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THE EFFECT OF ALKALI METAL IONS AND ALKALINE EARTH METAL IONS ON THE RHYTHMIC ACTIVITY OF GLOCHIDIA OF THE FRESHWATER MUSSEL *ANODONTA CYGNEA* L.

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Under natural circumstances the larvae of the freshwater mussel *Anodonta cygnea* L. leave the gill of the parent in spring. The larvae (glochidia) lying on the bottom have a rhythmical movement. This rhythmic activity can be observed as early as in the autumn on glochidia artificially removed from the lamellae of the gill of the parent. The clashing and opening of the valves of these larvae is operated by a rhythmic alternation of contraction and relaxing of the adductor muscle.

It was found in our previous studies (KOSHTOYANTS and SALÁNKI 1958, SALÁNKI 1960) on adult mussels that their rhythmic and periodic activity can be essentially influenced by different substances, especially K^+ and other ions. This effect manifests itself partly in the change of frequency in the rhythmic activity of adductor muscle partly in more frequent occurrence of lasting, tonic concentration. Nevertheless, the nature of both rhythmic action and periodic activity and the modes of their regulation as well are unknown and much debated problems. As considerable data may be obtained by investigations carried out in the course of ontogeny, it was suggested to study the rhythmic action of the adductor of glochidia. The first task was to clear the importance of factors which, according to our previous observations, are capable of influencing the rhythmic action and periodic activity in adult animals. Experimental results obtained upon the application of alkali metals and alkaline earth metals are reported in this paper.

Material and methods

The glochidia used in the experiments were obtained from adult specimens of the freshwater mussel, *Anodonta cygnea* L. They are to be found from October to March in a quantity of many thousands among the lamellae of the gill of the parent. The mussels were collected in autumn and were kept in streaming water, in darkness at low temperature until the removal of glochidia.

The glochidia are imbedded into mucous material, from which they were released by dispersing in tap water. The glochidia isolated in this manner with the help of fine pipettes were selectively allotted into groups of 25 each and were placed into the cavity of plexi vessels of 0.25 ml content. The glochidia freshly prepared in tap water showed reduced rhythmic activity.

A measure for the rhythmic activity was offered by the number of contractions observed during units of time in these groups of 25. As the size of the open glochidia was about 500×300 μ, the observations were performed under stereoscopic microscope. The initial part of the experiment served as self-control namely, previous to the addition of the experimental solution, the activity of glochidia was registered in the groups of 25 for five minutes. After this pretreatment period the number of rhythmic contractions was recorded for 10—30 minutes depending on the degree of the effect. The number of contractions per minute was registered. Each substance was tested by 4—10 parallel groups of larvae (100—250 glochidia). The values graphed in the figures are given in terms of hundred animals in order to facilitate comparison. The experiments were carried out at room temperature 18—20° C, illuminated by the lamp of the microscope used.

The results are presented in a system of co-ordinates the axes of which are as follows; abscisse: time in minutes (five minutes self-control before 0 point, and 10—30 minutes long examinations), ordinate: action/min. Thus these graphs illustrate the frequency changes of rhythmic movement. The single actions generally consist of fast (sometimes slow) contraction and of fast or slow relaxing. Relaxing did not occur on every occasion.

In the course of these studies special care was taken to use larvae only which did not suffer injury during dispersion and also which remained in open state during the time of grouping.

For experimental media 1×10^{-4}—2×10^{-1} M solutions of KCl, NaCl, $CaCl_2$, $MgCl_2$, LiCl, CsCl and RbCl dissolved in tap water were used. In order to examine the nature of solvent preliminary experiments were performed with lymph, physiological salt solution for *Anodonta* (MARCZYNSKI, 1959) and with distilled water.

Results

Upon the evidence of preliminary experiments, no considerable differences exist in the activity of glochidia when using either tap water or distilled water for dispersion and in subsequent observation. Neither the lymph obtained from the heart of adult animals nor the physiological salt solution for *Anodonta* proved suitable media for our purposes. The basic activity for hundred glochidia was less than twenty per minute in general. The differences between the values below twenty obtained in the single groups are negligible and are obviously attributable to the fact that the glochidia were not exactly in the same phase of larval development. Upon removing the liquid medium from the glochidia one part of the larvae closed after complete pipetting off, when restoring, however, the original solution they reopened and no increase in activity was observable. These findings suggest that the initial increase in activity lasting for some minutes after the application of experimental solutions is a response to the special substance used.

The effect of KCl on the rhythmic activity of glochidia

Experiments with KCl produced a considerable and lasting increase in activity depending on concentration at the end of which the glochidia closed. In case lower concentrations were used only increase in activity occurred,

which lasted over 30 minutes. The application of higher concentrations, however, gave rise not only to more pronounced increase in activity but also to the tonic contraction of gradually increasing number of glochidia until finally all experimental animals closed. Parallel with the increase in number of closing the activity values decrease, and when all animals are closed it falls to zero.

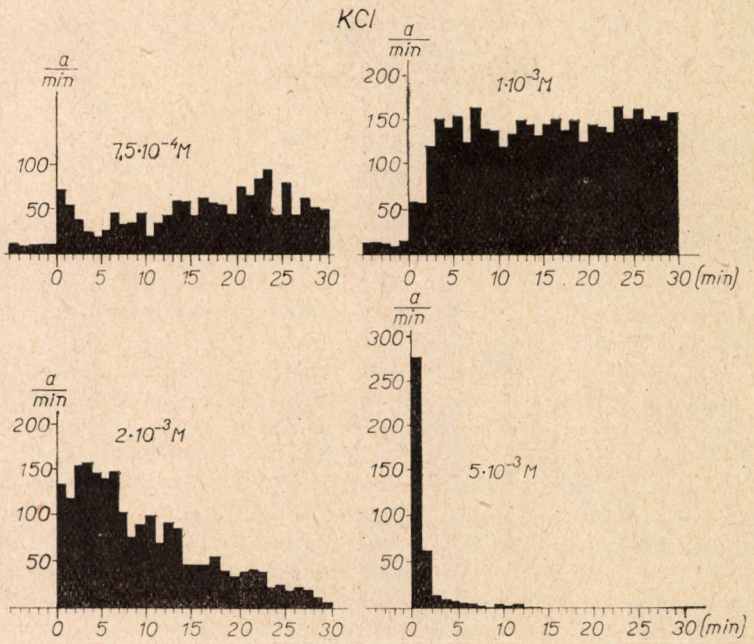

Fig. 1. The effect of different concentrations of KCl on the rhythmic activity of glochidia

Ordinate: the activity of 100 glochidia within one minute $\left(\frac{a}{min}\right)$, abscissa: time in minutes. Pretreatment period before zero point, on the right from the ordinate the minutes after the addition of KCl. The mode of illustration is the same in every figure

1. ábra. KCl különböző koncentrációinak hatása a glochidiumok ritmikus aktivitására

Ordináta: 100 glochidium aktivitása 1 perc alatt $\left(\frac{a}{min}\right)$, abszcissza: idő percekben. Az ordinátától balra a kontrollvizsgálat ideje, az ordinátától jobbra a KCl hozzáadása utáni percek. Az ábrázolás módja minden további ábrán ugyanilyen

1. рис. Действие разных концентраций KCl на ритмическую активность глохидий. ординат: активность 100 глохидий в 1 минут (а/мин). абсцисс: время в минутах. Налево от ордината видно время контрольных опытов, а направо — минуты после прибавления хлористого калия. Спссоб изображения на всех остальных рисунках такой-же

The results obtained are presented in *Fig.* 1. The smallest lasting increase in activity was observed in general at 1×10^{-4}—5×10^{-4} M concentrations of KCl. As regards this threshold concentration, the differences existing between the single populations are small, and in certain cases increase in activity was noted even below 10^{-4} M concentration.

In *Fig.* 1 the effect of KCl solutions of 7.5×10^{-4} M, 1×10^{-3}, 2×10^{-3} M and 5×10^{-3} M concentrations on glochidium populations of approximately

equal sensitivity are given. It is seen that on the effect of 7.5×10^{-4} M KCl a pronounced increase in activity (about five times greater than in the control group) ensues. This rate remains constant throughout the period of investigation (30 min). The increase in activity yielded by 1×10^{-3} M KCl is more considerable (cca. 10—15 times greater) and was observed also throughout the 30 minutes long period of investigation. A characteristic change takes place when 2×10^{-3} M KCl is used, namely the initial increase in activity is followed after some minutes by a decrease in activity to the level of control. This low activity rate lasts for about thirty minutes, and in the end no rhythmic contractions are observable. This decrease in activity is due to the permanent tonic contraction of gradually increasing number of glochidia until finally all of them get into closed state. Closing starts already in the 2nd-4th minute and in the thirtieth minute nearly 50 per cent of glochidia are closed. A greater initial increase in activity is yielded by applying higher KCl concentrations. Nevertheless, in that case a rapid closing of glochidia occurred and the rhythmic activity fell to zero within some minutes. Consequently when using 5×10^{-3} M KCl solution no rhythmic activity was observed at all in the tenth minute — as it is seen in *Fig.* 1 — because all animals are in closed condition.

These findings suggest that the rhythmic action of the adductor muscle of larvae and their lasting tonic contraction resulting in the tight closing of the two valves is a concentration dependent in the case of KCl. The concentration values able to produce within ten minutes increased activity together with a subsequent closing of larvae falls between 1×10^{-3} M and 5×10^{-3} M, nevertheless, some glochidia may close for longer-shorter period also at concentrations as low as 1×10^{-3} M. Closing taking place upon the application of 5×10^{-3} M KCl is very lasting and though this is substituted after 1—2 hours by the subsequent relaxing of adductor muscle, there is no more rhythmic activity to be observed and the glochidia are not able to close again.

The effect of NaCl, $CaCl_2$ and $MgCl_2$

Since from among the ions being involved in fundamental stimulatory processes not only K^+ but also Na^+, Ca^{++} and Mg^{++} are of importance, experiments were run to investigate the effect produced by the chlorides of these ions too. In the case of these substances considerable greater concentrations (by one order of magnitude higher) were necessary to produce measurable changes in the rhythmic activity of glochidia than in case of KCl. Even the modes of their effect differ considerably from that of KCl.

In the case of NaCl 7.5×10^{-2} M concentration produced striking increase in activity. Other consentrations as 1×10^{-1} M and 2×10^{-1} M were also tested. Lasting increase in activity could not be produced with NaCl, and the yielded effect ended within ten minutes. As it is seen in *Fig.* 2 an activity of about 30/minute was found in the groups of 100 glochidia upon the application of 7.5×10^{-2} M NaCl during seven minutes, after which it fell back to the level of control. During this period no tonic contraction of adductor muscle was observable and all glochidia were in open condition after the passing of 10 minutes. A more considerable increase in activity was observed in the first minutes subsequent to the application of higher concentrations of NaCl: 1×10^{-1} M and 2×10^{-1} M, but the rhythmic action did not last even

in this case over ten minutes. It is most striking that during the first minutes nearly 40—50 per cent of glochidia closed, however, in the case of 1×10^{-1} M concentration their gradual opening was observable and, after a period of 5 minutes, only about 10—15 per cent of them were shut. Nevertheless, this fact did not produce an increase in rhythmic activity during this period. A more lasting tonic contraction of adductor muscle was produced by higher concentration of NaCl. Accordingly, upon the application of 2×10^{-1} M solutions 70—75 per cent of glochidia are closed even in the tenth minute, and the rhythmic activity observed is small.

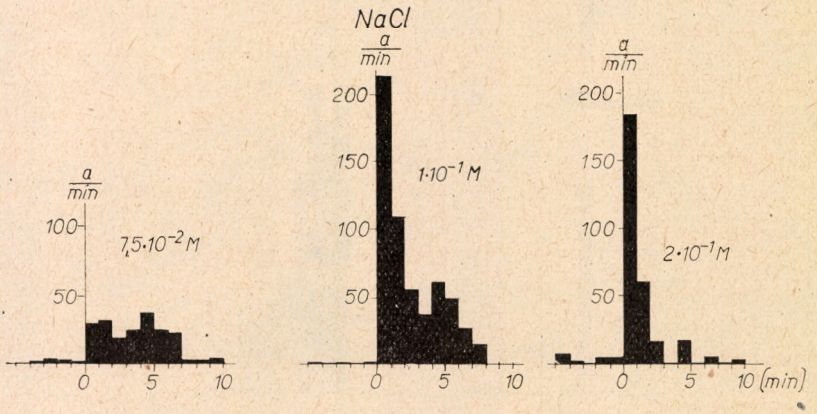

Fig. 2. The effect of NaCl on the rhythmic activity of glochidia. Mode of illustration as in *Fig. 1*

2. ábra. NaCl hatása a glochidiumok ritmikus aktivitására, Ábrázolás módja ugyanaz, mint az *1. ábrán*

2. рис. Влияние NaCl на ритмическую активность глохидий. Способ изображения такой-же как на *1. рисунке*

In the course of investigations performed with NaCl only an initial rise but no lasting increase in activity could be observed. The application of higher concentrations resulted in the closing of glochidia, resp. the relaxing of the adductor muscle, after which rhythmic activity was no more observable and the glochidia could not be induced to further contractions even by very concentrated KCl solution.

In *Fig.* 3 activity values produced by $MgCl_2$ are graphed. The $7.5 \times \times 10^{-3}$ M solution of this substance proved to be the threshold concentration. Maximum rate of activity was yielded by 5×10^{-2} M solution. In the first 1—2 minutes of examination considerable activity values were observed and later on the frequency of rhythmic contractions fell rapidly to the original value. This 5×10^{-2} M concentration produced also the most lasting increase in activity which, however, fell to the level of control at the end of the tenth minute. Thus, it is characteristic of $MgCl_2$ that, after a decrease in activity, there still exists an activity on threshold level, *i.e.* the rhythmic activity of larval adductor muscle is not damaged by this substance.

Upon the application of lower concentrations of $MgCl_2$ (7.5×10^{-3} M, 1×10^{-2} M) all glochidia remain open. On the effect of solutions of $2 \times$ and

5×10^{-2} M concentrations a considerable number of them rapidly close (about 10 resp. 80 per cent) then after 20—40 seconds the glochidia open again and display rhythmic action.

In the experiments performed with $CaCl_2$ *(Fig. 4)* noticeable increase in activity was produced by 1×10^{-1} M concentration. This increased activity,

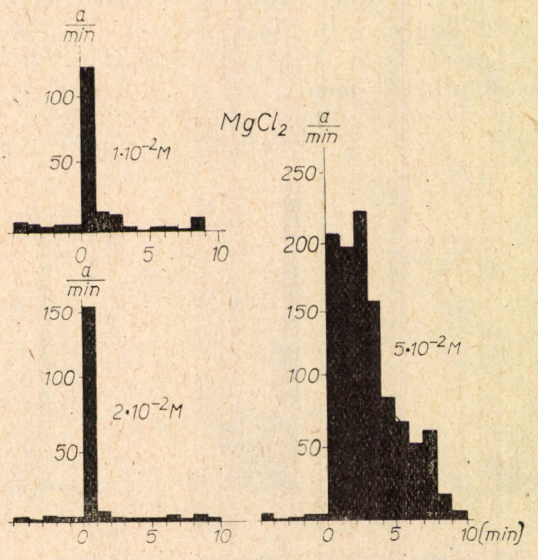

Fig. 3. The effect of $MgCl_2$ on the rhythmic activity of glochidia
3. *ábra.* $MgCl_2$ hatása a glochidiumok ritmikus aktivitására
3. *рис.* Влияние $MgCl_2$ на ритмическую активность глохидий

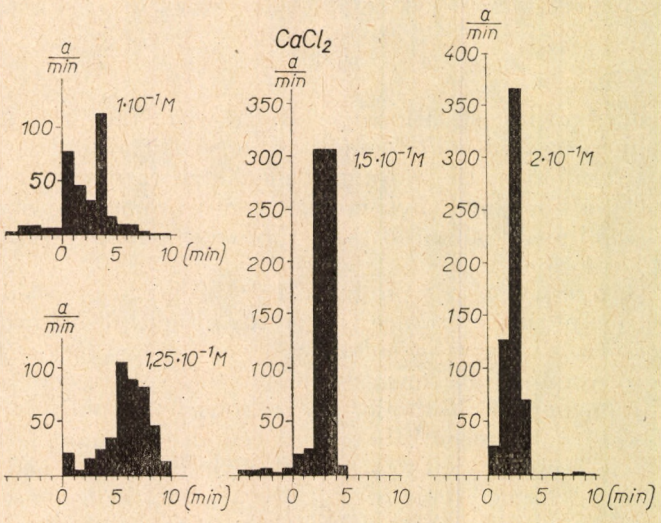

Fig. 4. The effect of $CaCl_2$ on the rhythmic activity of glochidia
4. *ábra.* $CaCl_2$ hatása a glochidiumok ritmikus aktivitására
4. *рис.* Влияние $CaCl_2$ на ритмическую активность глохидий

however, did not last longer than for some minutes and, after a gradual decrease, sank very soon to the level of control. Maximum activity rates do not occur in the first minute of observation but only in the third-sixth minute upon the addition of $CaCl_2$, as has been observed already when using threshold concentration, but even more upon the application of 1.25×10^{-1}, 1.5×10^{-1} and 2×10^{-1} M solutions. Thus a period of some minutes preceeds the activity increasing effect of $CaCl_2$. This increased activity lasts for 1—3 minutes and is very conspicuous in the case of higher concentrations. It is remarkable that the difference between threshold concentration and the concentration values yielding maximum rate in activity is small. It is worth noting that, in the case of higher activity values the duration of this increased activity is shorter, for instance when using 2×10^{-1} M solution it ends within four minutes. After this period of increased activity 50—70 per cent of glochidia are closed and even those remaining open do not display considerable rhythmic activity. There is an occasional closing and opening of single glochidia still observable which points to the fact that the adductor muscle has not lost its functioning capacity in opposition to previous observations made in connection with $MgCl_2$.

Thus, unlike the effect of KCl, $CaCl_2$ could not produce lasting increase in activity of glochidia similar to NaCl and $MgCl_2$.

The effect of LiCl, CsCl and RbCl

Considering the place of the following metals as lithium, caesium and rubidium in the periodic system in relation to kalium it was suggested to investigate the effect of these ions on the rhythmic activity of glochidia. It was also purported by these investigations to learn if the effect of K involved in the production of lasting increase in activity is strictly or only to a less degree specific, namely whether this effect could also be produced by similar ions.

It was found in the course of investigations that a relatively lasting increase in activity (lasting for 15—20 minutes) can be produced with the application of LiCl and CsCl, these two chlorides of the three monovalent ions, whereas with RbCl authors failed to produce the same effect.

In case of LiCl *(Fig. 5)* 1×10^{-2} M concentration yielded noticeable increase in activity lasting for about 10 minutes and of value a of 30/min. A more concentrated solution (5×10^{-2} M), however, produced a more considerable effect. The activity lasted for 10 minutes and the glochidia were open to the end of the period of investigation. Upon increasing the concentration of this substance the initial rise in activity may reach a higher, even values of some hundred, on the other hand the duration of the effect is considerable shorter, and falls within about 6 minutes to the level of control. The decrease in activity observed at higher concentrations of LiCl is due to the closing of gradually increasing number of glochidia. Thus upon the application of 1×10^{-1} M solution 70—80 out of 100 glochidia are closed in the tenth minute of observation.

CsCl solution has given rise to activity increase already at a concentration as low as 1×10^{-3} M. The 5×10^{-3} M concentration yielded an average activity of 30/min. lasting even over 10 minutes. On this occasion about 25 per cent of glochidia closed in the first ten minutes and practically all of them were

closed at the end of thirty minutes. Considerable activity rates were produced by 1×10^{-2} M CsCl solution lasting for more than 10 minutes. This was followed by a gradual decrease in activity with a simultaneous gradual closing

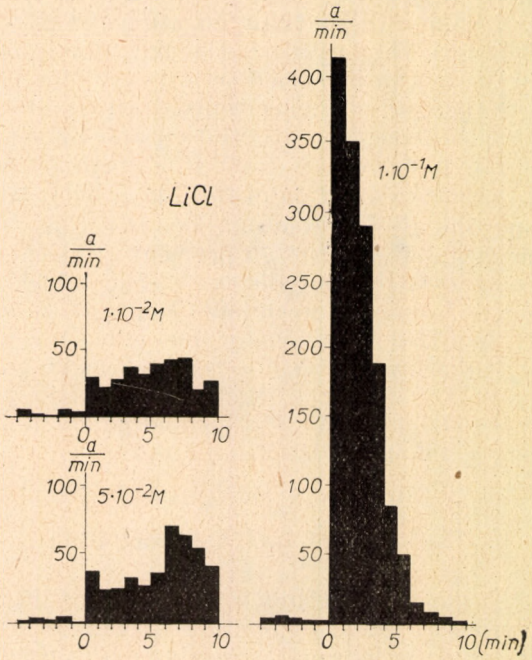

Fig. 5. The effect of LiCl on the rhythmic activity of glochidia
5. ábra. LiCl hatása a glochidiumok ritmikus aktivitására
5. рис. Влияние LiCl на ритмическую активность глохидий

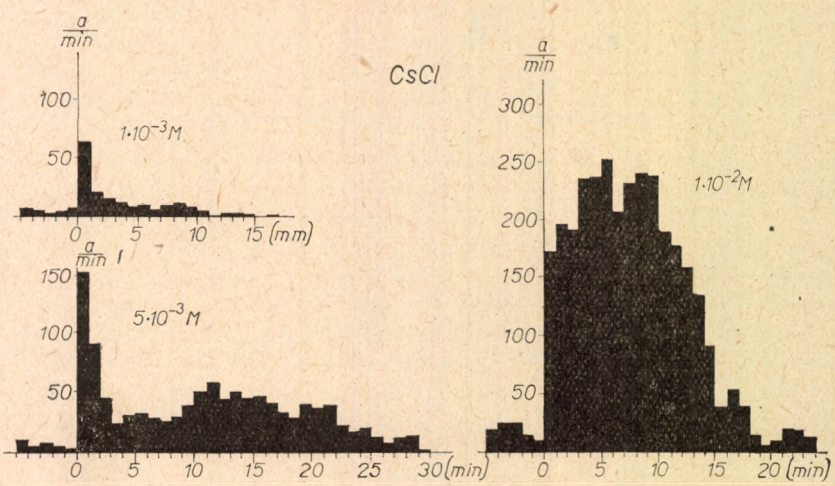

Fig. 6. The effect of CsCl on the rhythmic activity of glochidia
6. ábra. CsCl hatása a glochidiumok ritmikus aktivitására
6. рис. Влияние CsCl на ритмическую активность глохидий

of glochidia. In the 20th minute 80—90 per cent of the larvae are in closed state and the rhythmic activity displayed by the few glochidia still functioning is on the level of total control (*Fig.* 6).

The use of RbCl has not given rise to an increase in activity lasting over 10 minutes. As it is seen in *Fig.* 7, 2×10^{-3} M concentration already has proved effectual. Upon the application of 3×10^{-3} M solution increase in activity lasted for about 10 minutes, then it fell likevise to the level of control. It is worth mentioning that, in this case, a sudden increase occurred in the 4th—6th minute similar to that observed in the case of $CaCl_2$. An outstanding value was obtained with 5×10^{-3} M concentration in the first minute, later on, how-

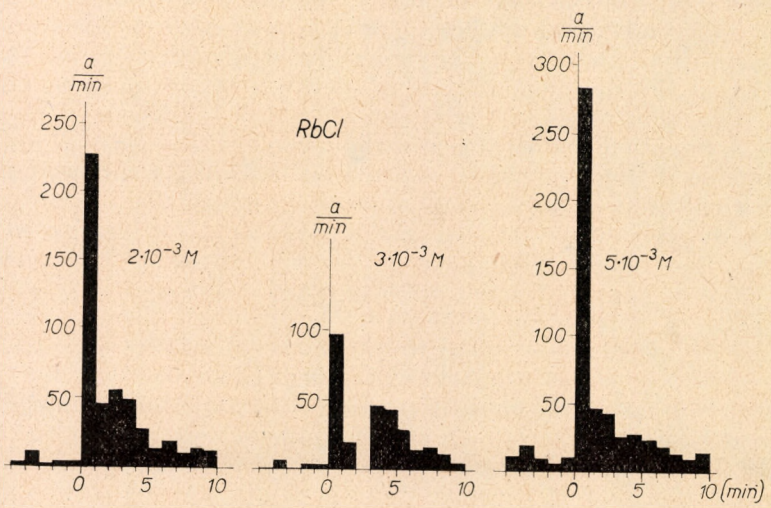

Fig. 7. The effect of RbCl on the rhythmic activity of glochidia
7. *ábra.* RbCl hatása a glochidiumok ritmikus aktivitására
7. *рис.* Влияние RbCl на ритмическую активность глохидий

ever, the activity became lower. The decrease in activity in the case of RbCl especially when higher concentrations are used occurs parallel with the closing of glochidia. Upon application of 5×10^{-3} M RbCl the ratio of glochidia being in closed condition is as high as 90 per cent already from the second minute.

The effect of RbCl may be summarized as follows. The application of this substance does not produce increase in activity lasting beyond 10 minutes; on the effect of higher concentration a lasting contraction of adductor muscle takes place together with a simultaneous rapid fall in activity. LiCl and CsCl, on the other hand, are able to produce increase in activity lasting over 10 minutes but, unlike the effect of KCl, they have a higher threshold concentration and even the concentration needed to produce lasting increase in activity is 5—10 times greater than in the case of KCl.

It is also characteristic of LiCl and CsCl that the increased activity produced by them falls to the level of control after 15—20 minutes even in case the glochidia are open and may be induced with KCl to close. Also the level

of the induced lasting activity differs from the values produced by KCl, namely in the case of KCl the maximum value of activity increase obtainable without closing of valves is higher than 100/min, whereas in the case of both LiCl and CsCl it does not rise above an average of 30/min.

Discussion

According to histological data (HERBERS, 1914) the early developmental forms of mussel, the glochidia do not have a developed nervous system. Their nerve tissue is still in the stage of differentiation. Consequently it seems unlikely that the embryonal adductor muscles have efferent innervation, and therefore its rhythmic activity is assumedly of myogene origin. Thus it is suggested that the rhythmic activity of glochidia is controlled by the direct effect of these substances on the muscles.

The assumption that changes in the osmotic value may be responsible for the produced effect should be rejected on basis of the different reactions obtained when using equally concentrated solutions of the ions investigated. Nevertheless, it is indisputable that the increase in activity observed in each case in the first minute subsequent to the application of the experimental solution may be regarded a non-specific reaction induced by the different osmotic value of the solution in question.

In the regulation of myogene rhythms the outer environment and inner metabolic processes are of primary importance (KOSHTOYANTS, 1957). Upon changing the ion milieu the existing condition of equilibrium disintegrates and this, as a non-specific effect, may also be responsible for the initial increase in activity. In the cases investigated, however, much rather specific ion effects are involved, which directly change the stimulatory and contraction processes of the nerve fibres. Scarcely any or only small changes were produced in rhythmic activity upon the application of low concentrations, whereas the use of higher concentrations yielded a lasting contraction of the embryonal adductor muscle. From this latter point of view, the ions investigated may be ranged in the following sequence according to their effectiveness: K^+, $Rb^+ > Cs^+$, $Mg^{++} > Li^+ > Ca^{++}$, Na^+ *(Table* 1*)*. The lasting contraction produced by highly concentrated solutions may last for 10—60 minutes, after the relaxing subsequent to this, however, the glochidium displays no rhythmic activity and does not respond to any external stimulus.

In the case of ions investigated in these experiments there were always concentrations to be found, which produced an activity of longer-shorter duration even without damaging the adductor muscle. This was most distinct upon the application of KCl, when namely a lasting considerable increase in activity was observable when using a solution of about 1×10^{-3} M concentration. This effect of K^+ is regarded closely related to the known role of this ion in stimulatory, membrane depolarizing processes. Regarding this lasting effect it is inferred that there exists a controlling mechanism in the adductor muscle of glochidia necessary for repolarization and relaxing which, in the case of not very high K ion concentration, is able to maintain the balance of ions and is responsible for its reconstitution after every contraction produced.

In case of higher concentrations the reconstituting mechanism gets soon exhausted and the adductor muscle contracts. This is visible upon the applica-

tion of 2×10^{-3} M and in particular 5×10^{-3} M solutions of KCl, when namely all glochidia gradually get into closed condition.

Upon the application of NaCl, $MgCl_2$ and $CaCl_2$ we failed to obtain lasting increase in activity, which is an indirect proof of the specific significance of K^+, MgCl and $CaCl_2$ solutions produced maximum effect in the first resp. 3—5 minutes. It is inferred that the differences in effect in the case of the various ions are obviously connected with their role in stimulatory and enzimatic processes. Nevertheless, further studies are needed for the correct interpretation of these characteristics.

It was conspicuous that whereas RbCl proved effective even at a nearly as low concentration as KCl, it could not produce lasting activity at neither concentrations. Contrary to this Li^+ and Cs^+ yielded increase in activity lasting even for 15—20 minutes, but the concentration required for this effect was about ten times greater than that of KCl producing similar effect, and also the rate of activity produced remained considerably below that registered in the case of KCl.

These findings emphasize the specific importance of K^+ as regards its influence on the rhythmic activity of the adductor muscle of larvae. It is also suggested by these results that general ion-effects produced by substances similar to K^+ in certain respect may be involved in the regulation rhythmic action.

Summary

Authors investigated the susceptibility of rhythmic activity of glochidia of freshwater mussel to the effect of various ions. 1×10^{-4}—2×10^{-1} M solutions of KCl, NaCl, $MgCl_2$, $CaCl_2$, LiCl, CsCl and RbCl were applied for the treatment and the number of closing of the embryonal valves were recorded by the minute in the groups of twentyfive glochidia under microscope. The observations lasted for 10—30 minutes in every case separately, depending on necessity.

In the course of investigations the followings were established. The about 1×10^{-3} M solution of KCl resulted in a considerable increase in activity, lasting even beyond the 30 minutes long period of investigation. A higher concentration of KCl gave rise to the contraction of embryonal adductor muscle resulting in the closing of glochidia. Relatively lasting (10—20 minutes long) increase in activity was produced only by Li^+ and Cs^+. The degree of this activity, however, was lower than in the case of K^+. Other ions yielded only initial increase in activity lasting for some minutes, and closing of glochidia was observable also in these cases upon the application of higher concentrations.

The specific effect of KCl is obviously due to its role played in both basic stimulatory processes and membrane depolarization, the lasting rhythmic activity increase itself, however, is based assumedly on those mechanisms of embryonal adductor muscle displaying myogene rhythm, by which it is capable of eliminating both depolarization and contraction produced by K^+.

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Table I — 1. táblázat

The effectiveness of substances investigated
A vizsgált anyagok hatásosságának összehasonlítása

	Threshold concentration 1.	Concentration producing fast closing 2.	Optimal concentration yielding lasting* increase in activity 3.	Lastingness of produced increase in activity 4.
KCl	1×10^{-4} M	5×10^{-3} M	1×10^{-3} M	over 30 min.
NaCl	$7{,}5 \times 10^{-2}$ M	2×10^{-1} M	—	—
$MgCl_2$	7.5×10^{-3} M	5×10^{-2} M	—	—
$CaCl_2$	1×10^{-1} M	2×10^{-1} M	—	—
LiCl	1×10^{-2} M	1×10^{-1} M	5×10^{-2} M	15—20 min.
CsCl	1×10^{-3} M	5×10^{-2} M	1×10^{-2} M	15—20 min.
RbCl	2×10^{-3} M	5×10^{-3} M	—	—

* Lasting over 10 minutes.

1. Küszöbkoncentráció.
2. Gyors bezárást előidéző koncentráció.
3. Optimális koncentráció, mely tartós, 10 percen túl tartó aktivitásfokozódást idéz elő.
4. A kiváltott aktivitásfokozódás tartóssága.

1. Таблица. Сравнение эффективности исследуемых веществ. 1. Пороговая концентрация. 2. Концентрация, вызывающая быстрое закрывание. 3. Оптимальная концентрация, вызывающая увеличение активности далее чем 10 минут. 4. Длительность увеличение активности

ALKÁLI FÉM ÉS ALKÁLI FÖLDFÉM IONOK HATÁSA AZ ÉDESVÍZI KAGYLÓ *(ANODONTA CYGNEA)* GLOCHIDIUMAINAK RITMIKUS AKTIVITÁSÁRA

Lábos Elemér és *Salánki János*

Összefoglalás

Szerzők édesvízi kagyló glochidiumok ritmikus aktivitásának különböző ionokkal való befolyásolhatóságát vizsgálták. Kísérleteikben KCl, NaCl, $MgCl_2$, $CaCl_2$, LiCl, CsCl és RbCl 1×10^{-4}—2×10^{-1} M-os oldatait alkalmazták és mikroszkóp segítségével figyelve meg 25-ös glochidiumcsoportokat, percenként regisztrálták az embrionális kagylóhéjak összecsapódásának számát. A megfigyeléseket esetenként — szükségtől függően — 10—30 percig folytatták.

A vizsgálatok során megállapították, hogy KCl 1×10^{-3} M körüli koncentrációja jelentős aktivitásfokozódást okoz, ami a vizsgált 30 percen túl is fennmarad. Magasabb KCl koncentráció az embrionális záróizom kontrakcióját eredményezi, ami a glochidiumok becsukódásához vezet. A többi vizsgált ion közül csak a Li^+ és Cs^+ okozott viszonylag tartós (15—20 perces) aktivitásfokozódást, annak mértéke azonban kisebb volt, mint K^+ esetében. Más ionok csak kezdeti, néhány percig tartó aktivitásfokozódást hoztak létre, magasabb koncentrációk pedig ez esetekben is zárást eredményeztek.

A KCl sajátos hatásának okát valószínűleg az alapvető ingerületi folyamatokban és membrándepolarizációban játszott szerepében kell keresni, maga a kiváltott, tartós ritmikus aktivitásfokozódás pedig feltehetően a myogen ritmust mutató embrionális záróizom azon mechanizmusain alapul, melyek segítségével az a K^+-mal előidézett depolarizációt és kontrakciót eliminálni képes.

ВЛИЯНИЕ ИОНОВ ЩЕЛОЧНЫХ МЕТАЛЛОВ И ЩЕЛОЧНО-ЗЕМНЫХ МЕТАЛЛОВ НА РИТМИЧЕСКУЮ АКТИВНОСТЬ ГЛОХИДИЙ БЕЗЗУБКИ *(Anodonta cygnea L.)*

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Резюме

Авторы изучали ритмическую активность глохидий беззубки и влияние на нее разных ионов. Были применены растворы хлористого калия, натрия, магния, кальция, лития, цезия, рубидия в концентрациях от 1×10^{-4} М до 2×10^{-1} М. Наблюдая группу глохидий из 25 животных при помощи микроскопа, ежеминутно регистрировали число захлопываний эмбриональной раковины. Исследования проводились в течении 10—30 минут.

Эксперименты показали, что хлористый калий в концентрации 1×10^{-3} М вызывает значительное увеличение активности, которое сохраняется дольше, чем в наблюдаемые 30 минут. Более высокие концентрации хлористого калия приводят к контрактуре эмбриональной запирательной мышцы, что приводит к закрыванию раковины животного. Из остальных ионов, изученных ими, только литий и цезий вызывают относительно длительное увеличение активности (15—20 минут), но степень этого увеличения меньше, чем при применении ионов калия. Остальные ионы вызывали только кратковременное увеличение активности, а более высокие концентрации и в этих случаях вызывали закрывание глохидий.

Своеобразное действие хлористого калия по всей вероятности обьясняется его ролью в основных процессах возбуждения и деполяризации мембраны, само же вызываемое длительное увеличение ритмической активности повидимому связано с тем механизмом эмбриональной запирательной мышцы, обладающей миогенной ритмикой, при помощи которого последний может прекращать контрактуру и деполяризацию, вызываемую калием.