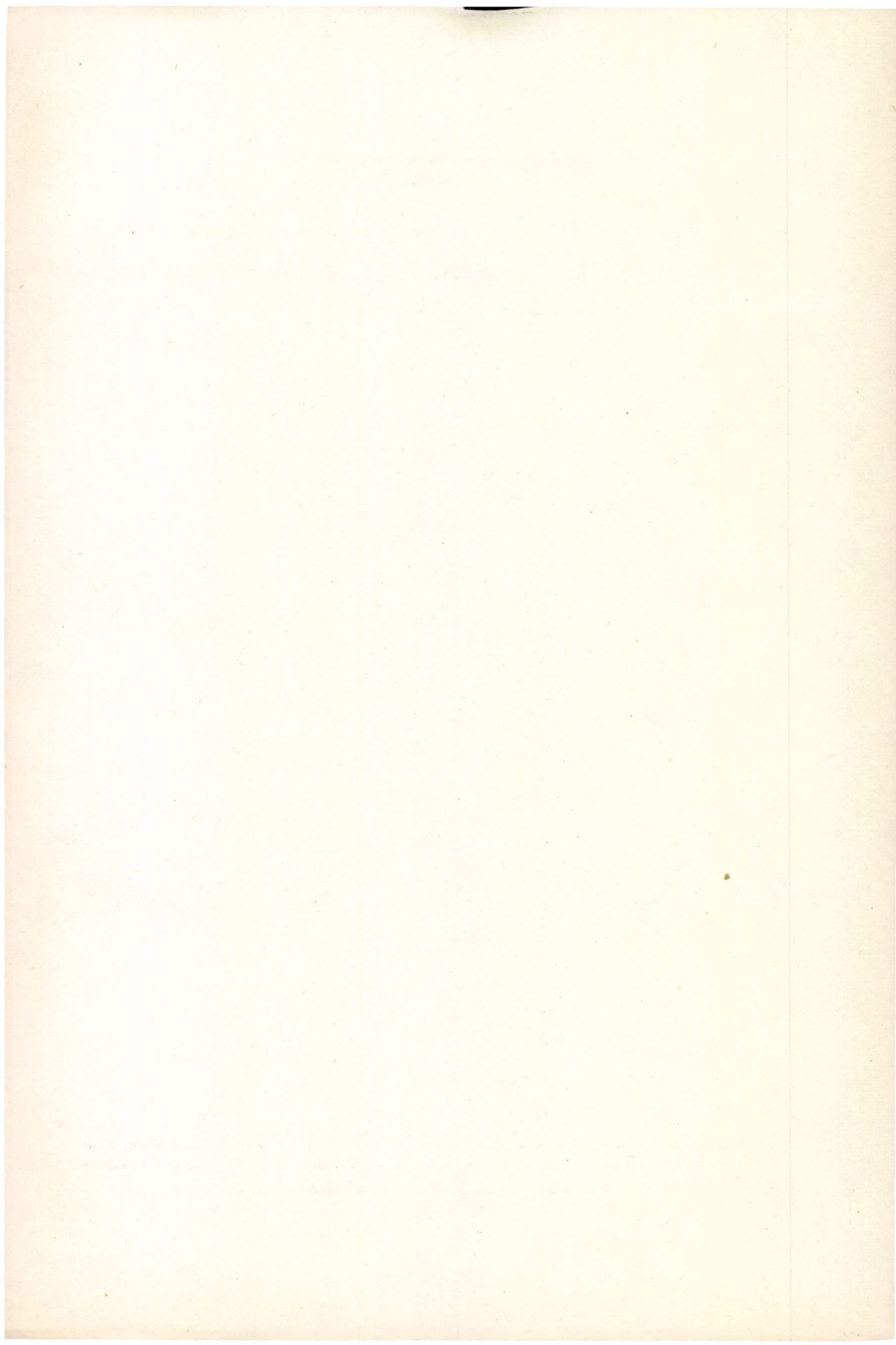
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A kiadásért felelős az Akadémiai Kiadó igazgatója

Műszaki szerkesztő: Merkly László

A kézirat nyomdába érkezett: 1967. júl. 20. — Példányszám: 900 — Terjedelem: 25.2 (A/5) ív + 1,5 (A/5) ív melléklet

67.64115 Akadémiai Nyomda, Budapest — Felelős vezető: Bernát György

Table 1 — 1. táblázat

Pike-perch (*Lucioperca lucioperca* L.) samples
Fogas süllő (*Lucioperca lucioperca* L.) halminták

Period of sampling Mintavétel ideje (hónap)	Organ studied — Vizsgált szerv	Chlorinated pesticide residue Klórozott pesticid maradékok (mg/kg)																													
		Balaton										Tolna reach of the Danube Tolnai Dunaág										Fish ponds — Halastavak									
		H C H				DDE	?	DDT	Ald.	Dield.	H C H				DDT	?	DDE	Ald.	Dield.	H C H				DDT	?	DDE	Ald.	Dield.			
		α	β	γ	δ						α	β	γ	δ						α	β	γ	δ								
August	meat — hús	0.00	0.00	ny	0.00	1.08	0.03	0.72	0.00	0.00																					
September		0.01	ny	0.20	ny	0.66	0.35	0.35	ny	ny																					
October		0.00	0.00	0.02	0.00	0.09	0.09	ny	0.00	0.00	0.00	0.00	0.04	ny	0.15	0.06	0.08	0.00	ny												
November		0.00	0.00	ny	0.00	0.21	0.16	ny	0.00	0.00	ny	ny	0.03	0.00	0.09	0.09	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.06	0.00	ny	0.00	0.00	
													0.04	ny	0.07	0.05	0.07	0.00	0.00	0.00	0.00	0.00	ny	0.00	0.04	0.00	0.02	0.00	0.00		
													ny	ny	0.07	0.07	0.07	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
August	liver — máj										*0.00	0.00	0.00	0.00	ny	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ny	0.00	0.00	0.00	0.00			
September		0.09	ny	0.41	ny	0.58	0.10	0.82	0.00	0.00										0.00	0.00	0.00	0.00	ny	0.00	0.00	0.00	0.00			
October		0.01	0.01	0.25	0.01	1.07	0.18	0.78	ny	ny																					
November		0.00	0.00	0.05	0.00	0.07	0.05	0.08	0.00	0.00	ny	ny	0.37	ny	0.29	0.22	0.29	ny	ny												
											0.00	0.00	0.11	0.00	0.18	0.11	0.11	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.10	0.00	0.08	0.00	0.00		
September	roe — ikra										*0.00	0.00	ny	0.00	ny	0.00	ny	0.00	0.00	0.00	0.00	ny	0.00	ny	0.00	ny	0.00	0.00			
October		0.01	0.01	0.25	0.01	1.07	0.18	0.78	0.01	0.01	ny	ny	0.51	ny	0.51	0.09	0.12	ny	ny												
November		0.00	0.00	0.03	0.00	0.02	0.02	0.02	0.00	0.00	ny	ny	ny	ny	0.79	0.26	0.26	0.00	0.00	0.00	0.00	0.00	ny	0.00	0.05	0.00	0.00	0.00	0.00		
		0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	ny	0.00	0.11	0.07	0.07	0.07	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00			
											0.00	0.00	ny	0.00	0.07	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
November	milt — tej										0.00	0.00	ny	0.00	0.40	0.27	0.27	0.00	0.00	0.00	0.00	ny	0.00	0.10	0.00	ny	0.00	0.00			
November		fat — zsír	0.00	0.00	0.29	0.00	0.24	0.00	0.29	0.00	0.00	0.00	0.00	ny	0.00	0.40	0.27	0.27	0.00	0.00	0.00	0.00	0.00	0.02	0.00	ny	0.00	0.00			
August	guts — belek	0.00	0.00	0.89	0.00	1.67	0.67	1.22	0.00	0.00										0.00	0.00	0.73	0.00	0.82	ny	0.91	0.00	0.00			
October		ny	ny	0.50	ny	1.00	0.20	0.30	0.00	0.00																					
November		meat — hús	0.00	0.00	0.01	0.00	0.01	ny	ny	0.00	0.00	3-5 cm long fish found in stomach contents gyomorban talált 3-5 cm-es halak																			
	whole — teljes	0.00	0.00	ny	0.00	0.21	0.16	0.00	0.00	0.00																					

* = 6 months old fish
tr = in traces
* = 6 hónapos ivadékok
ny = nyomokban

Table 2 — 2. táblázat
Pike (*Esox lucius* L.) samples
Csuka (*Esox lucius* L.) halminták

Period of sampling Mintavétel ideje (hónap)	Organ studied — Vizsgált szerv	Chlorinated pesticide residue (mg/kg) Klórozott pesticid maradékok																		
		Balaton										Tolna reach of the Danube Tolnai Dunaág								
		H C H				DDT	?	DDE	Ald.	Dield.	H C H				DDT	?	DDE	Ald.	Dield.	
		α	β	γ	δ						α	β	γ	δ						
August	meat — hús	ny	ny	0.40	ny	0.60	0.60	0.60	0.00	0.00										
September		0.03	ny	0.08	0.04	0.42	0.12	0.18	ny	ny										
October											0.00	0.00	0.00	0.00	0.08	0.01	0.04	0.00	ny	
November		0.00	0.00	0.02	0.00	0.04	ny	0.09	0.00	0.00	0.00	0.00	0.11	0.00	0.05	0.03	0.27	0.00	0.00	
											0.00	0.00	0.13	0.00	0.27	0.00	0.27	0.00	0.00	
August	liver — máj	* 0.50	0.20	1.40	0.20	2.00	1.10	3.90	ny	ny										
October											ny	ny	0.69	ny	0.54	ny	0.77	0.00	0.13	
November			0.00	0.00	0.09	0.00	0.04	ny	0.09	ny	ny	ny	ny	0.98	ny	1.32	0.35	1.33	0.00	0.00
											ny	ny	1.05	ny	0.86	0.83	2.35	0.00	0.00	
October	roe — ikra										ny	ny	0.05	ny	0.02	ny	0.05	0.00	0.05	
October			0.00	0.00	0.28	0.00	0.33	0.14	0.57	0.00	0.00	0.00	0.00	0.29	0.00	0.22	0.07	0.44	0.00	0.00
												0.00	0.00	0.12	0.00	0.25	0.06	0.36	0.00	0.00
September	milt — tej	0.05	ny	0.11	0.05	0.61	0.26	0.53	ny	ny										
October											ny	ny	0.04	ny	0.05	0.01	0.04	0.00	0.00	
November		fat — zsír	* ny	ny	4.40	0.15	1.33	1.80	6.66	0.00	0.00	0.00	0.00	1.33	0.00	0.83	0.83	3.33	0.00	0.00
											0.00	0.00	2.06	0.00	3.64	0.27	5.45	0.00	0.00	
August	blood — vér	0.05	0.10	1.00	0.05	1.50	1.00	1.50	0.00	0.00										
November			ny	ny	0.60	0.05	0.38	0.22	0.20	0.00	0.00									
14 cm bream found in stomach of pike from Balaton — Balatoni csuka gyomrában talált 14 cm-es keszeg																				
November	entire — teljes	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00										

* A 3 kg pike fished from Balaton in November — a Balatonból november hónapban kifogott 3 kg-os csuka

Table 3 — 3. táblázat
Carp (*Cyprinus carpio* L.) samples
Ponyt (*Cyprinus carpio* L.) halminták

Period of sampling Mintavétel ideje (hónap)	Organ studied — Vizsgált szerv	Chlorinated pesticide residue Klórozott pesticid maradékok (mg/kg)																										
		B a a t o n					Tolna reach of the Danube Tolnai Dunaág										Fish ponds — Halastavak											
		H C H				DDT	?	DDE	Ald.	Dield.	H C H				DDT	?	DDE	Ald.	Dield.	H C H				DDT	?	DDE	Ald.	Dield.
		α	β	γ	δ						α	β	γ	δ						α	β	γ	δ					
October	meat — hús	0.00	0.00	0.02	0.00	0.04	0.04	0.04	ny	ny		0.00	0.00	0.00	0.06	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.10	0.04	0.06	0.00	0.00	
November		0.00	0.00	0.05	0.00	0.13	0.10	ny	0.00	0.00	0.00	0.00	0.02	0.00	0.07	ny	0.05	0.00	0.00	0.00	0.00	0.00	0.02	0.00	ny	0.00	0.00	
											0.00	0.00	ny	0.00	0.12	ny	0.08	0.00	0.00	0.00	0.00	0.10	0.08	0.08	0.00	0.00		
											0.00	0.00	0.00	0.00	0.06	0.04	0.03	0.00	0.00	0.00	0.00	0.08	0.04	0.08	0.00	0.00		
											0.00	0.00	0.00	0.00	0.08	0.05	0.04	0.03	0.00	ny	ny	0.13	ny	0.17	0.03	0.19	0.00	0.00
											0.00	0.00	0.04	0.00	0.07	0.00	0.06	0.00	0.00	*								
											0.00	0.00	ny	0.00	0.05	0.00	0.03	0.00	0.00	ny	ny	ny	ny	0.06	ny	0.05	0.00	0.00
										0.00	0.00	0.02	0.00	0.08	0.07	0.05	0.07	0.00	ny	ny	ny	ny	0.03	ny	0.07	0.00	0.00	
October	liver — máj	0.00	0.00	0.05	0.01	0.03	0.00	0.02	0.00	0.00		0.00	0.00	0.00	0.04	0.04	0.04	0.00	0.00	0.00	0.00	0.05	ny	0.00	0.00	0.00		
November		0.00	0.00	0.02	0.01	0.02	0.00	ny	0.00	0.00	0.00	0.00	ny	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.05	ny	0.00	0.00	0.00		
											0.00	0.00	0.06	0.00	0.18	ny	0.12	0.00	0.00	0.00	0.00	0.08	ny	0.05	0.00	0.00		
											0.00	0.00	0.01	0.00	0.04	0.02	0.04	0.00	0.00	0.00	0.00	0.01	0.00	ny	0.00	0.00		
											0.00	0.00	0.00	0.00	0.08	ny	0.05	0.00	0.00									
											0.00	0.00	ny	0.00	0.01	0.00	ny	0.00	0.00									
October	roe — ikra	0.00	0.00	ny	0.00	ny	0.00	ny	0.00	0.00		0.00	0.00	0.00	ny	0.00	0.00	0.00	0.00	0.00	0.00	0.63	0.38	0.38	0.00	0.00		
November																						ny	0.00	0.00	0.00	0.00		
October	milt — tej	ny	ny	0.04	ny	0.07	ny	0.11	ny	ny		0.00	0.00	0.00	0.00	0.07	0.00	0.02	0.00	0.00	0.00	0.13	0.06	0.06	0.00	0.00		
November		0.00	0.00	0.05	0.00	ny	0.00	ny	0.00	0.00	ny	ny	ny	ny	0.04	ny	0.04	0.00	ny	0.00	0.03	0.00	0.13	0.00	0.00	0.00	0.00	
October	blood — vér	0.00	0.00	0.00	0.00	ny	0.00	0.00	0.00	0.00		0.00	0.00	ny	0.00	ny	0.00	0.00	0.00	0.00	0.00	ny	ny	ny	0.00	0.00		
November		0.00	0.00	ny	0.00	ny	0.00	ny	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.00	0.18	0.00	0.00	0.00	0.00	0.20	0.04	0.00	0.00	0.00		
November	fat — zsír										0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.17	0.51	0.00	0.00		
											0.00	0.00	0.04	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.00	ny	0.00	0.00		
																				0.00	0.00	0.00	0.06	ny	ny	0.00	0.00	
November	gall — epe																			0.00	0.00	ny	0.00	0.12	0.00	ny	0.00	0.00
																				0.00	0.00	0.00	0.00	0.15	ny	0.00	0.00	0.00
																				0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00
																				0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00
October	kidney — vese										0.00	0.00	0.00	0.00	ny	0.00	ny	0.00	0.00	0.00	0.00	0.01	ny	ny	0.00	0.00		
November		0.00	0.00	ny	0.00	ny	0.00	ny	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ny	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
October	spleen — lép										0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.10	0.00	0.00		
October		0.00	0.00	ny	0.00	ny	0.00	ny	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ny	0.00	ny	0.00	0.00		
November											0.00	0.00	0.00	0.00	0.23	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.31	0.00	0.13	0.00	0.00	
											0.00	0.00	ny	0.00	0.04	0.00	ny	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	
November	brain — agyvelő										0.00	0.00	0.07	0.00	0.38	ny	0.15	0.00	0.00									
											ny	ny	0.70	0.16	0.47	0.12	1.40	0.00	0.00									

* = carp spawn — ponty ivadékok

Table 4 — 4. táblázat
Bream (*Abramis brama* L.) samples
Dévérkeszeg halminták (*Abramis brama* L.)

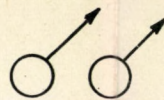
Period of sampling Mintavétel ideje (hónap)	Organ studied — Vizsgált szerv	Chlorinated pesticide residue Klórozott pesticid maradékok (mg/kg)																	
		Balaton									Tolna reach of the Danube Tolnai Dunaág								
		H C H				DDT	?	DDE	Ald.	Dield.	H C H				DDT	?	DDE	Ald.	Dield.
		α	β	γ	δ						α	β	γ	δ					
August	meat — hús	0.03	0.03	0.08	0.03	1.08	0.13	0.80	0.00	0.00	0.00	0.00	0.04	0.00	0.08	0.04	0.08	0.00	0.00
September		ny	ny	0.03	ny	0.83	ny	0.24	ny	ny									
		* 0.00	0.00	0.02	ny	ny	ny	ny	0.00	0.00									
September	liver — máj	0.03	0.02	0.15	0.01	0.16	ny	0.18	ny	ny	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
November		ny	ny	0.04	ny	0.10	0.04	0.14	0.00	0.00									
August	roe — ikra	0.08	0.10	0.65	0.06	0.60	0.60	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
September		ny	ny	0.30	ny	0.25	0.18	0.11	ny	ny									
August	fat — zsír	0.18	0.20	0.80	0.20	0.60	1.10	1.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
September		0.15	0.10	0.65	0.18	0.72	0.68	1.08	ny	ny									
November	blood — vér	0.00	0.00	0.41	0.00	1.10	0.12	1.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
August		0.08	0.11	0.38	ny	0.85	0.09	0.92	0.00	0.00									
November	spleen — lép	0.00	0.00	0.43	0.00	0.21	0.11	0.17	0.00	0.00									

* = bream spawn — keszeg ivadékok

Table 5 — 5. táblázat

Miscellaneous fish samples
Vegyes halminták

Period of sampling Mintavétel ideje (hónap)	Organ studied — Vizsgáltszerv	Chlorinated pesticide residue Klórozott pesticid maradékok (mg/kg)																										
		Balaton									Tolna reach of the Danube Tolnai Dunaág						Fish ponds — Halastavak											
		H C H				DDT	?	DDE	Ald.	Dield.	H C H				DDT	?	DDE	Ald.	Dield.	H C H				DDT	?	DDE	Ald.	Dield.
		α	β	γ	δ						α	β	γ	δ						α	β	γ	δ					
		Razor-fish (<i>Pelecus cultratus</i> L.) Garda (<i>Pelecus cultratus</i> L.)																										
September	meat — hús	ny	ny	0.01	ny	0.01	0.00	ny	0.00	0.00																		
November		0.00	0.00	ny	0.00	0.13	ny	ny	0.00	0.00																		
September	liver — máj	0.03	ny	0.10	0.00	0.13	0.32	0.15	0.00	0.00																		
	fat — zsír	ny	ny	0.10	ny	0.10	ny	0.05	0.00	0.00																		
	blood — vér	ny	ny	0.01	ny	0.10	0.07	0.07	0.00	0.00																		
November	entire — egész	0.00	0.00	0.12	0.00	0.03	0.03	0.05	0.00	0.00																		
	inner organs — belső rész	0.00	0.00	0.24	0.00	1.63	ny	ny	0.00	0.00																		
	roe — ikra	0.00	0.00	0.06	0.00	ny	ny	ny	0.00	0.00																		
		Balin (<i>Aspius aspius</i> L.) Ragadozó őn (<i>Aspius aspius</i> L.)																										
October	inner organs — belső rész	ny	ny	0.52	0.04	0.26	0.26	0.87	ny	ny																		
	meat — hús	0.00	0.00	0.19	0.00	0.10	0.10	0.10	0.00	ny																		
		Bullhead pout (<i>Amiurus nebulosus</i> LE SUEUR) Törpe harcsa (<i>Amiurus nebulosus</i> LE SUEUR)																										
November	inner organs — belső rész	0.00	9.00	0.17	0.00	0.33	0.00	0.00	0.00	0.00																		
	meat — hús	0.00	0.00	0.08	0.00	0.04	0.00	0.00	0.00	0.00																		
		Crucian-carp (<i>Carassius carassius</i> L.) Kárász (<i>Carassius carassius</i> L.)																										
November	entire — egész	0.00	0.00	ny	0.00	ny	0.00	ny	0.00	0.00																		
		Perch (<i>Perca fluviatilis</i> L.) (6—18 months old) Sügér (<i>Perca fluviatilis</i> L.) (6—18 hónapos)																										
November	meat — hús	ny	ny	0.03	0.03	0.05	0.00	0.04	0.00	0.00																		
	inner organs — belső rész	0.0	0.00	ny	0.00	0.01	0.00	0.01	0.00	0.00																		
	liver — máj	ny	ny	0.25	0.25	1.00	0.50	1.00	0.00	0.00																		
	roe — ikra	0.00	0.00	0.06	0.00	0.06	0.00	0.06	0.00	0.00																		
		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00																		
		Amurikele (<i>Stenopharygodonidella Vallenciennes</i>) (Age: 3 years, length: 58 cm, weight: 4000 gr) (Kor: 3 év, hossz: 58 cm, súly: 4000 gr)																										
November	meat — hús	ny	ny	0.01	0.00	0.03	0.02	0.03	0.00	0.00																		
	liver — máj	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00																		
	intestinal fat — bélzsír	0.00	0.00	0.00	0.00	0.02	0.00	0.02	ny	ny																		
	blood — vér	0.00	0.00	0.00	0.00	0.56	0.00	0.33	0.00	0.00																		
	kidney — vese	0.00	0.00	0.07	0.00	0.15	0.15	0.15	0.00	0.00																		
	gall — epe	0.00	0.00	0.03	0.00	0.11	0.00	ny	0.00	0.00																		
	spleen — lép	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00																		



Praeparat-Nro Prep. száma	P_2		P_3		P_4		
	Exp.	Enp.	Exp.	Enp.	Exp.	Enp.	
10/52-54							s. f. vernalis
22/22-24							s. f. vernalis
9/47-49							Übergangsform átmeneti forma
31/73-75							s. f. robustus
34/88-90							s. f. robustus



Praeparat - Nro Prep. száma	P ₂ Exp. Enp.		P ₃ Exp. Enp.		P ₄ Exp. Enp.		
4/21-23							s.f. vernalis
17/94-97							s.f. vernalis
2/9-11							Übergangsform átmeneti forma
11/58-60							Übergangsform átmeneti forma
15/82-84							s.f. robustus
27/52-54							s.f. robustus

