Further investigations into the life cycle and soil dependence of the water snail Aplexa hypnorum

by

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CONTENTS

1. INTRODUCTION

In the years 1960 to 1962 Den Hartog & De Wolf investigated the pulmonate gastropod *Aplexa hypnorum* (L.) in the former island of Zuid-Beveland (Netherlands) paying special attention to the life cycle of a population in a ditch near the laboratory at Yerseke (Den Hartog & De Wolf, 1962), the distribution in relation to soil type and salinity (Den Hartog, 1963), and the coenosis of the species (Den Hartog, 1963a). From 1962 to December 1966 sampling in the ditch was continued by De Wolf. The results of the continued investigation are reported in the present paper, particularly because these differ from earlier findings as regards the interpretation of the life cycle. In addition, some experiments on growth and survival of *Aplexa hypnorum* in different types of water were made in order to find out whether the occurence of the species in habitats on soil type no. 8 (sandy and light clay soils), on which it predominantly lives (Den Hartog, 1963), is dependent on the quality of the water.

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The adaptation of the life cycle of *Aplexa hypnorum* to drought conditions in summer, a condition forming an important aspect of this type of soil, is also discussed.

2. MATERIAL AND METHODS

Sampling was carried out as described by Den Hartog & De Wolf (1962): collecting as many animals as possible within half an hour, measuring their shell lengths to the nearest half mm, and returning them to the ditch. Whenever samples were taken, the water temperature was recorded.

During the experiments up to twenty animals were held in one-litre plastic jars at room temperature (17-23°C) and fed with decaying leaves of *Populus* and *Phragmites*. Water and food were renewed once or twice a week. The same method was used for larger numbers of *Aplexa hypnorum* kept in ten-litre tanks. Dead animals were daily removed. The pH of the water varied between 7.2 and 8.6; these values are normal, because twenty localities in Zuid-Beveland inhabited by the species have a pH of between 7.1 and 8.2.

3. LIFE CYCLE

Figs. 1 and 2 give size frequency distributions for monthly samples. Calculated mean sizes are shown in figs. 3 and 4, from which the development of the successive generations can be read.

Generation a

This generation had hatched immediately after the drought period in 1962. In March 1963 one animal of 4.5 mm was collected. Growth from 2 mm (November 1962) up to this size must have been restricted to the second half of March, since the temperature from December through the first half of March remained below zero. The animals reached a mean size of 8 mm in May, but no eggs were produced until June. In July only one specimen measuring 14 mm was collected. Although the numbers in this generation had been small as early as September, the generation was not totally wiped out during the winter. Consequently, the prolonged frost period from December 1962 through February 1963 may not be regarded as having been exceptionally harmful to the species.

Generation b

On 26 July, 1963, young animals with a mean size of 5.5 mm

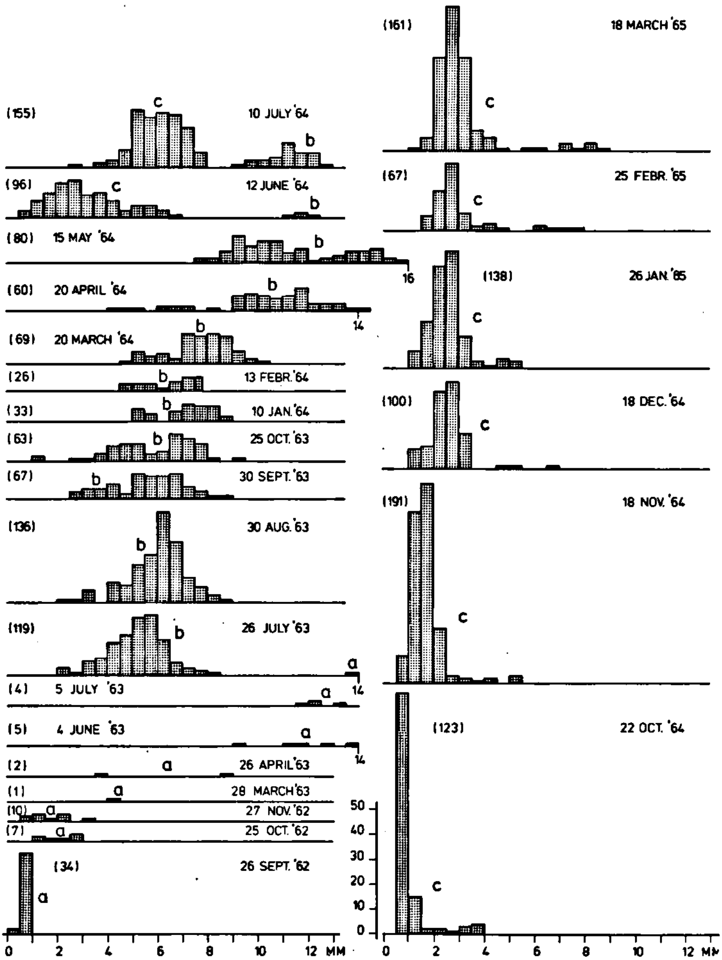

Fig. 1. Size frequency distribution of *Aplexa hypnorum*, September 1962 – March 1965. The total numbers collected are shown between brackets, letters a-c indicate the consecutive generations.

were collected. They must have reached this size in three weeks, since no young animals were present on 5 July. Moreover, laboratory data indicate that the development of the eggs at 20°C takes about

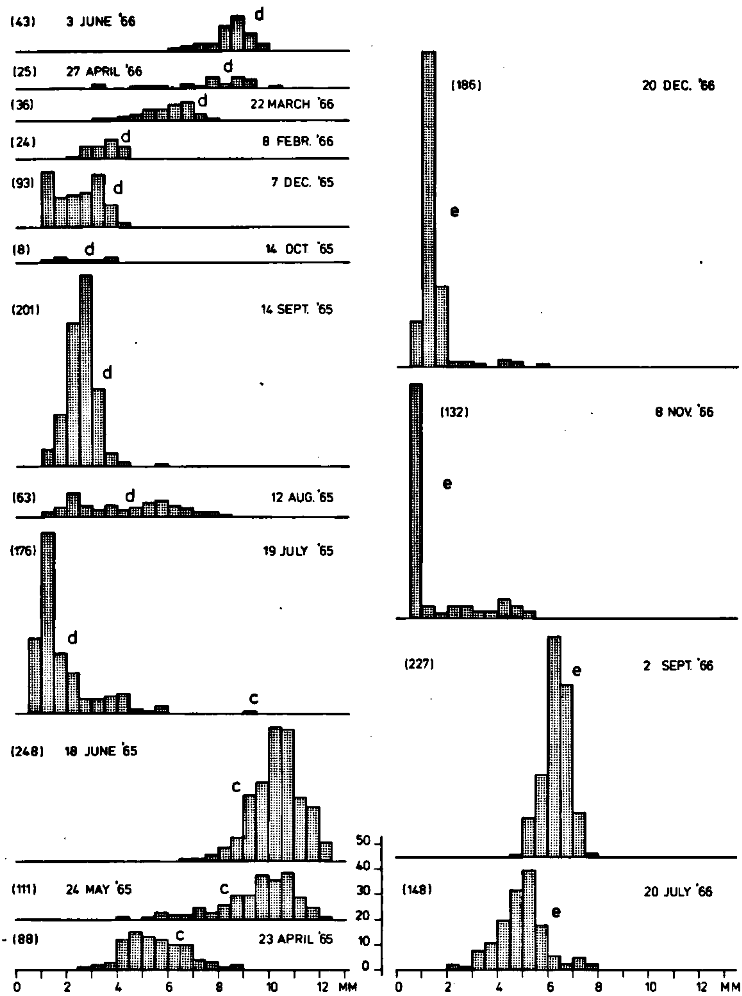

Fig. 2. Size frequency distribution of *Aplexa hypnorum*, April 1965 – December 1966. The total numbers collected are shown between brackets, letters c-e indicate the consecutive generations.

two weeks. Thus the eggs must have been deposited in June. The animals attained a maximum size of 9.5 mm in October, but did not

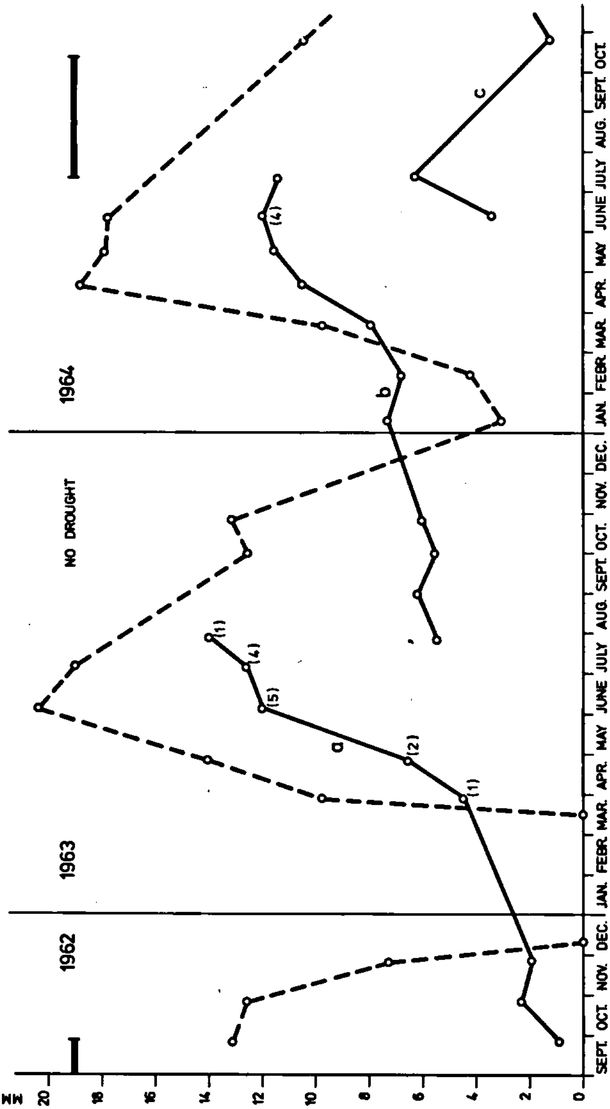

Fig. 3. Mean sizes of *Aplexa hypnorum* in consecutive generations (solid lines). For means based on five or less animals, the number in the sample is given between brackets. Dry periods are indicated by horizontal solid bars and water temperatures by a broken line. September 1962 – December 1964.

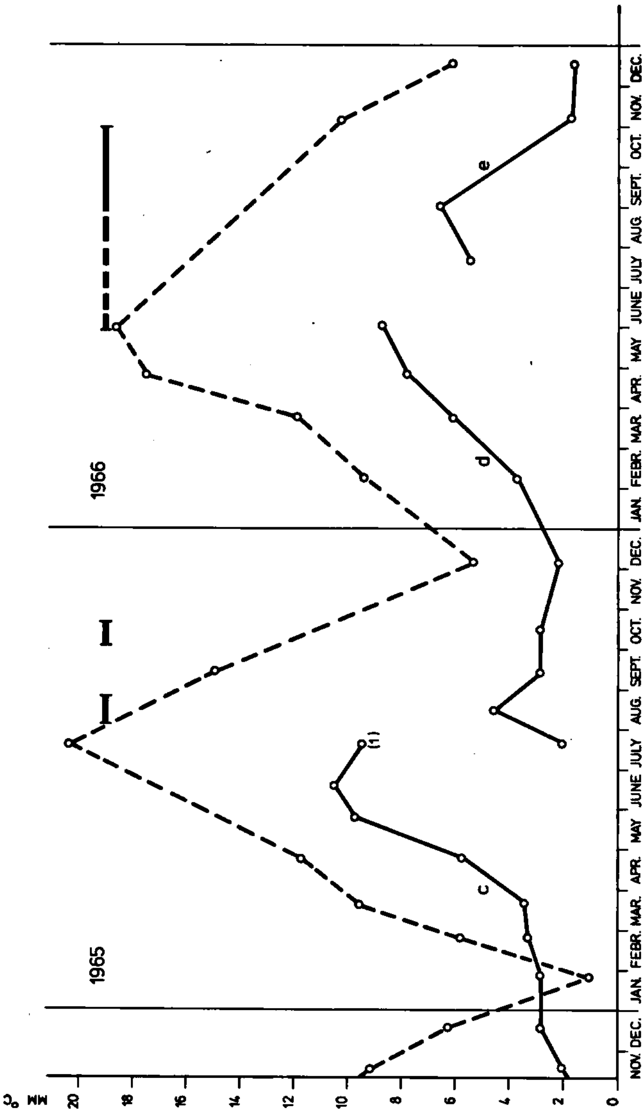

Fig. 4. As in fig. 3, but for the period November 1964- December 1966.

produce eggs. In April 1964 a mean size of 10.5 mm was reached and eggs were laid in May. From May to July the mean size remained about constant in spite of growth, owing to mortality among the larger animals (fig. 1).

Generation c

In May and June of 1964 the eggs hatched. The young animals grew to a size of 6.3 mm in July, but growth was then disturbed by a drought period lasting to the second half of October. As may be concluded from the samples of July and October 1964 (fig. 1), mortality among the larger animals was higher, either because they are possibly more sensitive to drought than smaller ones or can less easily find a damp hiding place (Den Hartog, 1963a). After the drought a large sample of animals (mean length of shell 1 mm) was collected (fig. 1). They must have survived the drought as eggs, since after July no mature animals were found. This conclusion was confirmed by the occurrence of newly hatched, very small snails still clustered on the lower surface of leaves on the bottom. The mean size of the animals fell to 1.3 mm in October, owing to mortality among the larger animals during the drought and the birth of new individuals after this period. After the temperature had risen in the spring and growth was resumed, the animals reached a mean size of 9.5 mm in May and deposited their eggs in June. The generation died out in July, before the beginning of the drought period.

Generation d

The animals of this generation, which had hatched in July 1965, had a mean shell size of only 2.2 mm in December, owing to mortality during the two dry periods in summer and slow growth during the progressively colder weather in autumn. After midwinter they grew steadily to as much as 8.8 mm in June, and produced their eggs before the uninterrupted part of the dry period.

Generation e

In 1966, for the same reasons as in generation c, the mean shell size of the animals fell to 1.8 mm in November.

4. EXPERIMENTS

From the foregoing it is apparent that *Aplexa hypnorum* never lays its eggs earlier than May. To find out whether temperature is the limiting factor here, a group with shells measuring from 4 to 14 mm was collected in the first week of April 1964 and reared at room temperature in a ten-litre tank in the laboratory. Two weeks later, egg masses had already been deposited on the leaves. From this observation and from the fact that in the ditch in March 1964 sexual maturity had not yet been achieved by sufficiently large animals at temperatures around 10°C, it may be concluded that optimum temperatures are between 10 and 17°C. Figs. 3 and 4 even indicate that the optimum temperature must be higher than 15°C.

In another experiment the growth of the species in the following types of water was studied:

a. water from a ditch situated in soil type no. 8 (Den Hartog, 1963), where the species was collected, salinity 1.4‰ Cl′;
b. water from a drinking pool for cattle, also in soil type no. 8 but not inhabited by *Aplexa hypnorum*, salinity 0.2‰ Cl′;
c. tap water;
d. tap water, salinity increased to 1.4‰ Cl′;
e. rain water;
f. rain water, salinity also increased to 1.4‰ Cl′.

Ten specimens of *Aplexa hypnorum* measuring 2 mm were reared at room temperature in each of the jars containing the various types of water. After a period of 46 days the shells of the remaining animals were measured. The results are shown in table 1. Analysis of variance shows a highly significant difference when the sizes are compared in pairs according to Newman & Keuls (De Jonge, 1963). Growth in water from the ditch was significantly faster than that in other types of water. In water from the drinking pool growth was better than in tap or rain water. Salinities in the indicated range do not appear to be an important factor.

In similar cultures the numbers of dead animals were daily recorded. Totals for ten-day periods are given in table 2; survival percentages are given in fig. 5. Unfortunately, owing to pollution of the water in the ditch, mortality in this type of water was high in the second, third, and fourth periods as shown in the figure. Thus, among the results of the experiments with the six different water types, only the figures for the first period can be used. Results obtained with five types of water (excluding the ditch water) during all periods should be taken into account. The results of the test for homogeneity (Wisniewski, 1968) of mortality in the six types of water in the first period, and those of the test for dependence (De

water from the ditch 1.4‰ Cl′	water from the drinking pool 0.2‰ Cl′	tap water	tap water 1.4‰ Cl′	rain water	rain water 1.4‰ Cl′
3.5	3.0	3.0	3.0	2.5	3.0
5.0	3.0	3.0	3.0	2.5	3.0
7.0	3.5	3.0	3.0	2.5	3.0
7.5	4.0	3.5	3.0	3.0	3.0
	4.5	4.0	3.0	3.0	3.0
	5.0		4.5	3.0	3.0
	5.0			3.0	3.0
	5.0				3.5
	5.5				3.5
mean: 5.75	4.28	3.30	3.25	2.79	3.11

Table 1. Size in mm of *Aplexa hypnorum* after 46 days in the various water types. Initial size 2 mm. Analysis of variance with logarithmic values, F = 10.7, P < 0.005. Each pair of mean values in italics is not significantly different at the 5% level as tested by the method of Newman & Keuls (De Jonge, 1963).

period in days	water from the ditch 1.4‰ Cl′	water from the drinking pool 0.2‰ Cl′	tap water	tap water 1.4‰ Cl′	rain water	rain water 1.4‰ Cl′
0-10	2	4	15	5	24	8
10-20	13	0	11	11	16	18
20-30	14	1	2	3	1	2
30-40	14	14	6	7	3	5
> 40	24	28	33	31	23	24

Table 2. Numbers of dead animals in the various water types during consecutive ten day periods.

Test for dependence (except for experiments in water from the ditch) $\chi^2 = 53.4$, $P < 0.0005$.

Test for homogeneity of mortality in the six water types in the first period, $\chi^2 = 36.8$, $P < 0.0005$.

Jonge, 1963) of mortality on the five water types during the whole experiment are highly significant.

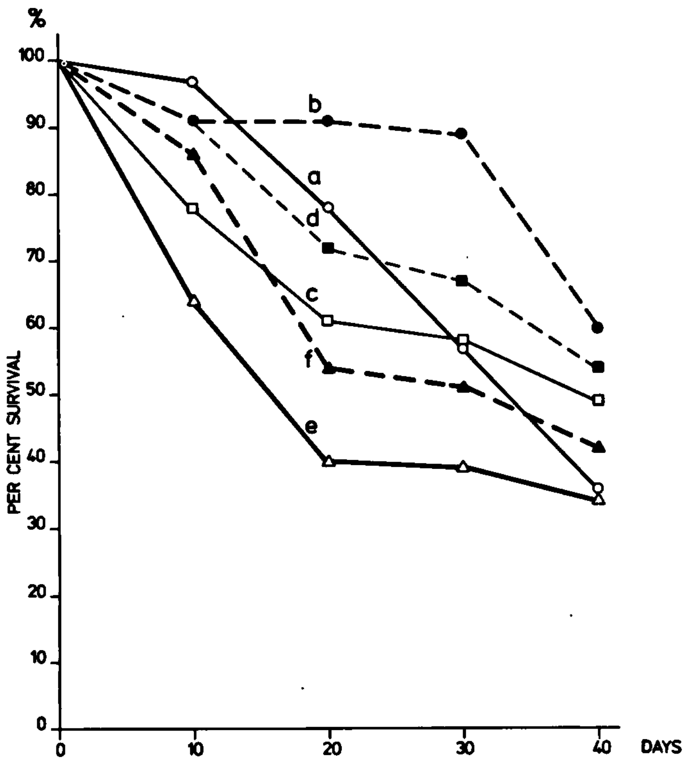

Fig. 5. Per cent survival of *Aplexa hypnorum* (2-9 mm) in various types of water; a, water from the ditch; b, water from the drinking pool; c, tap water; d, tap water, 1.4‰ Cl′; e, rain water, f, rain water, 1.4‰ Cl′.

An additional experiment was made to investigate the mortality of *Aplexa hypnorum* in water from the drinking pool and in water from the ditch sampled during a favourable period and kept in the laboratory. In both types of water, 25 specimens were still alive after 50 days.

It may be concluded that survival was highest in water from the ditch and from the drinking pool, and mortality highest in rain water. In both rain and tap water, survival was higher when the salinity had been increased to 1.4‰ Cl′ by adding sea water.

5. DISCUSSION

When in the spring *Aplexa hypnorum* has reached a shell size of

8 mm and the temperature has risen to 15°C, it becomes sexually mature. Earliest maturity occurs in May. It is often reached a month later, however, because the animals are too small, the temperature too low, or both. Eggs may be produced far into July, and shortly afterwards the parent generation dies. The eggs representing the new generation may hatch in May; the ones laid just before a dry period hatch immediately after it has ended. The eggs were never observed to hatch during the drought, although Den Hartog & De Wolf (1962) do not exclude the possibility of this happening. In autumn and winter (October 1964-March 1965, fig. 1, and November-December 1966, fig. 2) the new generation may consist of a small group of fairly large animals hatched before and a large group of smaller ones hatched after the drought.

The six large animals collected by Den Hartog & De Wolf (1962) in March and April 1960 and considered to belong to a previous generation, must undoubtedly have hatched from eggs laid early in the summer of 1959. Such large snails were also present in April and May 1964 (fig. 1). The large animals in the samples of August and October 1960 and February 1961, which the authors considered to belong to the parent generation of 1960, may have originated from pre-drought eggs of 1960. This seems likely, because in 1963 (fig. 1) and in 1966 (fig. 2) animals of the new generation also reached maximum sizes of 8.5 and 8 mm in July. The single specimen collected by Den Hartog & De Wolf (1962) during the drought of June to September 1961 had undoubtedly hatched before the dry period.

Towards autumn the snails either do not exceed 8 mm or they reach this size so late that the temperature has already fallen too much for them to mature.

These observations lead to the conclusion that only one generation is produced per annum. The shortest life span (8 months) extends between a drought in October and one in June of the next year. The longest (14 months) extends from May to July of the following year, i.e. if there is no dry period.

Den Hartog (1963) concluded from his investigations into the influence of soil type and salinity on the distribution of *Aplexa hypnorum* that in Zuid-Beveland the animals have a preference for soil types nos. 8 and 37, consisting of sandy and light clay soils, and having a salinity not exceeding 2.5‰ Cl′. Den Hartog (1963: 12, 14) stated: "The water-fixing capacity of these soils is high enough to enable the resting stages of *Aplexa* to survive drought even when the phreatic level falls considerably", and "*Aplexa hypnorum* occurs only in places where soil composition and salinity are favourable for it." The highest salinity measured by him was 1.85‰ Cl′.

In the present experiments the species shows the highest rate of survival in water from the ditch and in water from the drinking pool. Growth appeared to be better in the former. Since both habitats are on soil type no. 8, the presence of *Aplexa hypnorum* in the ditch may be explained by the low salinity and by the influence of other characteristics of the water on growth, rather than by a preference for the soil type in itself. It may also be concluded that in Zuid-Beveland the species occurs predominantly on this soil type and on soil type no. 37 in spite of the commonly occurring drought in summer and not because the eggs need a dry period for development, since in laboratory cultures and in the ditch in 1963, the eggs developed very well in the absence of drought conditions. When a dry period occurs the eggs and the small individuals of the new generation may survive under leaves on the bottom.

6. ACKNOWLEDGEMENTS

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7. SUMMARY

1. The occurrence of *Aplexa hypnorum* (L.) in various habitats on soil types nos. 8 and 37 in Zuid-Beveland depends not only on low salinity but also on other characters of the water.

2. *Aplexa hypnorum* is adapted to the dry periods on these soil types by the ability of eggs and juveniles of the new generation to survive such conditions.

3. There is only one generation a year.

4. Owing to a dry period in summer, when hatching is considered to cease temporarily, the new generation may be composed of two different size/age classes during autumn, winter, and early spring.

8. REFERENCES

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SAMENVATTING

Het onderzoek aan de waterslak *Aplexa hypnorum* (L.) vormt een voortzetting van dat van Den Hartog gedurende de jaren 1960-1962, zodat aanvullende gegevens zijn verkregen. *Aplexa hypnorum* wordt in het voorjaar volwassen, wanneer de schelp 8 mm of langer is en de temperatuur van het water hoger dan 15°C. Eieren kunnen van mei tot in juli worden afgezet. De oude generatie sterft in de loop van het late voorjaar en de zomer, maar in ieder geval tijdens zomerse droogteperioden, die kunnen voorkomen van juni tot in oktober. Eieren die vlak voor deze droogteperioden zijn gelegd komen onmiddellijk daarna uit. Het gevolg is dat, wanneer de droogte tamelijk lang duurt, in het najaar van dezelfde generatie twee groepen met verschillende schelpmaten aanwezig kunnen zijn. Deze zullen na de groei in het voorjaar weer samenvallen. In het najaar worden geen eieren gelegd, doordat de dieren dan nog te klein zijn. *Aplexa hypnorum* heeft dus één generatie per jaar. De kortste levensduur is acht maanden en ligt tussen een droogte in oktober en een in juni van het volgende jaar. De langste levensduur is veertien maanden, van mei tot juni van het volgende jaar, mits geen droge tijd voorkomt. Uit laboratoriumexperimenten blijkt dat naast het lage zoutgehalte in het water van het milieu (zie het werk van Den Hartog) ook de invloed van andere eigenschappen van het water op de groei van het dier van belang zijn voor zijn verspreiding. Hiermee zou het al of niet voorkomen van *Aplexa hypnorum* op de bodemtypen no. 8 en 37 kunnen worden verklaard.