

CHEMO-ECOLOGICAL RELATIONSHIP BETWEEN SOME FISH
SPECIES IN LAKE BALATON AND THE GLOCHIDIA
OF *ANODONTA CYGNEA* L.

FERENC LUKACSOVICS and ELEMÉR LÁBOS

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Introduction

In the course of ontogeny the larvae — glochidia — of some lamelli-branchiates are adapted to parasitic life, and become the temporary parasites of water vertebrates and most often that of fishes. In the case of small fish they get more frequently attached on the fin, while in that of bigger ones the swimming glochidia are getting with the inspired water on the lamellae of the gill (HARMS 1908). After attachment a cyst develops around the glochidia within some hours and the next stage of postembryonal development takes its beginning. The duration of parasitism varies and is specific primarily of the fish species in question: in the case of *Unio* genus it lasts 26—28 days at an average temperature of 16—17 °C, and in the case of the *Anodonta* genus about 21 days under the same conditions (HARMS 1908). The definitive organs of the animals develop during this period.

In the "free larval" stage the glochidia dispose of such temporary larval organs which may assumably have an important role in the mechanism of parasitisation. From these the most noteworthy are: the strong adductors, "teeth", byessus-gland and the mechano- and chemo-receptors (HERBERS 1913).

The role of the above mentioned organs and of the chemical and mechanical stimuli arriving from the surrounding — the host also included — in the mechanism of parasitisation is as yet an unsolved problem.

The clarification of this question is rendered even more difficult if it is considered that the glochidia respond with motor activity to a large number of chemical and mechanical stimuli (LEFEVRE, CURTIS 1912, ARBY 1921). The responses of muscles — depending on their nature — may either enable or secure attachment. From among the substances demonstrable also in the tissue fluid of various fishes e.g. certain bioamines are capable of producing rhythmic activity, while the uni- and bivalent cations — in physiological concentration — of rhythmic and tonic activity (LÁBOS, SALÁNKI 1963, LÁBOS, SALÁNKI, RÓZSA 1964).

The chief aim of the studies reported here is to examine the effect of the mucus of epidermis and of the serum of some fish species on the rhythmic and tonic activity of the adductor of glochidia in order to draw inferences as regards the mechanism of parasitisation.

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Material and method

In the experiments the following fish species were used: pelecus (*Pelecus cultratus*), bream (*Abramis brama*), pike-perch (*Lucioperca lucioperca*), carp (*Cyprinus carpio*), roach (*Rutilus rutilus*) and crucian carp (*Carassius carassius*). The experimental animals were selected irrespective of sex, and care was taken that they should be specimens just arrived at sexual maturity.

The serum was obtained by cutting off the tail and allowing the fish to bleed to death. The blood was centrifuged for 15 minutes at 4000 r.p./minute. The mucus was removed from the skin with a scalpel. Of both serum and mucus the following dilutions were made with filtrated Balaton-water: 1/2, 1/4, 1/8, 1/16, 1/32, 1/64, 1/128, 1/256, 1/512. The stock solution of epidermal mucus had a concentration of 0.09—0.14 g living matter/ml. The glochidia were obtained from the external lamellae of the gill of the adult. The effect of the various substances on motor activity was observed under a binocular microscope for 5—60 minutes, at a constant illumination of ca. 10 000 Lux. The investigation of the samples was carried out on 100 glochidia each. The frequency of rhythmic activity and the number of larvae entering into tonic contraction were recorded per minute.

Results

1. The effect of the epidermal mucus of fish

The mucus of epidermis of every fish species investigated (about 10—50 mg living matter/1 ml) is capable of producing rhythmic activity of a considerable degree. It has been also observed in all occasions that the number of glochidia entering into the state of several hours long tonic contraction increased when concentration and incubation period was risen. The glochidia getting into tonic contraction on the effect of the mucous substance whether undiluted or slightly diluted perform vivid, frequent rhythmic activity before closure. In case of dilutions greater than 1/16—1/32 of the watery extract of mucus the degree of phasic and tonic reaction observed is negligible. *Figure 1* shows the concentration dependency of activity and closure in the case of *Cyprinus carpio* with regard to the effect produced in the first 10 minutes of exposition. As the figure shows, there is a gradual increase in the number of closures with rising concentration and it is also visible that the dependency of activity on concentration has a maximum at a dilution of 1/8. The decrease of activity observable in more concentrated solutions is related to closure and its duration. *Figure 2* shows the changes of activity and closure plotted against time and produced by 1 : 4 dilution of mucus obtained from *Abramis brama*. Maximum activity is observable in the 7—8th minute of exposition. Then the glochidia are performing rhythmic contractions in every 10—12th sec in average. Subsequent to this a decrease in activity sets in, though about 50 per cent of the larvae are still in open state and capable of activity.

It has been also observed that there are differences in the effect produced by the epidermis-mucus of the various fish species investigated. These differences are of quantitative nature and manifest themselves in differences

Fig. 1. The effect of epidermal mucus on the rhythmic activity of glochidia. On the y-axis: the number of closures per minute. On the x-axis: the concentration of the mucus.

1. abra. *Cyprinus carpio* konyságára. Absz. számlált kontrakcióban le

of phasic and tonic activity during a given period. The water added to the rhythmic

Dilution
1/8 *Cyprinus carpio*
1/4 *Abramis brama*
1/2 *Lucioperca lucioperca*

The order of activity and closure produced (*fig.*)

Dilution
1/8 *Cyprinus carpio*
1/4 *Cyprinus carpio*
1/2 *Rutilus rutilus*

The rhythmic activity of glochidia with 20 mg living matter/ml mucus.

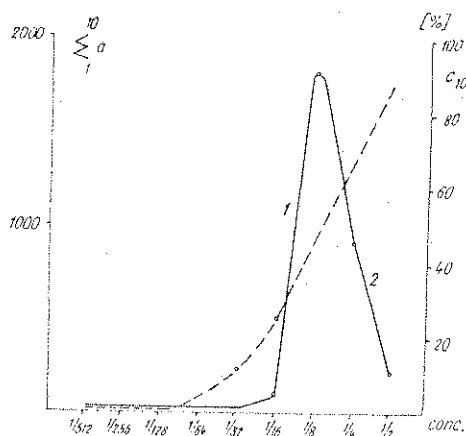


Fig. 1. The effect of mucus of epidermis of *Cyprinus carpio* on the rhythmic activity of glochidia. On the abscissa the dilutions of the stock solutions, on the left side of ordinate the number of contractions observed during the first 10 minutes, on the right side of the ordinate the per cent of glochidia being tonically contracted at the end of the single minutes are given. The data refer to 100 glochidia.

1. ábra. *Cyprinus carpio* epidermisváladékának hatása a glochidiumok motoros tevékenységére. Abszeisszán a törzsoldat hígításait, a bal ordinátán az első 10 perc alatt számított kontrakciók számát, a jobboldali ordinátán az egyes percek végén tónusos kontrakcióban lévő glochidiumok %-os arányát tüntettük fel. Az adatok 100 lárvára vonatkoznak

of phasic and tonic reactions produced at a given concentration and under a given period. The results are summarized in figures 3 and 4.

The water extracts may be arranged in the following order according to the rhythmic contractions produced (fig. 3).

Dilution	Species of fish
1/8	Cyprinus > Carassius > Rutilus > Abramis > Lucioperca
1/4	Abramis > Lucioperca > Cyprinus > Carassius > Rutilus
1/2	Lucioperca-Abramis > Carassius > Cyprinus-Rutilus

The order of activity may also be expressed on basis of the tonic reaction produced (fig. 4):

Dilution	Species of fish
1/8	Cyprinus > Rutilus > Abramis > Lucioperca-Carassius
1/4	Cyprinus > Rutilus > Abramis > Lucioperca-Carassius
1/2	Rutilus > Abramis > Cyprinus > Lucioperca-Carassius

The rhythmic activity produced by the mucus of *Abramis* has an extraordinary high frequency. When diluting the stock solution to 1/4 (about 20 mg living matter/1 ml water) and boiling it for 10 minutes the activity will

take place more quickly and the tonic increasing influence of the solution increases (fig. 5).

Occasionally the duration of phasic and tonic reactions is extremely long i.e. in case of *Lucioperca* the effect produced by 1/4 dilution lasted for over an hour (fig. 6). In case of *Pelecus* the mucus can be removed from the skin only together with the scales. For this reason in the evaluation of the effect other

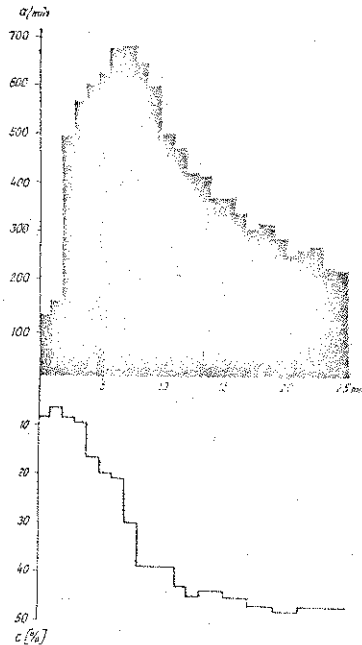


Fig. 2. Influence of epidermis mucus at a dilution of 1/4 in case of *Abramis brama*. On the abscissa time in minutes, on the ordinate upwards the frequency of rhythmic activity, downwards the ratio of closed glochidia are presented (100 animals)

2. ábra. *Abramis brama* epidermiszváladék 1/4-es hígításának hatása. Abszcisszán az időt percekben, az ordinátán felfelé a ritmikus tevékenység frekvenciáját, lefelé a zárt lárvák %-os arányát ábrázoltuk (100 állat)

factors should also be considered, because other substances as for instance particles of guanin are also present in the extract. Figure 7 illustrates the activity produced by the solution obtained by eluting the removed scales with water.

Experiments were run with the mucus of *Lucioperca* at two different times for the purpose to investigate the reproducibility of reactions. If the results thus obtained are illustrated on basis of equal view points, it can be easily decided if the reactions are reproducible or not (figs. 8 and 9). The deviations are due partly to the difficulty of preparing samples of equal dry matter content, but the sensitivity changes taking place in the glochidia during development are neither negligible.

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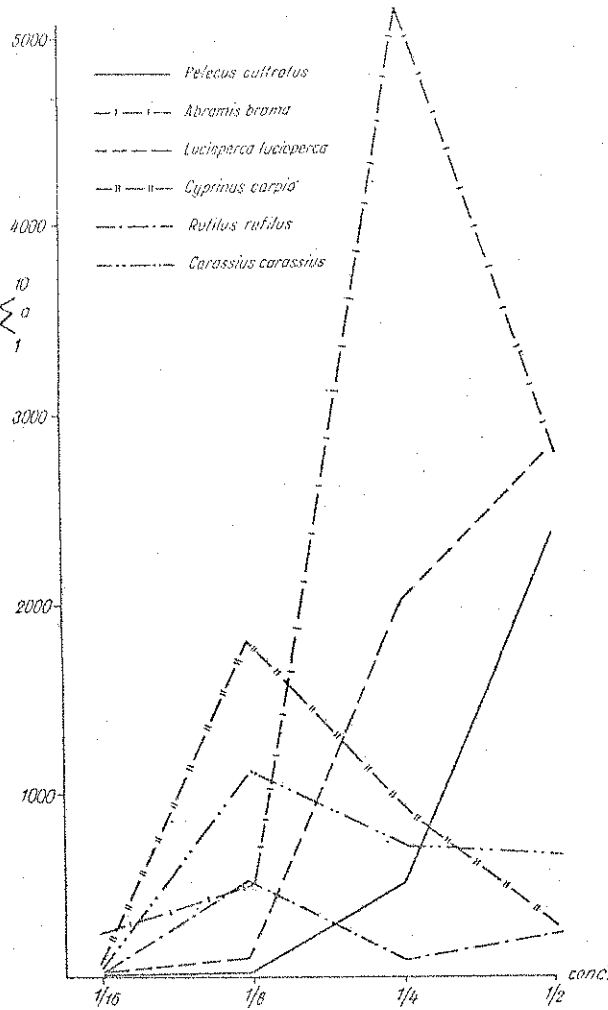


Fig. 3. Comparative data of the effect of epidermis mucus. Number of contractions observed during the first ten minutes of observation in the case of various fishes plotted against the degree of dilutions

3. ábr. Epidermisz nyálka hatásának összehasonlító adatai. Az első 10 perc alatt számlált kontrakciók a különböző halfajok esetében a hígítás függvényében

2. The effects produced by different dilutions of serum

The effect of blood obtained by cutting off the tail was examined after clotting and centrifuging.

Every undiluted serum investigated produced lasting closures in about 95–100 per cent of glochidia within some minutes. Tonic contractions lasted at least for a few hours. Closures were preceded by 1–10 rapid phasic contractions in the case of every glochidium. The whole process took place within the first minute of observation.

By diluting the serum the reaction becomes lasted. Closure is not instantaneous but takes place successively within 15–25 minutes. The duration

of activity varies in the different fish species and may even reach very high values. In case of more diluted solutions the ratio of closures becomes negligible or naught, and activity becomes limited only to the first 1—2 minutes or becomes imperceptible same as closures. *Figures 10 and 11* illustrate the above findings in the case of bream at different dilutions of serum.

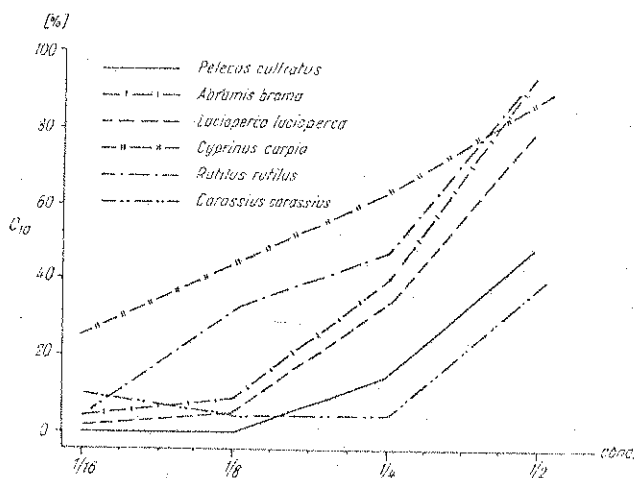


Fig. 4. Comparative data on the effect of mucus of epidermis. The ratio of closed larvae at the end of the 10th minute in the function of concentration in the case of different fish species

4. ábra. Epidermisz nyálka hatásának összehasonlító adatai. A 10. perc végén zárt lárvák %-os aránya a koncentráció függvényében a különböző fajok esetében

Both the ratio of closures and the total number of contractions produced in a given period are characteristic of the degree of concentration. In the followings this relationship will be exemplified with the case of bream.

As it is visible in *figure 12* the changes in the ratio of glochidia being closed at the end of the 25th minute may be illustrated graphically with an S shaped curve. Solutions diluted to 1/32 produced closure in 50 per cent of glochidia, moreover, a maximum in the concentration dependency of activity is also observable at this dilution. These phenomena were observable in the case of every serum investigated.

Comparison of the effects produced by the serums of the single fish species is made on basis of the number of contractions produced in the first 15 minutes at a dilution of 1/132. The order of activity of the various serums will thus be:

Abramis brama > *Cyprinus carpio* > *Lucioperca lucioperca* > *Pelecus cultratus* > *Rutilus rutilus* > *Carassius carassius*.

The degree of tonic reactions is estimated by the number of glochidia being in closed condition at the end of the 10th minute on the application of a 1/16 dilution.

Thus the order of activity will be:

Lucioperca lucioperca > *Abramis brama* > *Cyprinus carpio* > *Carassius carassius* > *Pelecus cultratus* > *Rutilus rutilus*.

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In figures 13 and 14 the differences between phasic and tonic responses obtained with serums of different fish species are illustrated in the function of dilutions.

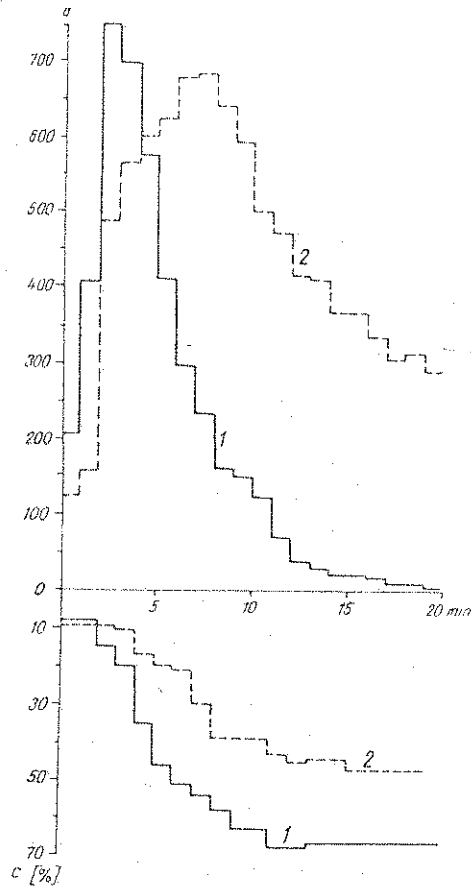


Fig. 5. Comparison between native and boiled mucus of *Abramis brama*. Abscissa: time, ordinate: frequency and number of closures

5. ábra. *Abramis brama* natív és forralt nyálkájának összehasonlítása. Abszcissza: idő, ordinátán a frekvencia, illetve a zárási arány

Discussion

Notwithstanding, that the mature glochidia are released from the gill of the mother only in November--December, they are in active motor condition as early as the middle of September. This motor maturity is a necessary prerequisite of virulence. According to literary data (HARMS 1907 and SCHIERHOLZ 1878) the time in which the virulent glochidia are discharged shows seasonal differences. The fact that from the discharged glochidia not every one is capable of development is attributable to environmental factors. Several

factors may contribute to the possibility of their further development. From these the frequency and topographic conditions helping them to reach a host are of importance. The frequency of mussels and fish is determined by the conditions prevailing in the habitat. The number of glochidia cannot be a limiting

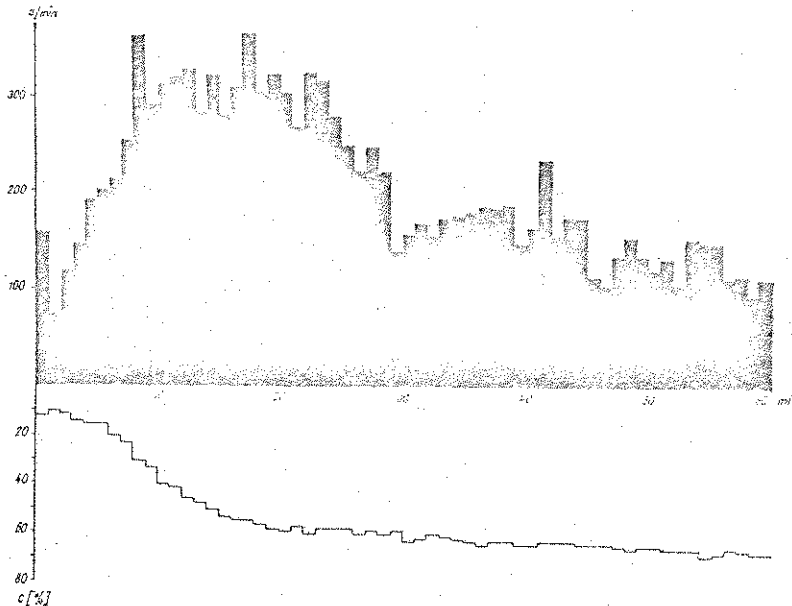


Fig. 6. The effect of the mucus of epidermis at a dilution of 1/4 in the case of *Lucio-perca lucio-perca* during the first 60 minutes of exposition. Abscissa: time in minutes, ordinate: frequency and number of closures.

6. ábra. *Lucio-perca lucio-perca* epidermisz nyálkájának 1/4-es hígításának hatása az első 60 perc alatt. Abszcissza: idő percekben, ordináta: frekvencia, illetve zárási arány

factor, because many 100 000 glochidia are discharged by one female (HARANGHY, BALÁZS, BURG 1964).

The duration of virulency in the free larval stage of glochidia is not known, though it may also help to reach a host successively. The movements by which a meeting is rendered possible are active on the part of the host and passive on that of glochidia. After being discharged from the gill the glochidia being transformed into meroplanktic elements (SEBESTYÉN 1964) are floating freely following the general water movement. In this state the glochidia are differentiated as regards their motor activity, but the degree of their locomotivity is negligible (tenths of mm/hour).

Byssus secretion seems to have a significant role in the mechanism that favours the free floating larvae to get attached on fishes (HERBERS 1913, HARMS 1909, LILLIE 1895). This substance facilitates floating and attachment, the latter also indirectly by contributing to the glochidia getting attached to water plants and any artificial objects. The question how far the possibility of finding a host depends on the ethology of host, more concretely on the way of living and feeding of fish may assumably be solved when surveying the list of species on which developing glochidia were found:

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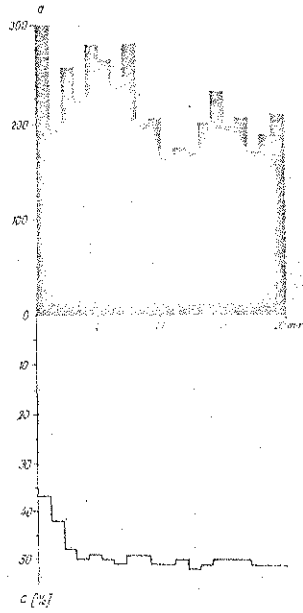


Fig. 7. The effect of the water extract (6.67 g dry matter/45 ml water) of scales and mucus of epidermis in case of *Pelecus cultratus*. Time curves

7. ábra. *Pelecus cultratus* pikkely és epidermisz nyálka vizes kivonatok (6,67 g szárazanyag/45 ml víz) hatása. Időgörbék

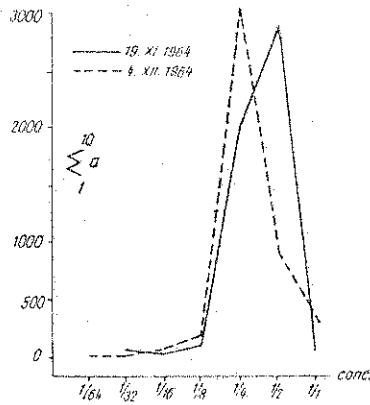


Fig. 8. Concentration dependency of the activity increasing influence of mucus in case of *Lucio-perca lucio-perca* on basis of observations made during the first 10 minutes. Comparison between measurements carried out at two different times

8. ábra. *Lucio-perca lucio-perca* epidermisz nyálka aktivitásfokozó hatásának koncentráció-függése az első 10 perc alapján. Két különböző időpontban végzett vizsgálat összehasonlítása

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Cyprinus carpio (LEYDIG 1866), *Perca fluviatilis* (SCHIERHOLZ 1878), *Acerina cernua*, *A. schraetzer*, *Rhodeus amarus*, *Carassius vulgaris*, *Tinca vulgaris*, *Leuciscus virgo*, *Cottus gobio*, *Squalius cephalus* (HAZAY 1885), *Alburnus alburnus*, *Osmerus eperlanus* (FAUSSEK 1895), *Phoxinus phoxinus*, *Leuciscus rutilus* (HARMS 1907), *Gasterosteus aculeatus*, *G. pungitius*, *Esox lucius* (WEGENER 1909), *Micropterus salmoides*, *Fundulus diaphanus*, *Apomotis cyannelus*, *Lepomis humilis*, *Pomoxis annularis* (YOUNG 1911).

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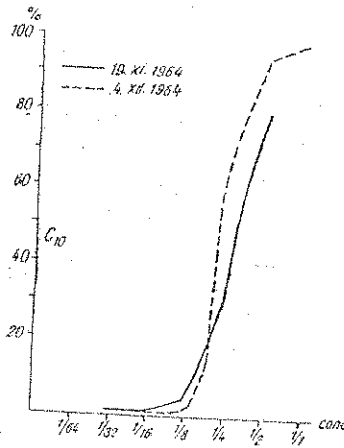


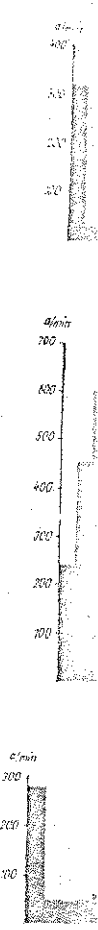
Fig. 9. Concentration dependency of the tonic increasing effect of the mucus of epidermis in case of *Lucio-perca lucio-perca* in the first 10 minutes of exposition. Comparison between the results obtained on two different occasions
 9. ábra. *Lucio-perca lucio-perca* epidermisz nyálka tónus okozó hatásának koncentráció függése az első 10 perc alapján. Két különböző időpontban végzett kísérleti eredmény összehasonlítása

On basis of the aboves most freshwater fishes may be taken as hosts irrespectively, if they are predators or plankton consumers, or consumers of pelagic or bottom fauna. Attachment may occur anywhere on the surface of fish. This establishment is confirmed by the experiments reported here. By infecting *Phoxinus* artificially attachment occurred on places of most varying bend, nevertheless it was more frequent on surfaces of short radius of curvature. In the case of these fish species other factors as consistency and proportion of the surface of epidermis, the type of scales may also be involved in the mechanism of attachment. The size of the opening and cavity of mouth acts as a limiting factor in the process of attachment. In case of fish feeding by filtration the water used for breathing is also filtrated through and in most cases glochidia clustered into groups are not able to penetrate into the gill.

The contraction of the adductor is a prerequisite in the attachment of glochidia. The possibilities of producing these contractions by pure mechanical stimuli has been investigated experimentally. Excitation of the sensory cells on the ventral surface of glochidia with glass rods drawn out very thin will produce vivid contractions. The data of 50 experiments show the followings: in 42 cases contraction lasted less than one minute, in 6 cases between 1—5 mi-

Fig. 10. The effect in minutes
 10. ábra. *Abramis* az idő percekben

mechanism. Experiments show that the produce contraction question (fig. 4) contraction, but extract is efficacious



latis (SCHIERHOLZ 1878),
mus vulgaris, *Fuca vulga-*
s (HAZAY 1885), *Alburnus*
phoxinus, *Leuciscus*
pungitius, *Esox lucius*
lucius diaphanus, *Apomotis*
 (OUNG 1911).

minutes, and only on two occasions over 5 minutes. This implies that contraction is producible also by pure mechanical stimuli, but for its permanency another factor is also needed. These results contradict to LEFEVRE and CURTIS (1912) according to whom the attachment of hooked glochidia is based on tactile

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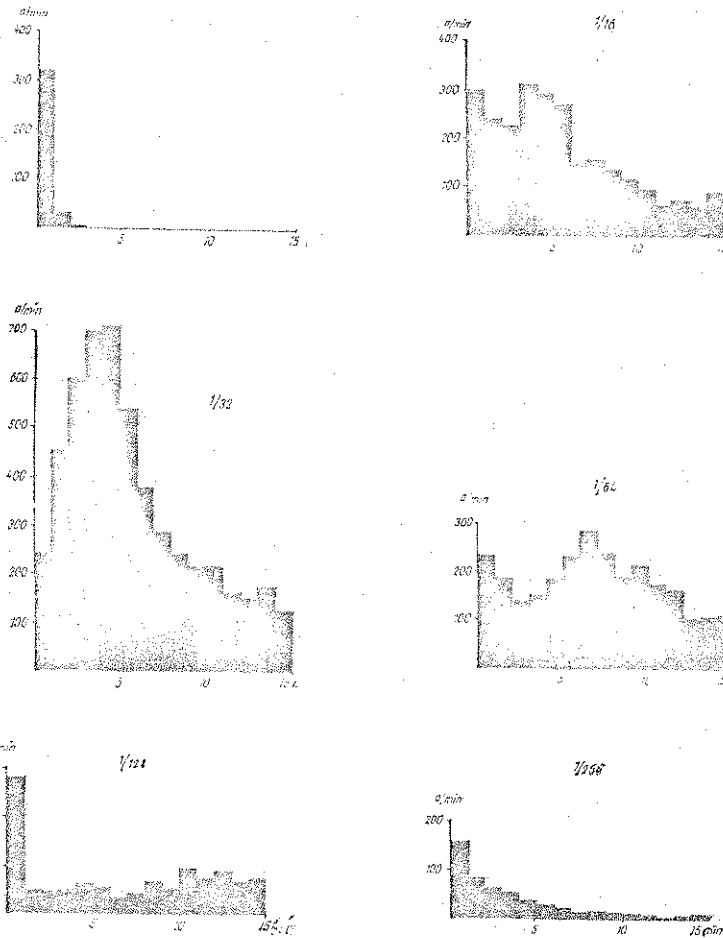


Fig. 10. The effect of serum of *Abramis brama* at different dilutions. On abscissa time in minutes, on ordinate frequency of rhythmic activity are given

10. ábra. *Abramis brama* szérumának hatása különböző hígításokban. Abszcisszákon az idő percekben, az ordinátákon a ritmikus aktivitás frekvenciája van feltüntetve

mechanism. Experiments performed with epidermis mucus and serum definitely show that the chemical composition of these substances is suitable to produce contraction lasting for several hours irrespectively of the fish species in question (fig. 4 and 14). Accordingly both kinds of stimuli are able to produce contraction, but only the chemical one is capable of its preservation. Epidermis extract is efficacious regardless if it contains scales or not (fig. 7). All epi-

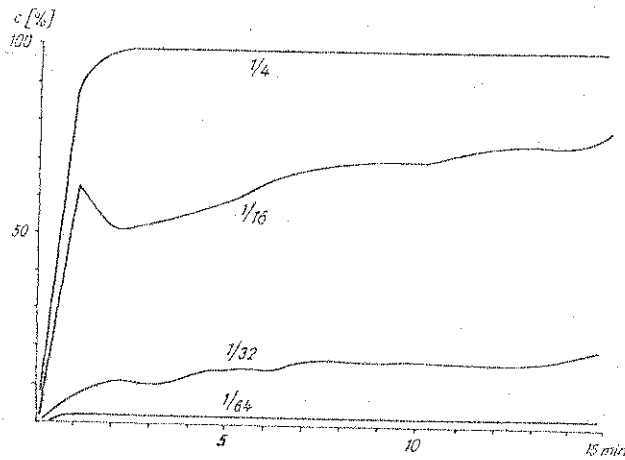


Fig. 11. Serum of *Abramis brama*. Time dependency of tonic effect at different dilutions

11. ábra. *Abramis brama* széruma. A tónusokozó hatás időfüggése különféle hígításoknál

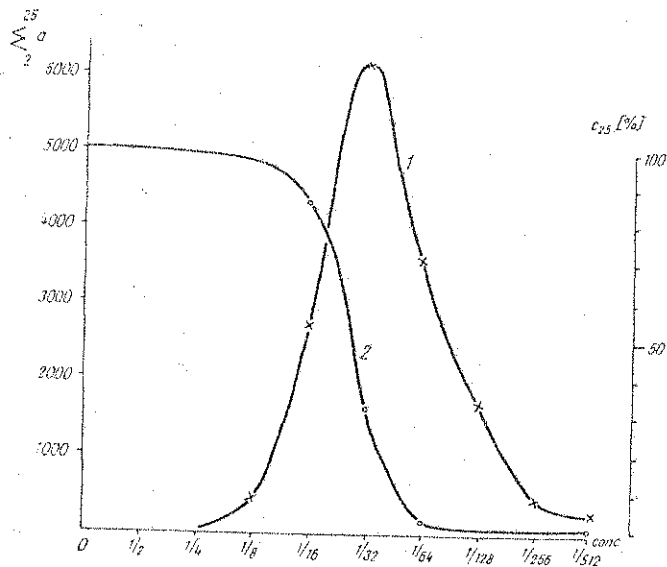


Fig. 12. Serum of *Abramis brama*. Concentration dependency of activity producing and tonic increasing effect. On the abscissa the dilutions, on the ordinate the number of contractions between 2—25 minutes and the number of closed glochidia at the end of the 25th minute are illustrated

12. ábra. *Abramis brama* széruma. Az aktivitás kiváltó és tónusokozó hatás koncentrációfüggése. Abszcisszán hígítás az ordinátákon az első 2—25 perc között számlált kontrakciók ill. a 25. perc végén zárva talált lárvák száma látható

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dermis extracts and serums investigated lose in their effectiveness when they are diluted. The degree of dilution at which epidermis extracts are producing half maximum effect i.e. tonic contraction in 50 per cent of glochidia varies

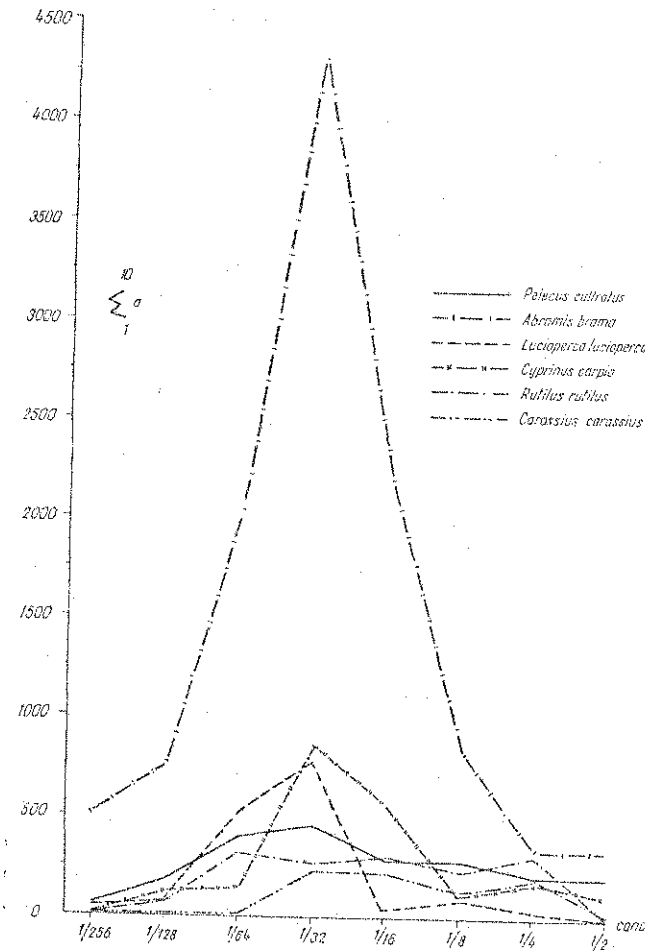


Fig. 13. Activity increasing influence of the serum of various fish species in the function of dilutions in the first 10 minutes of observation

13. ábra. A különböző halfajok szérumának aktivitásfokozó hatása a hígítástól függően az első 10 perc alapján

with the different species, it is, however, never greater than 1/4. The dilution of mucus to 1/32 proved to be unefficacious. Accordingly, a mucus extract of a concentration of 3—5 mg living matter/1 ml water is not sufficient to favour parasitism by pure chemical induction. Because mucus substances of such or greater concentrations may not be present at larger distances from

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the surface of fish, it is concluded that real chemotactic mechanisms cannot be involved in case of greater shoal of fish.

The fact, that mucus of epidermis is able to produce considerable rhythmic activity suggests that the glochidia getting in contact with the surface of fish and thus with the mucus will start a rhythmic movement by virtue of the substances present in mucus, whereby the possibility of penetrating the tissue increases. Getting hooked up attachment is secured by the tonic reactions induced by serum or more concentrated mucus. HEARD and HEND-

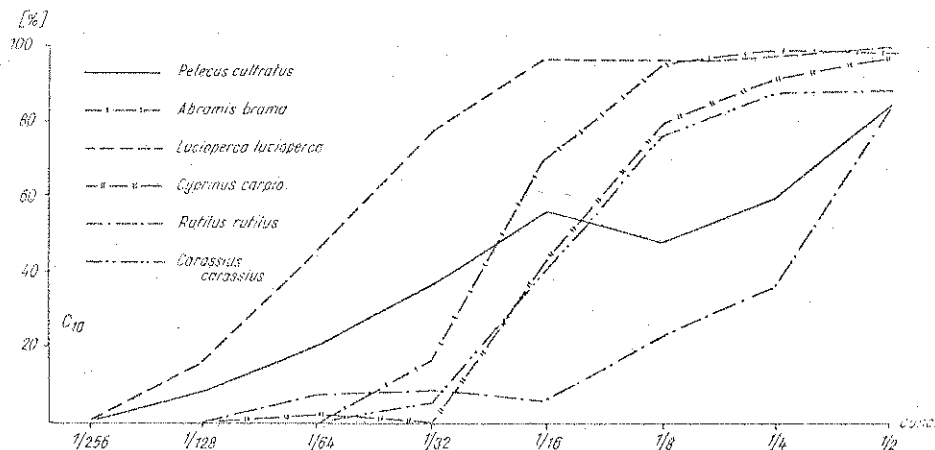


Fig. 14. The effect of serum of various fishes on closure in the function of dilutions on basis of observations made during the first 10 minutes of exposition

14. ábra. A különböző halfajok szérumának zárást okozó hatása a hígítástól függően az első 10 perc alapján

RIX (1964) recently reported similar results on marine Lampsilinae suggesting tactile stimulus as the starting and tissue fluid as the lasting factor interfering in the process of attachment.

In case of the attachment to the gill sustenance of tonicity is assumably due to agents present in extravascular fluids and blood serum. In undiluted condition the blood serum of various fish species produces immediate lasting tonic contraction of every glochidium (figure 14). A dilution of the serum to 1/16 acts similarly in the case of *Lucioperca*, whereas its efficacy in the case of *Rutilus* is very small. On the other hand, in the case of other species it produced lasting tonic contraction in 50 per cent of glochidia in the first 10 minutes of exposition. Though there may be differences in the serum of different fish species, still the glochidia getting attached to the gill are exposed to the influence of undiluted serum, which induces immediate closure independent of species. This and previous findings show, that on basis of tonicity increasing influence of mucus and serum none of the fish species excels as the distinguished host of glochidia.

It was demonstrated by FAUSSEK (1885) and HARMS (1909) that glochidia may develop even on the body surface of Cyclostomata and Amphibia.

This supports the there is no specif

In the con mucus and serum tonic responses p activity orders. A by the mucus and *perca* proved to l the mucus and se of dilutions. The equal grounds is of the mucus of of *Lucioperca*. Th considering the d ever, are very tro dry matter conte as the relationshi

Accordingly favouring attach instance the osm

NaCl solutio produce lasting $\Delta C^{\circ} \sim 0.7$, Kos tions of a molar c SALÁNKI 1963).

From amor importance is att organic effective increasing effect. of this.

The same a quantitative eval (and serum) decre efficacy is not n constituents then of *Abramis*, that i It is known, that agent the so calle 1955) which is pa *mis* belonging to *Cyprinus* and *Ru* the IIIrd group. I graphs presented are more effective toxicity. It is not produced. This a process in ontoge 1964) tryptamine, has no ecological i increasing effect

This supports the assumption made in the course of the present studies that there is no specific agent present in the epidermis mucus and serum of fishes.

In the course of examinations performed with different dilutions of mucus and serum quantitative differences were observed in the rhythmic and tonic responses produced. These differences are expressed in this paper as activity orders. As the results show, greatest rhythmic activity was produced by the mucus and serum of *Abramis*. Except for *Abramis*, *Cyprinus* and *Lucioperca* proved to be more active in many respects. The activities produced by the mucus and serum of *Carassius* and *Rutilus* decreased rapidly in the course of dilutions. The serum of *Pelecus* behaves in the same way. Classification on equal grounds is difficult because for instance the tonicity increasing effect of the mucus of *Rutilus* is more pronounced than that observed in the case of *Lucioperca*. The activity order of mucus may be rendered more definite by considering the differences in dry matter content. Studies of this kind, however, are very troublesome due to the difficulty of preparing solutions of given dry matter content, and because the conversion of dilution values is not real as the relationship between effect and concentration is not linear.

Accordingly, it is suggested, that the properties of serum and mucus favouring attachment of glochidia may be more general ones. It may be for instance the osmotic concentration of the blood.

NaCl solutions having osmotic pressure equivalent to that of the serums produce lasting tonic contractions in glochidia (in freshwater bony fish $\Delta C^\circ \sim 0.7$, KOSTOJANC 1955). The same situation exists in KCl solutions of a molar concentration which nearly equals that of lymph K (LÁBOS, SALÁNKI 1963).

From among the anorganic constituents of mucus considerably less importance is attributable to Na and K (OOSTEN 1957) and it is assumed that organic effective materials may also contribute to the formation of tonicity increasing effect. The thermolability of *Abramis* mucus is also indicative of this.

The same assumption is supported by the observation, not subject to quantitative evaluation as yet, that the activity increasing effect of mucus (and serum) decreases during stay. In undiluted stock solution this change in efficacy is not measurable. It is suggested therefore, that besides anorganic constituents there may also an organic effective agent be present in the serum of *Abramis*, that is able to induce rhythmic activity of an extremely high level. It is known, that the serum of various fresh-water fishes contains an effective agent the so called ichthyotoxin (BUNDER 1934 — quotation from KOSTOJANC 1955) which is parenterally toxic on mouse. The serum of *Lucioperca* and *Abramis* belonging to the IIrd group set up by BUNDER is toxic. The serums of *Cyprinus* and *Rutilus* are toxic in a smaller degree. These species belong into the IIIrd group. By comparing these above facts with the effect-concentration graphs presented in figure 14 it becomes evident that serums of greater toxicity are more effective in producing increased tonicity than those ones of less toxicity. It is not unprobable that ichthyotoxin is also involved in the effects produced. This agent is not toxic on glochidia but influences an important process in ontogenesis. As experimental results show (LÁBOS, SALÁNKI, RÓZSA 1964) tryptamine is the most effective from among biogen amines. This question has no ecological importance, because the influence is concealed by the tonicity increasing effect of undiluted serum. Nevertheless, as far as the physiology

of the activity of adductor is concerned it deserves attention and further investigations.

As regards the ecological aspects of development of glochidia further interest is commanded to the factor inducing the beginning of development. This factor may originate either from the tissues of the host or is released from the adductor of glochidia during tonic contraction. It is assumed that feeding itself may also furnish sufficient basis for further development. HEARD and HENDRIX (1964) emphasize the significance of free amino acids in the lysed host tissues and blood.

Summary

1. In this paper the effect of mucus of epidermis and serum of some fish species living in Lake Balaton (*Cyprinus carpio*, *Carassius carassius*, *Rutilus rutilus*, *Abramis brama*, *Lucioperca lucioperca* and *Pelecus cultratus*) produced on the larvae of *Anodonta cygnea* L. was investigated.

2. Motor activity of adductors may be induced also by tactic stimuli, but its tonicity is only of short duration.

3. The mucus obtained from epidermis is capable of producing considerable rhythmic and tonic activity in case of every fish species investigated.

4. The concentration dependency of rhythmic activity of a group of glochidia has a maximum, and the dependency of tonic responses on concentration may be illustrated graphically with an S-shaped curve.

5. In the lasting attachment of glochidia important ecological role is attributed to undiluted substances producing instantaneous and lasting tonic reactions. It is feasible that the attachment of glochidia is rendered possible by the rhythmic activity preceding tonicity.

6. The chemoecological estimation of data shows that the mucus of epidermis and serum of fish species do not differ qualitatively and so on basis of these the glochidia do not have a distinguished host.

7. Quantitative differences were observed when using different dilutions. The activity produced with the mucus and serum of *Abramis* is most conspicuous, and it is assumably due to an organic substance (ichthyotoxin?) whereas the chemoecologically important act may be explained also by the inorganic salt constituents of tissues.

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1. Szerzők m
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és szérumának hatá
2. Az adduct
a tónus időtartama
3. Minden v
ritmikus és tónusos
4. A ritmikus
válasz a koncentráci
5. A glochidia
a hígítatlan anyag
tényező indítóokká
boakadását teszik v
6. A kemoök
halfajok epidermis
alján nincs kitűn
7. A hígítások
és szérum aktivitás
kemoökológiai szem

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KEMO-ÖKOLÓGIAI KAPCSOLATOK VIZSGÁLATA NÉHÁNY BALATONI HALFAJ ÉS AZ *ANODONTA CYGNEA* L. GLOCHIDIUMA KÖZÖTT

Összefoglalás

Lukacsovics Ferenc és Lábos Elemér

1. Szerzők néhány balatoni halfaj (*Cyprinus carpio*, *Carassius carassius*, *Rutilus rutilus*, *Abramis brama*, *Luciopeca luciopeca* és *Pelecus cultratus*) epidermisz nyálkájának és szérumának hatását vizsgálták *Anodonta cygnea* L. glochidiumain.
2. Az adductorok motorikus aktivitása taktikus ingerrel is kiváltható, azonban a tónus időtartama csak rövid ideig áll fenn.
3. Minden vizsgált halfaj epidermiszváladéka és széruma képes jelentős fokú ritmikus és tónusos aktivitás előidézésére.
4. A ritmikus aktivitás koncentráció függése egy maximumot mutat, a tónusos válasz a koncentrációtól S alakú görbe szerint függ.
5. A glochidium tartós megtapadásában jelentős ökológiai szerepet tulajdonítanak a hígítatlan anyagok azonnali és tartós tónust kiváltó hatásának, míg a mechanikai tényező indítóként szerepelhet. A tónust megelőző ritmikus aktivitás a glochidiumok benkadását teszi valószínűbbé.
6. A kemoökológiai szempontból értékelt adatok arra utalnak, hogy a vizsgált halfajok epidermisz nyálkája és széruma nem tér el egymástól kvalitatíve, így ennek alapján nincs kitüntetett gazdája a glochidiumnak.
7. A hígítások során kvantitatív eltérések voltak. Kiemelendő az *Abramis* nyálka és szérum aktivitása, amelyért organikus anyag (ichthyotoxin?) tehető felelőssé, míg a kemoökológiai szempontból fontos aktust a szövetek sóösszetétele is magyarázza.

ИССЛЕДОВАНИЕ ХЕМО-ЭКОЛОГИЧЕСКИХ СВЯЗЕЙ МЕЖДУ ГЛОХИДИЯМИ
Anodonta cygnea L. И НЕСКОЛЬКИМИ ВИДАМИ БАЛАТОНСКИХ РЫБ

Ф. Лукачевич, Э. Лабон

1. Авторы изучали влияние кожной слизи и сыворотки нескольких видов балатонских рыб (*Cyprinus carpio*, *Carassius carassius*, *Rutilus rutilus*, *Abramis brama*, *Luciopeca luciopeca*, *Pelecus cultratus*) на гложидии беззубки.
2. Моторную активность аддукторов можно вызывать и тактильными раздражениями, но тоническое сокращение сохраняется только короткое время.
3. Экстракты кожи и сыворотки всех видов рыб способны вызывать значительную ритмическую и тоническую активность гложидиев.
4. Ритмическая активность показывает один максимум, зависящий от концентрации, экстрактов кожи и сыворотки рыб, а тоническая реакция зависит от концентрации по S-образной кривой.
5. В прикреплении гложидиев приписывают значительную роль быстрому и длительному действию неразбавленных веществ, вызывающих тонус, а механический фактор выступает в качестве пускового механизма в этом процессе. Ритмическая активность, предшествующая тонусу, делает возможным приклепление гложидиев.
6. Данные, рассмотренные с хемо-экологической точки зрения, указывают, что слизь кожи и сыворотка изучаемых видов рыб не отличается друг от друга, значит, по этим показателям гложидии не выбирают своих хозяев.

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