The life cycle and some other biological details of the fresh-water snail Physa fontinalis (L.)

by

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CONTENTS

1. INTRODUCTION

Particulars on the life history of fresh-water pulmonates are generally scarce, especially in Europe, notwithstanding the fact. that they can as a rule be collected without much difficulty.

Most fresh-water snails act as the first intermediate hosts of digenetic trematodes, worms which may cause dangerous diseases like schistosomiasis and liverrot to man and cattle. Because of the direct interest for their object of study a number of parasitologists have traced the life cycles of the Lymnaeidae: *Lymnaea truncatula* (Müll.) (WALTON, 1918; WALTON & JONES, 1926), *Lymnaea brazieri* (Smith) (ROSS & MCKAY, 1929), *Fossaria modicella* (Say) (VAN CLEAVE, 1935), *Acella haldemani* (Desh.) (MORISSON, 1935), *Stagnicola emarginata angulata* (Sow.) (CORT, MCMULLEN, OLIVIER, and BRACKETT, 1940), *Lymnaea stagnalis* var. *lillianae* F. C. Baker and var. *sanctae mariae* Walker and *Stagnicola palustris elodes* (Say) (BRACKETT, 1940), of the Planorbidae: *Australorbis glabratus* (Say) (LUTTERMOSER, 1943) and finally of the Physidae: *Physa parkeri* Currier (CORT, OLIVIER, and MCMULLEN, 1941).

Other investigations made us familiar with the life histories of *Lymnaea columella* (Say) (BAILY, 1931), *Myxas glutinosa* (Müller) (FELIKSIAK, 1939), *Lymnaea peregra* (Müller) (BOYCOTT, 1931) and *Stagnicola catascopium* (Say) (MCE. KEVAN, 1943).

A survey of these observations is given in table 1. It is shown, that the life span of the mentioned pulmonates varies from a few months to 3—4 years. The greater part of the studies considered were carried out in nature. The results of experiments in aquaria are much less convincing. DEWITT (1954) reported on *Physa gyrina* Say that although the life span under natural conditions amounted to 12 to 13 months, aquarium reared specimens under favourable

Species	Author	Year	Life span etc.	[1])	Country
Lymnaea brazieri (Smith)	Ross & McKay	1929	1 year 2-3 gen./year	A, F	Australia
L. columella (Say)	Baily	1931	abt. 7 months sev. gen./year	A	USA
L. peregra (Müller)	Boycott	1936	2 gen./year	A	England
L. stagnalis (L.)	Hazay	1881	3 years	A ? F	Hungary
	Künkel	1908	abt. 2 years	A	Germany
	Holzfuss	1914	14-22 months	A	Germany
	Schodduyn	1925	3-4 years	A	France
	Boycott	1936	1 year	F	England
	Wesenberg-Lund	1939	abt. 1½ year	F	Denmark
L. stagn. lillianae F. C. Baker	Brackett	1940	13-16 months	F	USA (Wisc.)
L. stagn. sanctaemariae Walker	Brackett	1940	13-16 months	F, A F	USA (Wisc.)
L. truncatula (L)	Walton	1918	min. 17 w./gen.		England
	Walton & Jones	1926	3 gen./year	F, A	(Wales)
Acella haldemani (Desh).	Morrison	1935	1 year	F	USA (Wisc.)
Fossaria modicella (Say)	Van Cleave	1935	2 gen./year; 4 & 8 months	F, A	USA (Wisc.)
Myxas glutinosa (Müller)	Feliksiak	1939	springg. abt. ½ yr; wintering gen. abt. 1 yr	F, A	Poland
Stagnicola catascopium (Say)	Mc.E. Kevan	1943	2 gen./year	(A)	Scotland
St. emarginata angulata (Sow.)	Cort, McMullen, Olivier & Brackett	1940	13-16 months	F	USA (Mich.)
St. palustris elodes (Say)	Bracket	1940	abt. 1 year	F	USA (Wisc.)
Australorbis glabratus (Say)	Luttermoser	1943	1½-2 years	A, F	Venezuela
Physa parkeri (Currier)	Cort, Olivier & McMullen	1941	13-14 months	F	USA (Mich.)
Physa gyrina (Say)	DeWitt	1954	12-13 months 2 gen./year [2])	F	USA (Mich.)

[1]) F = field; A = aquarium; (A) = a cooling water reservoir of a factory with a rather high temperature. [2]) according to a private communication.

Table 1. Survey of the life histories of a number of fresh-water pulmonates.

conditions could be kept alive for about 700 days. Such an observation clearly demonstrates the differences between field and aquarium observations. The example of *Lymnaea stagnalis* (L.) is interesting in this respect. According to BOYCOTT (1936) all *Lymnaea*-species are annuals, with a life of 9—15 months. WESENBERG-LUND (1939) came to the same conclusion and he remarked that in Denmark *L. stagnalis* does not survive 2 winters. HAZAY (1881) found that this species becomes 3 years old and is sexually mature after about 3 months. The investigation was carried out in more or less natural circumstances, but the method followed is not quite clear. Animals from the same capsule grew much faster in a pond than in an aquarium. KÜNKEL (1908) could keep aquarium-reared specimens alive for about 25 months; these were mature after 9 months (emerged late in summer). In laboratory-raised snails (HOLZFUSS, 1914) the parent generation lived about 22 months, whereas the filial generation died after 14 months. They were adult after 3 months. DYBOWSKI (1900) noticed copulation among snails 143 days after they had hatched in an aquarium. He, too, demonstrated the differences in size of shells with 7 whorls of *L. stagnalis* in nature as compared with those reared by him. Curiously enough, according to SCHODDUYN (1925), the snails were not mature before about 22 months and died after more than 2 years. His conclusion is, that the large animals found in nature are 3—4 years of age. It is obvious that this conclusion is premature, as the behaviour of his aquarium-snails differs considerably from the normal course. For the same reason there is some risk in concluding that the natural duration of life of *Australorbis glabratus* (Say) is 1½—2 years, just by comparing the size of the largest natural specimens with laboratory-reared ones (LUTTERMOSER, 1943).

Therefore in the investigation described here the life history and other biological phenomena of *Physa fontinalis* (L.) were studied in the field.

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2. MILIEU, MATERIAL AND METHOD

As far as necessary and practicable, animals were collected with a maximum frequency of once a fortnight in a small ditch in the Botshol polder (province of Utrecht, municipality of Abcoude-Proosdij) and incidentally at other places. A general description of Botshol has been published by WESTHOFF (1949).

The ditch is situated in a pasture, of which the N.W. side is limited by the lake the Grote Wije and the S.E. side by a smaller pool with fresher water. The drainage of the area is conducted via the pool and a system of ditches, whereafter the superfluous water is discharged by a small pumping-engine into the Grote Wije.

The ditch has only an open connection with the pool via a culvert, but the Grote Wije has a predominating influence on the composition of the water, as may be seen from table 2.

Date: 17-10-'53 3 p.m.	temperature ° C.	specific conductivity Ohm^{-1}/cm^{-1} at 18° C.	calcium content ° G.H.	magnesium content ° G.H.	chloride content mg $Cl^{-}/1$	depth
Grote Wije	13.6	2032	8.9	9.6	608	—
Ditch (at A)	12.3	1860	11.4[1])	9.2	528	abt 1 m
Ditch (at B)	12.8	1870	11.2[1])	9.5	541	10-20 cm
Pool	13.5	247	9.4	6.8	341	—

[1]) The high Ca-content possibly indicates the influence of manuring of the pasture.

Table 2. Data on the composition of the water at the habitat at Botshol.

In the part, where *Physa* was collected (A), flora and fauna deviated strongly from those on the other side of the culvert, near the pool (B). Therefore the chemical data are dealt with separately though there is much similarity. The Cl'-content may be much higher in summer, up to about 900 mg/1. The pH, determined on different dates, showed little variation, viz. 6.8—7.2. The water is fairly clear, but in winter it is sometimes a milky turbid in consequence of the decay of the plants.

From May to the end of October the surface at A is more or less covered with *Hydrocharis morsus-ranae* L. and large quantities of the alga *Rhizoclonium hieroglyphicum* (C. A. Agardh) Kützing, *Lemna trisulca* L. and *Potamogeton pectinatus* L. being present to a less extent. The margins are grown over with *Nasturtium officinale* R. Br., *Mentha aquatica* L., *Alisma plantago-aquatica* L., *Sparganium ramosum* Huds., *Galium palustre* L., *Iris pseudacorus* L., *Typha angustifolia* L., *Comarum palustre* L. and *Lysimachia nummularia* L.

In winter the vegetation is scanty, and except the decaying parts of the plants mentioned only *Lemna trisulca* is left. The bottom is practically without any vegetation and consists of peat.

In part B the alga *Vaucheria dichotoma* C. A. Agardh dominates and covers the bottom as a carpet 1—2 cm thick. Only few specimens of *Hydrocharis* are found there, and along the sides occur e.g. *Solanum dulcamara* L. and *Eupatorium cannabium* L.. The layer of algae proved to be a suitable biotope for gastropods; the numbers in table 3 relevant to B were collected in a felt-like piece of algae of perhaps 1 dm^2. In this table the mollusc faunas of the two biotopes are compared.

	A	B
Valvata cristata Müller	—	404
Bithynia tentaculata (L.)	13	—
„ *leachii* (Sheppard)	25	19
Physa fontinalis (L.)	48	—
Lymnaea palustris (Müller)	—	1
„ *ovata* Drap.	27	—
„ *stagnalis* (L.)	42	—
Planorbis corneus (L.)	3	—
„ *carinatus* (Müller)	24	—
„ *vortex* (L.)	4	2
„ *vorticulus* Troschel var. *chartea* Held	212	6
„ *contortus* (L.)	4	4
„ *crista* (L.)	—	86
„ *complanatus* (L.)	82	73
Acroloxus lacustris (L.)	36	—
Pisidium species	6	6
Total number of specimens	526	601

Table 3. List of the molluscs, collected 28-9-1953 in the parts A and B of the ditch in Botshol.

In spite of the conformity of the chemical composition of the water the differences in the molluscfauna are evident. Strikingly, in the shallow biotope B the small species dominate.

The collection of quantitatively comparable material in a water biotope is not simple, if we are not concerned with sessile animals (see e.g. KUIPER, 1947, WHITEHEAD, 1935).

Physa fontinalis (L.) predominantly inhabits floating water plants. Their position in the water depends on the direction of the wind, and the density of the snail population is determined by the density of the vegetation on the spot. Collecting a drum of plants (about 7½ liter), and separating the molluscs from it by sieving and rinsing, proved to be a reasonable method. Samples taken in this way practically exclude the influence of the observer and are suitable for statistical treatment. In 1953 and in the beginning of 1954 this method was applied. Starting 24-5-1952 the samples were taken in the same way, with the only difference, that less attention was paid to the size of the samples. The shells of *Physa fontinalis* (L.) were measured and the plants were searched for egg capsules, which are easily recognizable with the naked eye. The number of eggs was determined microscopically, paying attention to details like e.g. the occurrence of twins.

3. LIFE CYCLE

a. Spring and wintering generations.

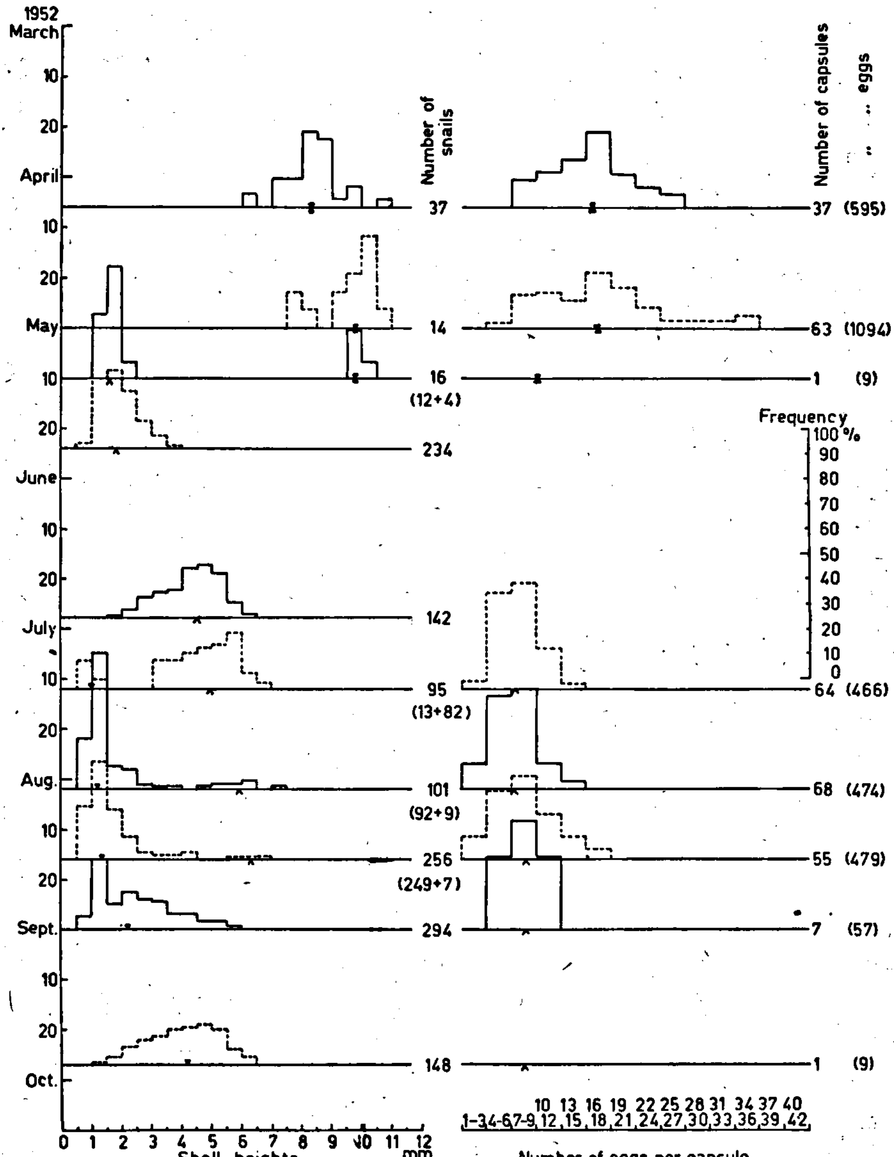
The life history can easily be reconstructed on the basis of the shell heights. Graphs 1 and 2 (left-hand part) represent a number of frequency curves for 1952 and 1953, in which the shell height in groups of 0.5 mm has been plotted against the frequency in percent. The average values of the heights are indicated.

In the early spring only adult animals of a certain generation (I) are present. About the beginning of May the first young ones of a new generation (II) see the world; in the later captures of May their number increases rapidly, whereas the adults (I) disappear.

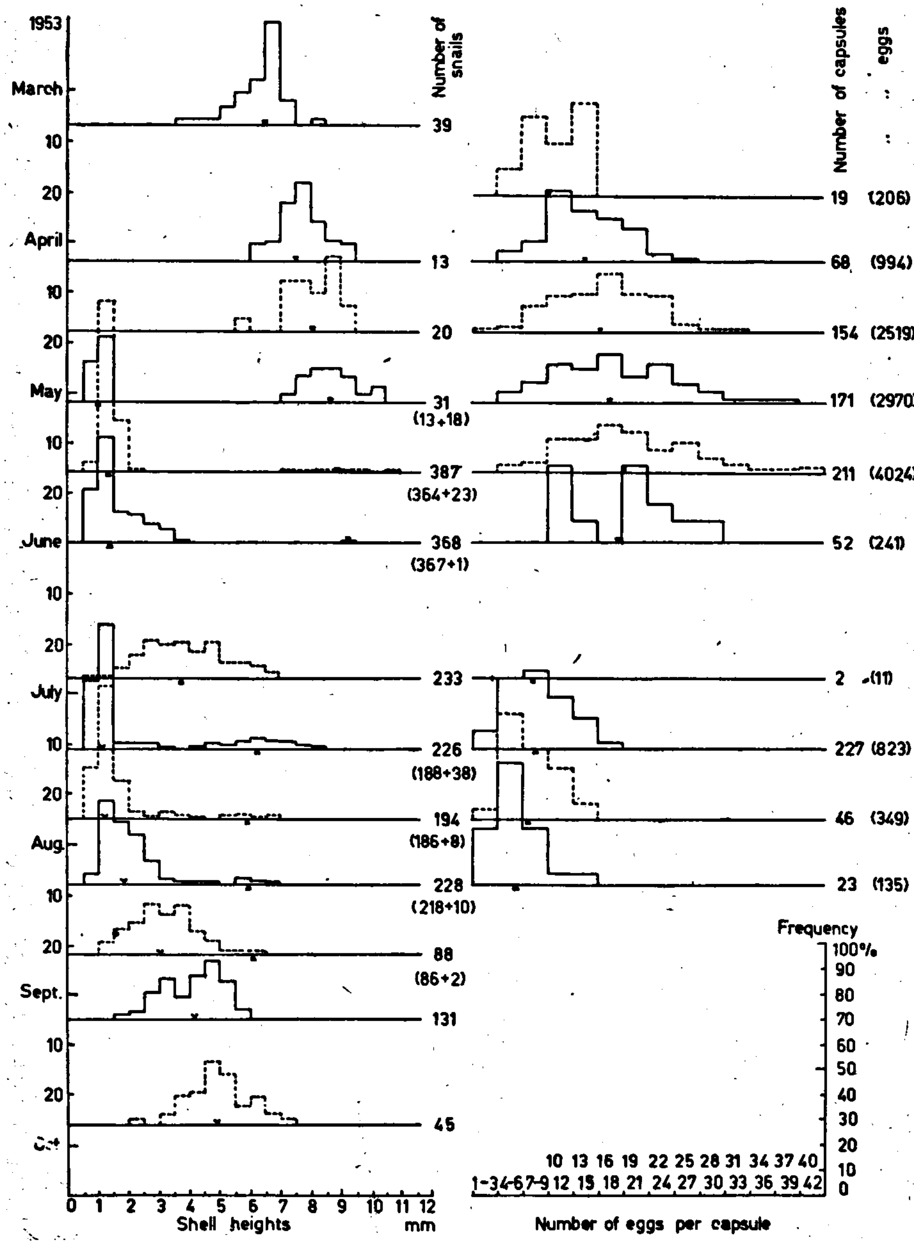
Thus, on 30-5-1953 only one full-grown specimen was found alive. On 10-5-1952 4 adult snails were collected, but on 24-5 not a single specimen was found. On 26-5-1951 still 108 full-grown animals were observed, so in that year the last of these presumably died in the beginning of June.

The juvenile snails (II) grow rapidly, while young ones still emerge (in the groups 0.5—1.0 and 1.0—1.5 mm). At the end of June all eggs, deposited by the previous (wintering) generation (I), are hatched: animals of about 1 mm are no longer collected.

About the beginning of July again freshly hatched juveniles are noticed. Their number rapidly increases in the course of this month and in August. Apparently a new (wintering) generation (III) is concerned here. Meanwhile the *Physa*'s of the spring generation (II) prove to have grown at a high rate, but they strongly decrease in quantity. From the shape of the successive frequency curves it may be deduced that the adults (II) disappear; firstly, there is no longer a gap in the graphs of the spring and the wintering generation, secondly, the maximum height diminishes and thirdly, capsules are no more found, in any case not in 1953 (see discussion of the capsules,



Graph 1. Frequency of the shell heights and of the numbers of eggs per capsule (1952).



Graph 2. Frequency of the shell heights and of the numbers of eggs per capsule (1953).

4a). In mid-August the juveniles of generation III are well grown, and few, if any, young snails emerge any more. This generation winters and dies the next spring after the breeding period, by which the annual cycle is closed.

Thus two generations occur each year, a spring generation (from early in May till the middle of August) and a wintering generation (from the close of June till the end of May of the next year). This result is in good agreement with FELIKSIAK's observations (1939) for *Myxas glutinosa* (Müller) in Poland in the field. According to CORT, OLIVIER and MCMULLEN (1941) *Physa parkeri* Currier in Michigan (U.S.A.) produces only one generation in nature, whereas DEWITT (according to a private communication) found two generations per year in *Physa gyrina* Say. The temperatures there resemble those prevailing in Poland.

b. Influence of temperature on rate of growth.

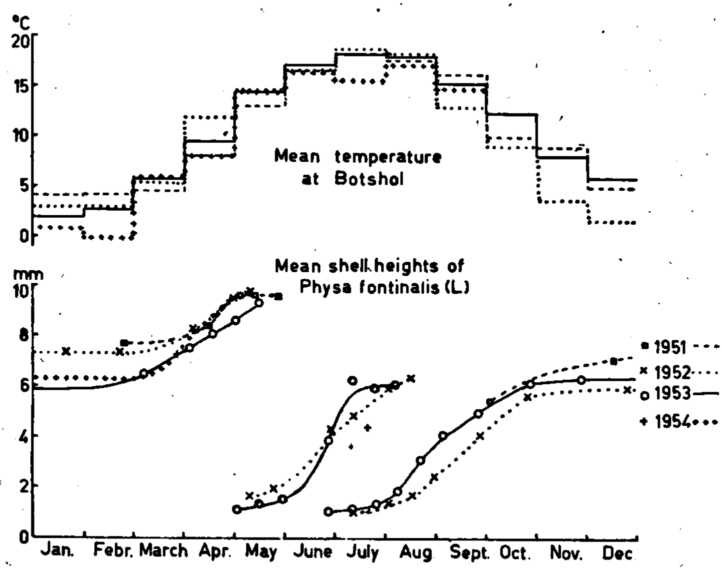
The mean heights as a function of the time are represented in graph 3. The curves give an impression of the growth of *Physa fontinalis* (L.). They are not true growth-curves as given by e.g. BAILY (1931) or BACKMAN (1943), who studied the growth of individuals, whereas here the behaviour of a group is dealt with. In our case the steady hatching of juveniles and the extreme mortality of the young snails influence the pattern.

It may be concluded that in winter growth practically stops. The wintering generation of 1951 e.g. showed a rise of the average values of about 0.02 mm per week from the middle of December till mid-February. From mid-November until the middle of February 1953 this figure amounted to about 0.01 mm per week. In the winter 1953/1954 the situation was nearly identical. Similar low rates of growth during the winter have been established by many workers, e.g. for *Loligo vulgaris* Lam. (TINBERGEN & VERWEY, 1945), *Eriocheir sinensis* H. Milne Edwards (KAMPS, 1937), *Lymnaea emarginata angulata* (Sow.) (CORT, MCMULLEN, OLIVIER, and BRACKETT 1940), *Lymnaea stagnalis lillianae* F. C. Baker (BRACKETT, 1940), and various *Sphaerium* spec. (THIEL, 1929 [1])). The temperature has a minimum in this period; the mean maximum air-temperature in this time is $< 6^\circ$ C., just like the water temperature.

WREDE (1928) observed, that at 4—6° C. *Physa fontinalis* (L.) is contracted and motionless, so that feeding and growth are out of the question.

[1]) Cessation of the growth at temperatures < 8—9° C.

The "growth"-curve of *Paphia undulata* (Born) (WINCKWORTH, 1931), comparable with our curves, meanwhile shows, that such a restingtime in the period of the lowest temperatures, need not be tied to a definite temperature. The essential point seems to be the minimum temperature. In the case of *Paphia* this is about 24° C.



Graph 3. Mean temperatures and mean shell heights during the years 1951, 1952, 1953, and 1954 (Botshol).

In summer, in the months of June and July (spring generation), the rate of "growth" is much higher, viz. about 0.75 mm per week, whereas for the wintering generation in August and September this is 0.5 mm per week (less than in June: the temperature falls again).

These figures clearly illustrate the influence of the temperature on the rate of growth.

(to be continued)