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THE REPRODUCTIVE CYCLE AND THE GLOCHIDIUM OF ANODONTA CYGNEA L. FROM LAGO TRASIMENO (CENTRAL ITALY)

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I. INTRODUCTION

The genus *Anodonta* is well represented in the fresh waters of Italy. Notwithstanding the large populations and the facility of collecting specimens, very few data are available regarding the biology and ecology of these bivalves.

In the hope of filling this gap and of obtaining reliable data for a systematic review of this difficult group (cf. ALZONA, 1971), we have focused our attention on some populations living in the river Po (near the delta) and in lake Trasimeno. These localities seem to be highly satisfactory for our purposes because of the abundance of specimens at various stages of growth that can be gathered there. This seem to be a clear demonstration that in such localities the life cycle of *Anodonta* still follows a regular pattern.

Here are reported the results of the study of the reproductive cycle of *Anodonta cygnea* L. (*Anodonta piscinalis* Auct.) in lake Trasimeno as

well as of the peculiar phenomenon owing to which the larval form (glochidium) is found attached to the gills and the fins of various species of fish.

II. MATERIALS AND METHODS

We have studied the fresh water mussel *Anodonta cygnea* L., subfamily Anodontinae, family Unionidae, order Eulamellibranchiata.

This mollusc is provided with a large equivalve shell 90-100 mm long, a relatively small umbonal cavity with no teeth on the hinge. Such characteristics, after which the genus is named, distinguish this mollusc from other genera provided with teeth, such as for instance those belonging to the Unioninae subfamily.

Externally the shell is brownish and slightly grooved with concentric ridges; internally it is pearly and almost completely smooth. In adult specimens the valves are oval-shaped; in young individuals they have a small rostrum near the umbo.

Anodonta cygnea L. is found in sandy as well as in muddy bottoms, particularly in lakes, and at depths ranging from 0.5 to 4-5 m. We gathered *Anodonta* in three stations on lake Trasimeno: Castiglion del Lago, Passignano and Monte del Lago. Owing to the shallowness of the waters of the first two stations we were able to collect the mussels by hand, but at Monte del Lago where the water is deeper, we had to dredge the bottom for 30-40 m at a depth of about 3 m.

A good number of the specimens we collected were kept for comparison in a large outdoor tank of the Istituto di Idrobiologia of Monte del Lago. We tried to reproduce the natural environment by providing the bottom of the tank with a layer of 10 cm of mud and pumping in water from the lake every day. Twenty-twentyfive specimens of fish of each of the various species commonly found in the lake: Perch (*Perca fluviatilis* L.), Pumpkinseed (*Lepomis gibbosus* L.), Pike (*Esox lucius* L.), Tench (*Tinca tinca* L.) and Sand smell-like fish (*Atherina boyeri* Risso) were collected every month to study the frequency of glochidia and the various stages of their parasitic life.

For the study of the reproductive cycle 10 adult *Anodonta* were sacrificed every month and studied both directly at the dissecting microscope and in histological sections of the mantle, gills and other parts of the body fixed in Bouin solution and processed as is usual. The number of the specimens was kept low because of the difficulty experienced in obtaining many individuals at the same time and also to preserve the populations in order to have at our disposal sufficient material for the whole period of our investigations.

Finally, for the study of glochidium morphology, glochidia on fish, fins and gills as well as in the mother gills of *Anodonta* were examined in histological sections. Isolated glochidia were also observed at the Jeol SM-2; for this method of observation the glochidia were previously washed in ethanol 75° and then pressed on to an electroconductive glue on a copper support. After having been dried they were covered with a thin layer (200-300 Å) of evaporated gold and palladium.

III. ENVIRONMENT

Lake Trasimeno lies at about 258 m above s.l. and is the largest fresh water basin in central Italy (about 130 km^2); its perimeter is almost circular. Unfortunately between 1950 and 1960 the hydrographic conditions of the lake slowly but persistently deteriorated; it became almost

marshy with an enormous increase of hydrophites. In the early sixties owing to a series of hydraulic modifications that caused the water level to rise again, a marked increase of animal populations together with an enormous increase of hydrophites occurred.

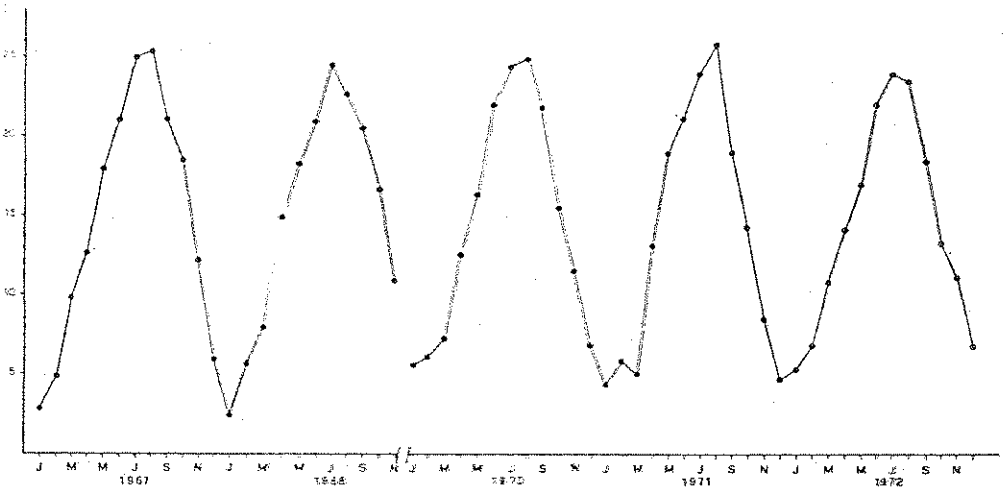

Fig. 1. — Graph of the mean monthly temperatures of lake Trasimeno in 1967, 1968, 1970, 1971, 1972, according to the data of the Istituto Italiano di Idrobiologia of Pallanza.

The lake is 4-5 m deep except in a small central area were it is over 6 m. The shallowness of this basin and the fact that its waters are provided mostly by rain are responsible for the high thermic excursion. The average surface temperatures (except in December and January) are over 4°C and do not depend exclusively on the temperature of the air. Bottom temperatures vary from a minimum of 1°C in January to 28°C in August. Fig. 1 shows the graphs of the seasonal temperatures of the years 1967-1968 drawn from the data collected by the Istituto Italiano di Idrobiologia of Pallanza in 1971 (see CAROLLO & BARBANTI, 1971) also the seasonal temperature pattern of 1970, 1971, 1972, drawn during our research.

IV. REPRODUCTIVE CYCLE

Data concerning the spawning period of Unionidae and particularly of *Anodonta cygnea* L. are relatively scanty and often discordant.

Temperature and other physico-chemical factors (HARMS, 1909) are believed to affect spawning and the maturation of gonads (expulsion of glochidia).

A very long period of sexual maturity has been reported for the *Anodonta* of the river Thames at Reading (NEGUS, 1966), from late summer until the end of April. According to this author the fully developed larvae remain in the mother gills throughout autumn and winter instead of being eliminated.

LEFEVRE & CURTIS (1910) and COCKER et al. (1921) reported that elimination of glochidia occurs in April in relation to the increasing temperature of the water. In Belgium (ADAM, 1960) the reproductive cycle is quite similar because the glochidia developed during the winter months are eliminated in the early spring.

In central and eastern Europe (HARMS, 1909; ZHADIN, 1938, 1952; BRODNIEWICZ, 1968) gametogenesis begins during the second half of August and continues to the end of September: in October the production of eggs comes to an end and the mother gills begin to fill with glochidia, which, however, will not be eliminated untill late spring (May or June). These authors consider the increase in water temperature as responsible for glochidium spawning. No data are available on the reproductive cycle of *Anodonta* and other Unionidae in Italy.

Personal observations. On the basis of the examination of 10 specimens collected and sacrificed at monthly intervals from July 1970 to May 1972 we have traced a precise pattern of the reproductive cycle of *Anodonta cygnea* L. living in lake Trasimeno.

July 1970: most individuals collected in this month show well developed germinal follicles of both sexes but only a few ripe eggs and small batches of sperm; in some individuals the germinal follicles are very small.

August: almost all the individuals of both sexes are now full of

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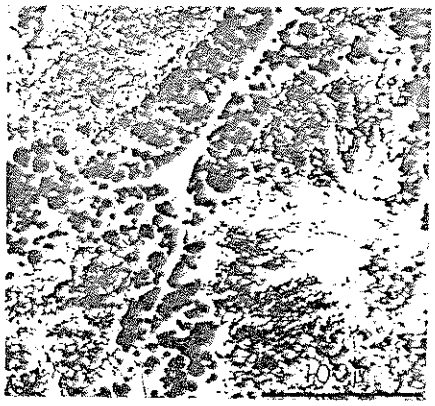
Fig. 2. — Testicular grains of a male sample killed on September 18, 1970 in full gametogenetic activity. Spermatogons, spermatocytes and spermatides are leaning against the walls of the grain: the spermatozoa are massed in the lumen.

Fig. 3. — Large quantities of eggs in the gonads of a female (sample) killed on September 18, 1970 in full gametogenetic activity.

Fig. 4. — Glochidia at different stages of development, all from the mother gills of a female killed on November 20, 1970. An individual still enveloped in the egg membrane (*a*); a completely developed glochidium (*b*).

Fig. 5. — Sections showing glochidia in the mother gills of a female killed on November 20, 1970. Shell (*s*); thorny apex of the shell (*a*); hinge (*c*); embryo - mantle (*m*); embryo adductor muscle (*ma*); sections of the embryo byssus (*sb*); branchial groove (*b*).

Fig. 6. — Glochidia firmly attached to a fin (*f*) of *Tinca tinca* L. kept in 8% formalin. The fixing agent has spoilt the shells a little leaving the underlying embryo adductor muscle partially exposed.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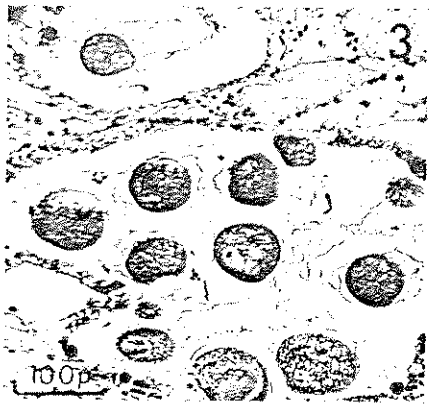
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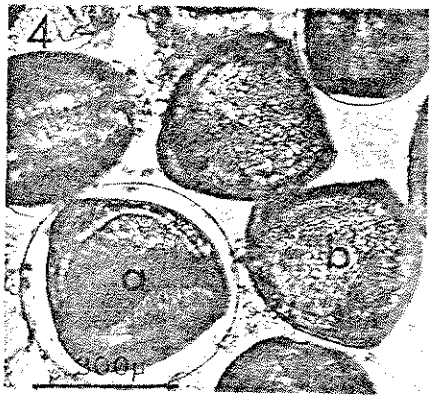
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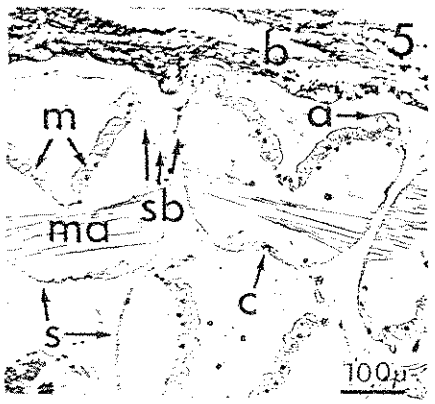
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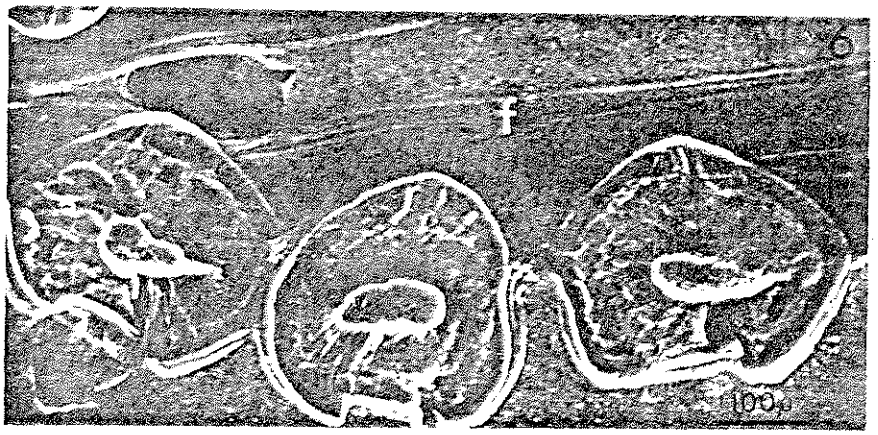
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eggs and well developed germinal follicles; however, a few female specimens still present relatively small follicles and consequently very few eggs.

September: all the individuals are in full sexual maturity and the follicles are so full of masses of gametes that they are easily detectable in histological sections and at the dissecting microscope (Figs 2, 3). Neither developing eggs nor glochidia are present in the mother gills.

October: great quantities of eggs and sperm are present in the lumen of the germinal follicles and batches of developing eggs are to be found in the gills.

November: specimens of both sexes show evident signs of follicle regression (reduced gametogenesis and follicle dimensions). In the mother's gills, which reach a thickness of about 1/2 cm, an enormous number of glochidia are present with a few developing eggs (Figs 4, 5).

December: the follicle and gill situation is very similar to that of the precedent month.

January 1971: the dissecting microscope reveals the regression of the germinal follicles which is confirmed at histological level. The female follicles now present a few oogons and oocytes and very rare eggs; in the lumen of most male follicles only a few ripe gametes are present; some, however, still show large quantities of sperm. In the mother's gills, glochidia are very abundant but there is no evidence of developing eggs.

February: conditions are very similar to those of the preceeding month.

March: in all specimens gamete production has almost ceased. The germinal follicles are still evident but empty, or almost empty. The mother gills contain glochidia only in the central area, the external sections are almost empty.

April: histological sections of the visceral mass of specimens of both sexes show the presence of extremely reduced germinal follicles nevertheless a slight gametogenetic activity is still present in female and male specimens. The mother gills are empty and no glochidia are present anywhere.

May-June: there are no substantial differences from the preceeding month.

July: the histological sections of samples collected in this month, present germinal follicles at an active stage of development. In agreement with the results of the previous year, there is evidence of sexual revival.

August: active gametogenesis occurs in specimens of both sexes.

The examination of samples collected at monthly intervals from August 1971 to April 1972 confirm our findings of the preceding year: developing eggs are to be seen in the gills towards the end of September;

gametogenesis becomes slower in the months of November and December; by the end of April the complete absence of glochidia is evident.

V. GLOCHIDIUM

Bibliographic data. According to various authors (ZHADIN, 1938, 1952; ADAM, 1960; NEGUS, 1966; BRODNIEWICZ, 1968), in the female *Anodonta* the glochidia developed during winter months are eliminated in spring, sometimes late in June. Similar conclusions were reached by HARMS (1909) who, however, reported in October the presence of well developed glochidia which persisted all through the winter.

We do not actually dispose of any other data so we have turned our attention to the process and the period of glochidium elimination in order to confirm the previous data or, eventually, to seek the possible reasons for the discordance. The study concerning the period of glochidium release is particularly interesting for two reasons: (i) to control and verify the accuracy of the biological-reproductive cycle as set forth in the preceeding section; (ii) to establish the correct meaning of the presence of fossil glochidium shells for the seasonal dating of river and lake sedimentation. In fact, the presence of fossil glochidia has already been used to define the seasonal fluvial and lacustrine sedimentations, assuming that spawning occurs only in spring. It is clear that, should this assumption prove incorrect, the conclusions would be invalidated (BRODNIEWICZ, 1968, 1969).

VI. GLOCHIDIA ON FISHES

Personal observations. In opposition to ADAM's statement (1960) that *Gasterosteus aculeatus* L. is the only glochidium host, we found that the glochidium of *Anodonta* is present on all the species of fish collected in lake Trasimeno, although in different degrees (Fig. 6).

In order to evaluate possible preferences of glochidia for given species of fish we undertook a first cycle of observations (February-November 1968) on a good number of specimens (25-50 of each) collected twice a month. The species examined from February to April 1968 were: *Lepomis gibbosus* L. (Pumpkinseed), *Perca fluviatilis* L. (Perch), *Esox lucius* L. (Pike), *Tinca tinca* L. (Tench), *Atherina boyeri* Risso (Sand smell-like fish), *Anguilla anguilla* L. (Eel) and *Scardinius erytrophthalmus* L. (Rudd).

The latter showed no evidence of glochidia. Glochidia were found in 53% of *Lepomis*, in 16.6% of *Tinca*, in 54.5% of *Perca* and in 37.5% of *Atherina*. Glochidia were also present in *Anguilla* and *Esox*. However, because of their low number and of the relatively small number of sample fish of the last two species, we did not calculate percentages.

Considering the total percentage of fish with glochidia in each month we obtained the following results: 75.4% in February; 58.6% in March and 28.4% in April. The glochidia found in the specimens examined were respectively 386, 380 and 121.

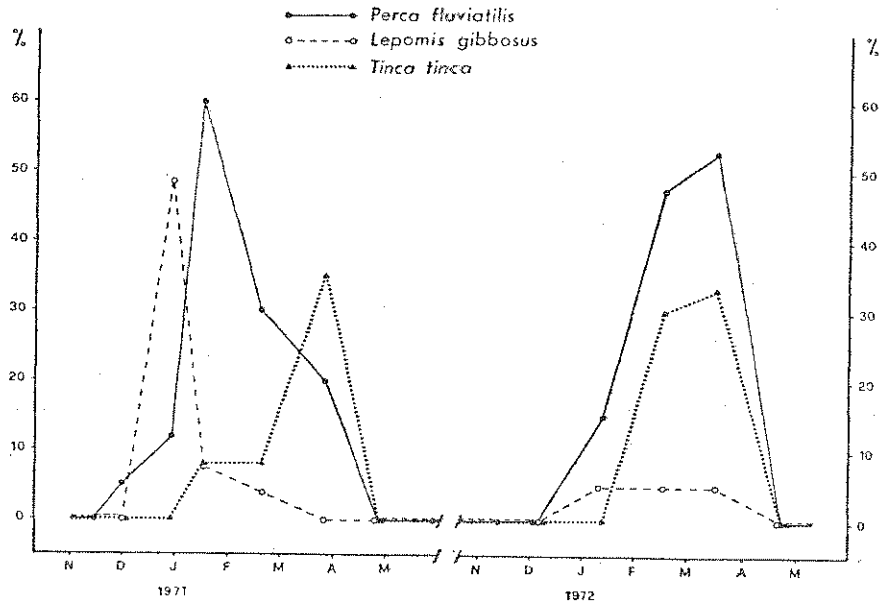


Fig. 7. — Percentages of glochidium infestation frequency on the most representative fish species found in lake Trasimeno. The irregular infestation frequency in the winter of 1970-1971 seems due to the irregularity of the environmental temperatures.

From May to November 1968 no glochidia were observed in any of the fish samples. These preliminary data on the monthly distribution of glochidia on fishes are in strict accordance with our direct observation of the reproductive cycle in adult *Anodonta* and expecially with the first appearance of glochidia in the mother's gills and with their total release. These results, at least apparently, are in agreement with those of ZHADIN (1938, 1952) and of BRODNIEWICZ (1968, 1969).

The second part of this investigation was carried out uninterruptedly from July 1970 to April 1972 and particular care was devoted to those fish that the previous partial analysis had shown to be most appropriate for the study of the phenomenon.

The species regularly examined were: *Perca fluviatlis* L., *Lepomis gibbosus* L., *Tinca tinca* L. (20-25 specimens each); data were occasionally obtained also from *Atherina boyeri* Risso and *Esox lucius* L.

The first glochidia were found in *Perca fluviatilis* L. (Figs 7, 8), precisely in 2% of the individuals examined at the end of November. No glochidia were observed on the other species collected during the same period. In December glochidia were present on 29% of all the fish

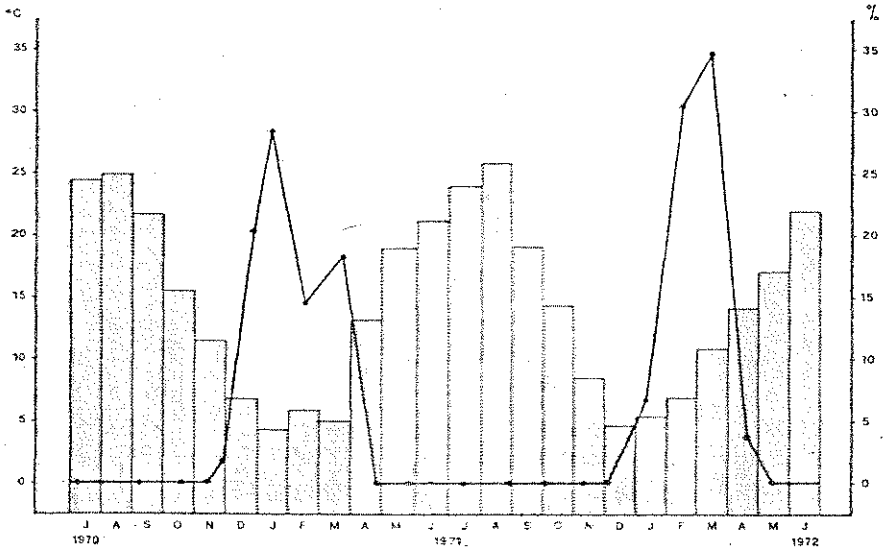


Fig. 8. — The graph showing the number of individuals carrying glochidia (continuous line) is superimposed to the line indicating temperatures from July 1970 to July 1972. The seasonal expulsion of glochidia is very likely connected with the environmental temperature. The sudden decrease in expulsion of glochidia during February 1971 seems related to the extremely variable temperature registered in the winter of 1970-1971.

examined. In detail: 12% in *Perca*, 48.5% in *Lepomis*, 20% in *Esox* and 10.5% in *Atherina*. In December there were no glochidia on *Tinca*.

The general percentage was still 29% in the next month (January 1971), with a substantial increase in *Perca* (60%), a decrease in *Lepomis* (7.6%) and first appearance in *Tinca* (8%).

In February 1971 the total percentage of glochidium decreases (14.5%), particularly in *Perca* (30.4%) and in *Lepomis* (4%). *Tinca* maintained the same percentage (8%), whereas an increase occurred in *Esox* (33.3%).

At the end of March 1971 (25.III.1971) the total percentage was 18.3% (Fig. 8). In that period glochidia were found on 20% of *Perca*, on 35% of *Tinca*, on 50% of *Esox* and on 15% of *Atherina*. *Lepomis* instead was already devoid of glochidia.

In the next collection (April 26, 1971), as well as in all the other

monthly collections till the end of December, no glochidia were found attached to the body of any of the fish examined.

In January 1972 glochidia were again present on 6.7% of all the fish examined: 15% of the *Perca* were infested, 5% of *Lepomis* but no glochidia were to be seen on *Tinca*.

In February the total percentage increased to 30.6%: 47.6% of *Perca* were infested, 30% of *Tinca*, 50% of *Atherina* but no glochidia on *Lepomis*.

In March the average percentage of infested fish was slightly higher (34.7%): 52.9% of *Perca*, 33.3% of *Tinca*, 5% of *Lepomis* and 50% of *Atherina*.

In April the results obtained were similar to those of the same month of the preceeding years, except for *Atherina* where glochidia were still present on 15% of the specimens.

VII. ATTACHMENT OF GLOCHIDIA TO THE FISH BODY

In lake Trasimeno the glochidia of *Anodonta* were found attached not only to the gills of fishes, but also to the lips, the fins and the parts of the body where the absence of scales made attachment easy.

The various parts of the fish body are infested in a different measure. In order to establish which parts of the body are mostly infested we counted the glochidia found on each species of fish and then drew the percentages corresponding to the fins and gills (Fig. 9).

VIII. GLOCHIDIUM MORPHOLOGY

Bibliographic data. Though many authors (LEA, 1958; BRAUN 1878; SCHIERHOLTZ, 1888; LILLIE, 1895; FAUSSEK, 1895, 1902, 1903; HARMS, 1907a, 1907b, 1909; HERBERS, 1913; AREY, 1921, 1923, 1932a, 1932b, 1932c; ALIEV, 1962; BRODNIEWICZ, 1968; ZS.-NAGY & LABOS, 1969), have described the structure of glochidia and the various phases of their development, little is known about the morphology of the embrionic shells and of the structures for attachment to fish (INABA, 1941)(1).

We have studied the valves of many glochidia with the scanning microscope and in particular the structure and arrangement of the spines (teeth) of the apical hooks (thorny processes) for a better understanding

(1) While this paper was being prepared, WOOD (1974a, 1974b) published two works on glochidium of *A. cygnea* in which she confirms the information given by preceeding authors. Moreover she confirms the permanence of mature glochidia in mother demibranchs from October to May but does not specify anything about the absence or presence of glochidia on fishes during the same period.

of the mechanism of attachment to fish. Our attempt is to lay the groundwork for a future study of glochidia belonging to populations of *Anodonta cygnea* L., both in Italy and other European countries, and of other species of Unionidae, with the purpose of finding eventual additional parameters for the evaluation of specific differences (GIUSTI, 1973).

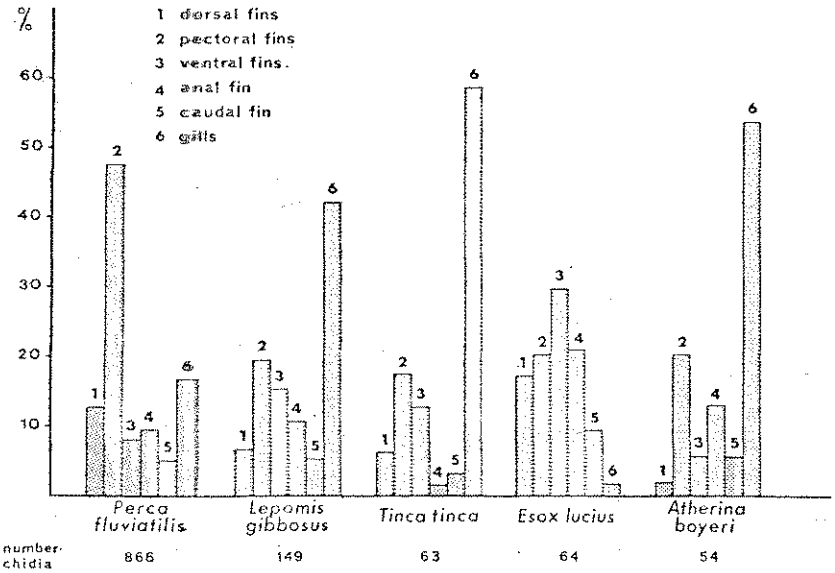


Fig. 9. — Graph showing the percentages of glochidium infestation in the different parts of the fish body. During the infestation period, of the 615 *Perca fluviatilis* examined 167 were seen to be infested and 53 *Lepomis gibbosus* out of 173, 39 *Tinca tinca* out of 140, 7 *Esox lucius* out of 18, 31 *Atherina boyeri* out of 99 (the data concerning these two last species were occasionally gathered).

The shape of the glochidium (Figs 10-12) is triangular and unequilateral as described by BRODNIEWICZ (1968) for the glochidium of *Anodonta* in Poland. The height is about 400 μ. The two valves are of the same size, kept together by a ligament. The external surface is covered with a great number of small villi-like processes (Figs 13-15). At the base of the shell these small formations are more numerous and distributed at random. In the central area of the shell they are less instead frequent and shorter, ranged in parallel rows; at the apex they are fewer and shorter still.

Small niches are scattered all over the surface (Fig. 15). Fragments of valves show that the glochidium shell consists of two layers: the external which is but a thin pellicle bearing the above mentioned processes

and the internal which is a crystalline like formation with numerous holes. In fact, the niches found on the external surface are formed by the pellicle covering the holes of the internal layer (GIUSTI, 1973).

In both valves the structure for attachment located at the anterior end consists of a long pointed process with numerous teeth (thorns) on its superior face (Figs 16-21). They are of different lengths: the central ones, ranged in two lines, are long and thick, the lateral very short and thin. A large area at the apex of the valves surrounding the base of the thorny processes is provided with many small thorns which become progressively smaller towards the periphery of the area.

When a glochidium attaches itself to a fish the thorny process of the valve turns inward so that the thorns of the upper end penetrate into the fish tissues (Fig. 6).

IX. CONCLUSIONS

Considering the data obtained by means of this research, the reproductive cycle of *Anodonta cygnea* L. in lake Trasimeno is now rather well known. The histological data of the genital tissue of specimens collected every month during 2 years, the direct observation of the mother gills for the evaluation of the presence of glochidia and finally the determination of the presence of glochidia in the various structures of the body surface of the commonest fishes of the lake, demonstrate a precise and well defined seasonal reproductive cycle of this fresh water mussel.

Fig. 10. — Valve of a glochidium shell from the mother gills of a female *Anodonta*. The triangular valve is asymmetrical because of the uneven development of the two longer sides.

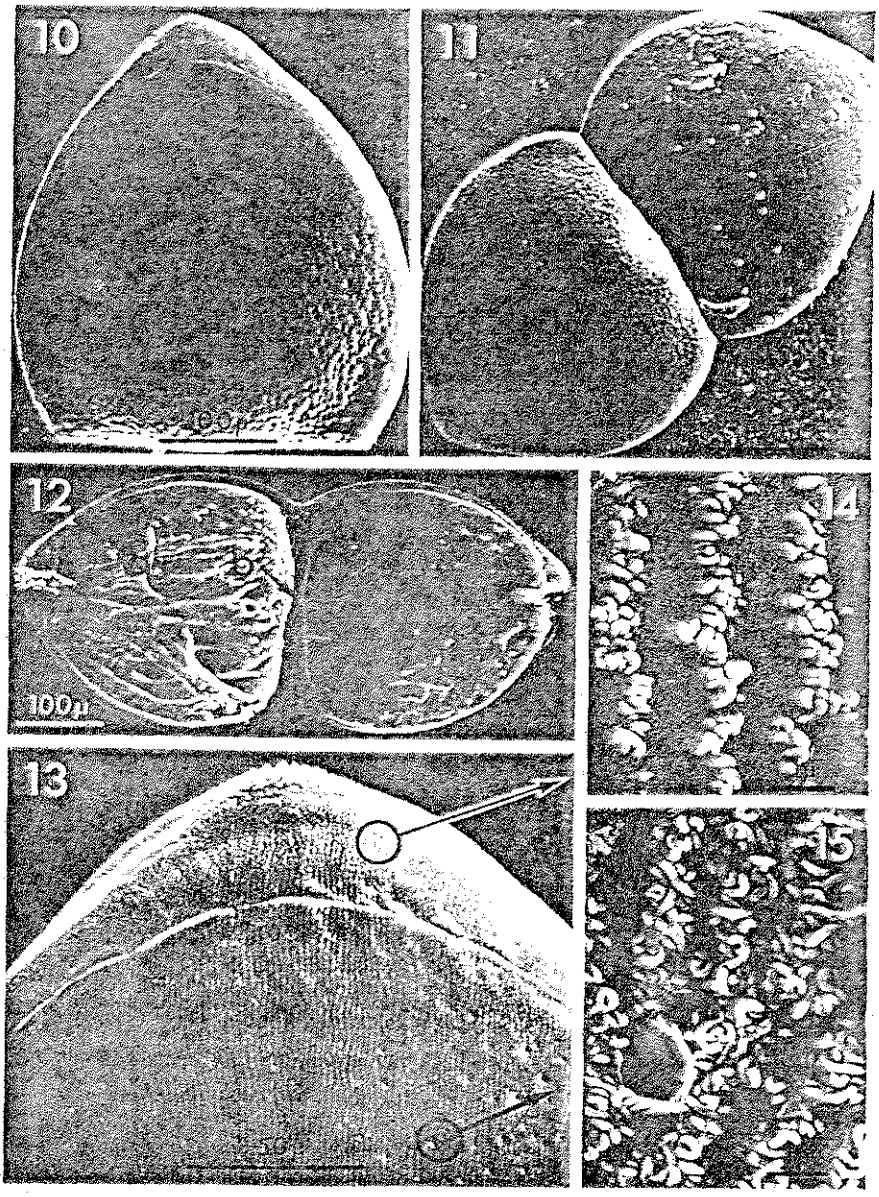
Fig. 11. — The two valves of a glochidium shell are identical.

Fig. 12. — The inner side of a glochidium valve. The thorny apex (*a*); the hinge (*b*).

Fig. 13. — Apex of a glochidium valve. Note the niches formed by the depressions in the external pellicle over the holes in the internal crystalline layer; they are limited to the sub-apical zone circumscribed by a clearly visible groove. The peripheral zone is devoid of niches. The irregularities in the pellicle that covers the outer surface of the valve are arranged in rows parallel to the major axis of the valve. The two circlets mark the areas magnified in Figs 14 and 15.

Fig. 14. — External surface of the embryo membrane covering the valves. In the peripheral zone marked with a circlet in the upper corner of Fig. 13 the villosity is remarkably reduced.

Fig. 15. — External surface of the membrane that covers the valves. In the central zone of the valve — marked with a circlet in Fig. 16 — rows of well developed villosities are to be seen. The niches are formed by the depression of the external pellicle covering the holes in the crystalline layer which forms the internal frame of the valve.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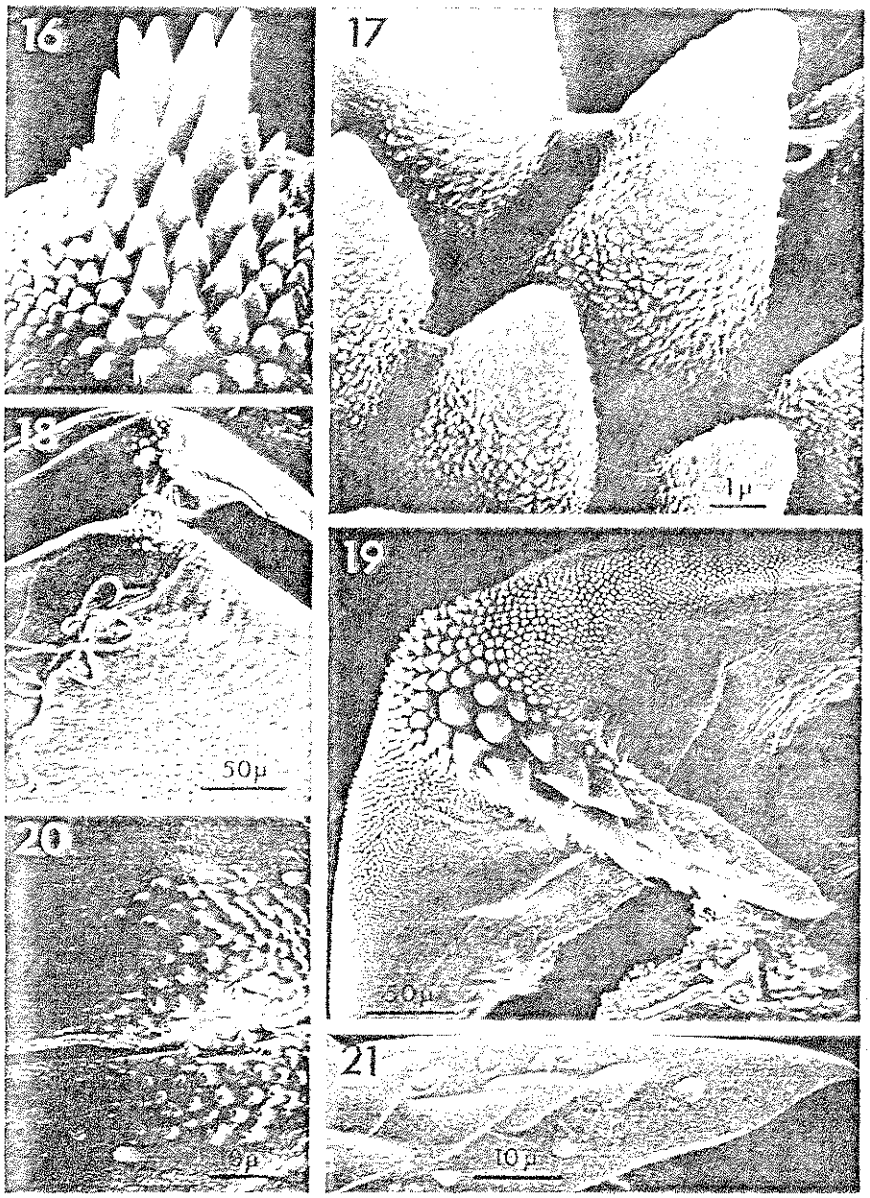

Fig. 16. — The apex of a glochidium shell with its thorns; the long central thorns are pointed surrounded by smaller ones with rounded tips.

Fig. 17. — The side thorns round the apex show the same villosity as the external pellicle of the valves.

Fig. 18. — The long slender filament known as « embryo byssus » which rises from the anterior opening of the valves.

Fig. 19. — The apex of each valve of a glochidium shell penetrates into the cavity by means of a long pointed appendix bearing many thorns on its upper surface.

Fig. 20. — When the shell is closed the thorny zones of both valves turn inwards facing each other like teeth enabling the glochidium to attach itself firmly to its host.

Fig. 21. — A detail of the pointed appendix on the apex of the valves.

Gametogenesis occurs all the year around but from April to July it is very slight and does not result in the formation of ripe gametes. In fact, during this period adult larvae (glochidia) were never found in the mother's gills nor attached to body surfaces of fish. In the second half of the summer, gametogenesis proceeds at a fast rate; germinal tissues are well developed and, particularly in males, ripe gametes are often found. In late September specimens of both sexes are fully ripe and in October the female gills (demibranchs) are full of developing eggs and young larvae.

In November the first glochidia appear in the gills, fins and other parts of the body surface of fish; this condition persists throughout the winter. The elimination of glochidia (spawning) from the gills of the mussels seem to be strictly correlated to temperature. An irregular percentage of glochidia found attached to fishes (Figs 7, 8) seems to run parallel to the irregular pattern of the water temperature.

The reproductive cycle of *Anodonta cygnea* L. in lake Trasimeno lasts therefore from July to March, whereas the period of attachment of glochidia to fish lasts from November to April.

Our data do not agree with those reported for *Anodonta* in other European areas, according to some authors (LEFEVRE & CURTIS, 1910; COKER et al., 1921; ADAM, 1960; NEGUS, 1966) the reproductive cycle proceeds uninterupredly from late summer to the end of spring; others, instead, affirm that the reproductive activity is much shorter: from August to the end of October (HARMS, 1909; ZHADIN, 1938, 1952; BRODNIEWICZ, 1968).

Unfortunately, it is not possible to furnish a reliable explanation of the discrepances between the results of the several authors nor between their data and ours. It seems however evident that, for a careful evaluation of the duration of the reproductive cycle of this particular species, certain parameters should always be considered: we refer, in particular, to the necessity of evaluating the exact period of appearance of glochidia on fishes in order to be able to draw final conclusions regarding the duration of the reproductive cycle.

The reason why some authors (LEFEVRE & CURTIS, 1910; COKER et al., 1921; ADAM, 1960; NEGUS, 1966) report a long period of reproductive activity lies in the fact that they have examined only the mussels and particularly the eggs and developing larvae in the mother's gills. Others (HARMS, 1909; ZHADIN, 1938, 1952; BRODNIEWICZ, 1968) describe only a limited spring spawning because they did not pay attention to a probable previous elimination of glochidia nor did they study the presence of glochidia on fish during the winter months. BRODNIEWICZ (1969) reporting on the spring spawning of glochidia, mentions also occasional limited spawning during the preceeding winter months. How-

ever, not having specified whether these data were obtained from field or laboratory studies, comparisons between her observations and our data are useless. If we combine BRODNIEWICZ's data with those of HARMS, according to which glochidia taken from the gills of mussels during winter are able to attach themselves to the fish epidermis, we may advance the hypothesis that in other European areas also both the phase of glochidium elimination (spawning) and the beginning of fish infestation are very similar to the phases reported for our *Anodonta* of lake Trasimeno.

It is very important to establish whether our hypothesis is correct or whether owing to the cooler climate of northern and central European localities there really exists a delay in gametogenesis and spawning. If our hypothesis is valid, several conclusions concerning seasonal dating of fluvial and lacustrine sedimentation, based on the presence of fossil glochidium valves should be reconsidered, as some of them have been drawn from the assumption of one single spring spawning (BRODNIEWICZ, 1968, 1969).

Our data demonstrate a peculiar reproductive cycle and therefore present difficult problems. From a comparative point of view two facts are of particular interest: summer gametogenesis with an autumn winter spawning, and the duration of the reproductive cycle.

From the physiological point of view as has been clearly demonstrated in marine bivalves: LOOSANOFF, 1942, 1945, 1961; CHIPPERFIELD, 1953; RENZONI, 1961a, 1961b, 1961c, 1962) the occurrence of spawning during the period of maximum phytoplancton bloom and therefore of maximum productivity is explained by the higher availability of food for the young larvae; for *Anodonta* the explanations and the considerations should be quite different becouse the peculiar modality of life of the larvae should be taken into account. Glochidia develop at the expense of the yolk material and remain in the mother gills of the « parent » without any particular demand on it (HARMS, 1909). Once the glochidium has left the « parent » and reached the host (the fish), it does not need any planktonic food, but uses the small amount of material from the digestion of the epidermal cells of the fish (HARMS, 1909).

Shortly after, the glochidium abandons the host, falls to the bottom and starts its autonomous life.

The question that immediately arises is: why such a long period of « gestation » in the mother gills and of « quiescence » attached to the host body? It is difficult to formulate an answer. One of the most reasonable hypothesis seem to be the necessity of spending a given period attached to the body of the fish before reaching the age when an autonomous life is possible and when the fragile glochidium shell has greater chance of maintaining its integrity even after heavy waves and current movements. Another possible hypothesis is that parasitism is secondary

to a simple phenomenon of phoresis due to the need of using fish to reach and colonize other niches in the same area.

As to the preference of glochidia for certain species of host fishes our data give no evidence of specificity between the glochidium and the fish. All the most common species of lake Trasimeno acted as hosts for the mussel larvae, though sometimes to very different degrees.

Since fish infestation is rather casual, as is the number of glochidia that can have the possibility of attaching themselves to the various parts of the body of fishes, and since the different behaviour of the various species of fish may have a direct influence on the glochidia-fish contact, the percentages of infestation are likely to undergo such variatios as to be considered unworthy of particular attention. *Perca fluviatilis* which lives on plancton is attached by more glochidia than the detritivorous and bottom living *Tinca tinca*. A possible explanation for this may lie in the fact that fish of the former species, during certain periods of the year, probably move towards the muddy bottom and, while preying upon smaller specimens, come into contact with the bivalves which discharge their load of mature larvae upon them. Such an interpretation is supported by the observations of MORETTI (personal communication) who affirms that in the stomach of some *Perca fluviatilis* of lake Trasimeno, larvae and residuals of larvae of *Trychoptera* have been found. Such larvae usually live in the sandy and muddy bottoms of that lake.

Another surprising fact is the high concentration of glochidia in typically predatory fishes, such as *Esox lucius*. In our view the pike, and other ambush predators, remain quiet for long periods near the bottom and in so doing have many opportunities of coming into contact with *Anodonta* ready to eliminate glochidia.

Observations on the structure of the glochidium shell, such as those conducted on the Unionidae of the U.S.A. and Japan (LEA, 1958; INABA, 1941) are of extreme interest for systematic purposes.

We believe that our scanning microscope study of the fine morphology of the glochidium shell and of the various structures for the attachment of larvae to the host if extended to glochidia of other populations will be of great help for the solution of the many problems related with the taxonomic position of the various species of European Unionidae.

SUMMARY

The different phases of the biological cycle of *Anodonta cygnea* L. living in lake Trasimeno (Central Italy) are described in the present paper.

Researches have been carried out on histological sections of germinal

tissues and gills of specimens of both sexes sacrificed every month and verified by following the course of the parasitic phase of life of glochidia on the fish of the lake. Moreover, the various species of fish heavily infested by glochidia have been identified and the glochidium infestation frequency has been determined.

The structure of the glochidium shell has been studied with the scanning microscope for a better understanding of the mechanism of attachment to fish and to collect more information in order to compare the species of *Anodonta* from lake Trasimeno with those of other parts of Europe.

RIASSUNTO

Nella presente nota gli Autori descrivono le diverse fasi del ciclo biologico riproduttivo della *Anodonta cygnea* L. vivente nel lago Trasimeno.

L'indagine è stata condotta su sezioni istologiche di porzioni di tessuto goniale e di branchie prelevate da individui di ambo i sessi catturati mensilmente ed è stata controllata seguendo il decorso della fase di vita parassitaria dei glochidium sui pesci del lago.

Sono state inoltre identificate le specie ittiche più infestate dai glochidium e sono stati definiti gli indici di frequenza dei glochidium su ciascuna di esse.

Con l'aiuto del microscopio elettronico a scansione gli Autori hanno, infine, attentamente esaminato la conchiglia dei glochidium alla ricerca di caratteri utili per una migliore definizione della specie di *Anodonta* in esame e per giungere ad una più precisa comprensione del meccanismo mediante il quale il glochidium si attacca al pesce ospite.

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