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Ewa MIANOWSKA

Department of Agrocenology, Institute of Ecology, Polish Academy of Sciences,
Dziekanów Leśny near Warsaw

RESEARCH ON THE BIOLOGY AND ECOLOGY OF *PANAGROLAIMUS RIGIDUS* (SCHNEIDER) THORNE

V. EFFECT OF TEMPERATURE ON FECUNDITY AND DEVELOPMENT

ABSTRACT: Under laboratory conditions at 10°C the life cycle (from the egg to the laying of the first egg) lasted 37.7 days, at 20°C – 14.6 days, and at 30°C – only 9.1 days. At 20°C females of *Panagrolaimus rigidus* (Schneider 1866) Thorne 1937 were for the longest time fecund and showed the highest fecundity rate. Least fecund were *P. rigidus* females reared at 10°C. At 10°C larvae hatched from all the eggs laid by the females, while at higher temperatures a considerable percentage of eggs did not undergo further development. The females lived for a slightly longer time than the males. At 10°C females lived on the average for 61.8 days, and the males – for 50.0 days.

Contents

1. INTRODUCTION

The biology of the individual nematode species is relatively little known. Studies carried out so far indicate that the saprobiotic nematodes of the genera: *Rhabditis* and *Diplogaster* have a short life history, completed within one week, and the females of these nematodes lay during life about 200 eggs (H i r s c h m a n n 1960).

Nematodes belonging to parasaprobiotic species, e.g. *Cephalobus persegnis* Bastian 1865, appear to have a slightly longer life cycle which at temperature of 15–16°C lasts 12–13 days. The females lay about 300 eggs (P o p o v i c i 1972).

The life history of the parasitic species *Ditylenchus triformis* Hirschmann and Sasser 1955 at temperatures 24–26°C lasts 16–21 days; during this period the females lay on an average 79 eggs (Hirschmann 1962). The females of the mycophagous species *Aphelenchus avenae* Bastian 1865 lay during their life time about 300 eggs (Fischer 1969). The parasitic species differ considerably from one another in respect of the length of their life histories. The development of the nematodes representing the species *Aphelenchoides ritzemabosi* Steiner 1932 lasts 14 days, that of *Ditylenchus dipsaci* Filipjev 1936 – about 25 days, and that of *Heterodera schachtii* – 35–56 days (Wilski 1967). An exceptionally long life cycle has been recorded for *Meloidogyne acrita* Chitwood 1949, since it may last as long as 90 days (Ritter and Ritter 1958 after Wallace 1963).

The number of eggs laid by the females of the parasitic species also varies considerably. For instance, during its life a *D. dipsaci* female lays 207–498 eggs (Yüksel 1960), while the females of another parasitic species – *Pratylenchus penetrans* Chitwood and Oteifa 1952 lay much fewer eggs, only 39–53. The fecundity and the growth rate of the different nematode species obviously depends to a large extent on the temperature under which they live.

The aim of the present research was to study the effect of temperature on the number of eggs laid and on the growth rate of the parasaprobiotic species *Panagrolaimus rigidus* (Schneider 1866) Thorne 1937.

2. MATERIAL AND METHODS

In the research the method worked out by German investigators (Kämpfe and Schmidt 1966) and modified by the author of the present paper was used. The females of *P. rigidus* derived from an agar culture containing some chicken egg yolk were placed in a drop of water. After 24 hours the eggs laid by these females were transferred with a pipette to a drop of 2% Difco agar previously placed on a slide. The slides with agar on them were kept in a moist chamber to prevent the drying up of the agar and nematodes. Every day the number of hatched larvae was recorded. As soon as the nematodes attained sexual maturity a male and a female were placed together on each agar drop. Daily observation of these pairs, and transferring them to fresh drops made it possible to follow the course of egg laying, evaluate the fecundity of females, and finally the length of life and the survival rate of the nematodes.

The observations were carried out at three different temperatures: 10, 20 and 30°C. At each temperature 30–50 *P. rigidus* pairs were observed.

3. RESULTS

3.1. Egg development

At 10°C the first larvae hatched 6 days after the laying of eggs, whereas the last larvae hatched on the 13th day (Fig. 1). At this temperature larvae hatched from all the eggs laid. At 20°C the first larvae hatched on the second day, and the last ones – on the 7th day. Only 84% of eggs developed. The shortest period of development was recorded for 30°C. Larvae began to hatch already on the first day,while the last eggs hatched on the 3rd day following their laying The proportion of eggs that did not develop at 30°C was as high as 31%.

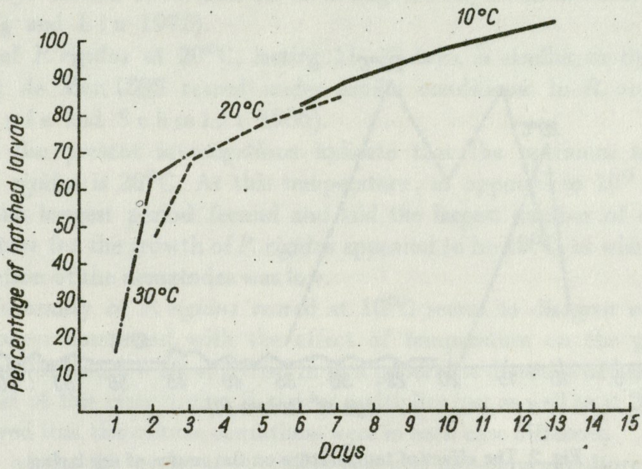

Fig. 1. The effect of temperature on the rate of hatching of *Panagrolaimus rigidus* (Schneider 1866) Thorne 1937 larvae

Elongation of the incubation period of eggs at low temperature was also observed by M a m i y a (1971) who investigated the development of *P. penetrans* at varying temperatures. He found that when kept at 15°C, the eggs required for their full development 25 days, whereas when kept at 25°C – only 8–10 days.

The retardation of growth of a certain proportion of eggs, observed during the present series with *P. rigidus*, as a result of high temperature, was also reported by other authors who studied different species. For instance F i s c h e r (1969) found that most of the eggs of *Aphelenchus avenae* did not develop at 35°C. Similarly, eggs of the nematodes of the genus *Trichodorus* did not develop at 35°C (R h o d e and J e n k i n s 1957).

3.2. C o u r s e o f e g g l a y i n g

The first to start laying eggs were the females reared at 30°C. The first eggs were already seen on the 8th day of life of the females, and the last ones on the 18th day (Fig. 2). At this temperature, the females were fecund on the average for 4.7 days. During this period each of the females laid from 6 up to 126 eggs. Maximum egg laying occurred on the 11th day of the life of a female. The average number of eggs laid on that day by one female was 5.9.

At 20°C the first eggs appeared on the 11th day, and there were females which still laid eggs on the 35th day. At this temperature, the females were fecund on an average for 11.5 days. The number of eggs laid during this period by one female varied considerably – there were females which laid only one egg each, and also females which laid 344 each. At 20°C two egg laying peaks could be observed: on the 15th and 26th days of life of a female. On these days a female laid an average of 7.6 eggs.

The fecundity period of the *P. rigidus* females kept at 10°C was much delayed, relative to the fecundity period of the individuals reared at 20° and 30°C. The females kept at the temperature of 10°C laid the first eggs only on the 22nd day, but some of them kept laying

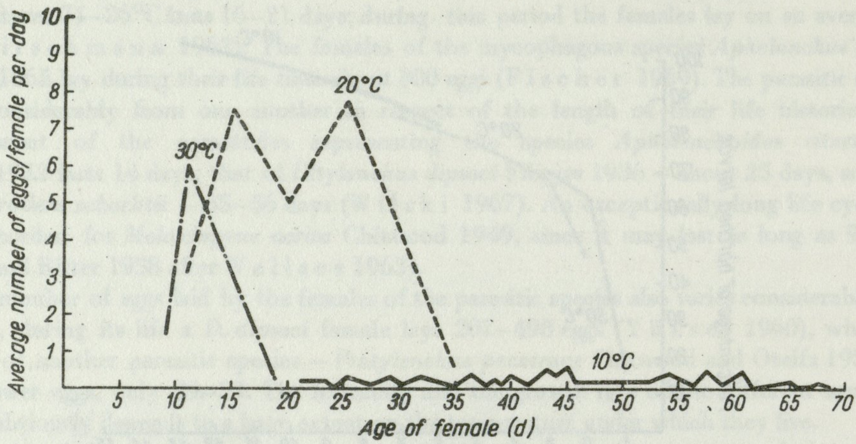

Fig. 2. The effect of temperature on the course of egg laying

Table I. The effect of temperature on the length of the life history and fecundity in *Panagrolaimus rigidus* (Schneider 1866), Thorne 1937
Mean values and range (in brackets)

	10°C	20°C	30°C
Life history in days	37.3 (21–52)	14.6 (11–23)	9.1 (8–18)
Fecundity period of females in days	5.3 (1–13)	11.5 (1–20)	4.7 (1–10)
Total number of eggs laid by one female	7.7 (1–27)	111.2 (1–344)	43.7 (6–126)

eggs until the 67th day of their life. Their fecundity period was shorter than that of the females kept at 20°C (Table I). The number of eggs laid by one female throughout its fecundity period was small, on the average 7.7 eggs. At this temperature no egg laying peaks could be seen, the average number of eggs laid by one female during a day was never above 0.6.

3.3. Length of life history

The shortest life cycle (from the egg to the laying of the first egg) of *P. rigidus* was recorded for individuals reared at 30°C. At 20°C their life cycle lasted slightly longer, being the longest at 10°C (Table I). These findings agree with the generally known phenomenon of development acceleration by increasing temperatures.

The elongation of the life cycle, as recorded for *P. rigidus* during the present series, was also reported from other nematode species. For example, the life cycle of *P. penetrans* reared at

15°C lasts 86 days, whereas at 25°C only 25 days (M a m i y a 1971). At 16°C the life cycle of *Aphelenchoides bessyi* Christe 1942 lasts on an average 24 days, and at 35°C – only 8 days (H u a n g, H u a n g and L i n 1972).

The life cycle of *P. rigidus* at 20°C, lasting 11–23 days, is similar. to the life cycle of *Rhabditis oxycerca* de Man 1895 reared under similar conditions. In *R. oxycerca* it lasts 10–19 days (K ä m p f e and S c h m i d t 1966).

The results of the present investigations indicate that the optimum temperature of development for *P. rigidus* is 20°C. At this temperature, as opposed to 10° and 30°C, the females were for the longest period fecund and laid the largest number of eggs. The least favourable temperature for the growth of *P. rigidus* appeared to be 10°C, at which temperature the rate of reproduction of the nematodes was low.

The very low fecundity of *P. rigidus* reared at 10°C seems to disagree with the results presented in the paper concerned with the effect of temperature on the growth of two *P. rigidus* populations (M i a n o w s k a 1976). In that paper, the densities of nematodes reared at 10°C indicate that at this temperature *P. rigidus* multiplies just as well as at 20°C. However, it must be remembered that the culture conditions were in each case different.

The observation of the life cycle of *P. rigidus* required non-natural culture conditions on agar, which (especially at 10°C) does not provide a good medium for the growth of bacteria and fungi which are the main source of food for the species under study. This must, no doubt, have affected the reproduction of the nematodes. In the previous series with two *P. rigidus* populations the cultures were carried out under conditions similar to a natural habitat, because the nematodes were reared in glass beakers containing sand and wheat seedlings. It is possible that in this case the presence of plants had a stimulating effect on the growth of *P. rigidus*. The experiments carried out by K o z ł o w s k a and D o m u r a t (1971) showed that *P. rigidus* multiplied much better in the presence of plants than in sand alone.

As the studying of the biology of nematodes under natural conditions is very difficult, it is sometimes necessary to carry out investigations under the artificial conditions of a laboratory, but it must then be taken into account how much the changed environment differs from the natural one, and how it may affect the results.

3.4. Length of life

At all the temperatures used the females lived slightly longer than the males. The longest life period was recorded for the nematodes reared at 10°C, much shorter for those at 20°C, and the shortest for those at 30°C (Table II). The analysis of variance has proved that the differences in

Table II. The effect of temperature on the length of life of *P. rigidus* (in days)
Mean values and range (in brackets)

10°C		20°C		30°C	
females	males	females	males	females	males
61.8 (33–86)	50.0 (25–85)	37.8 (13–65)	29.0 (11–53)	18.2 (13–26)	17.9 (13–26)

the length of life of the nematodes reared under different temperatures are statistically significant. Significant were also the differences in the length of life of the females and males reared at the same temperature. An exception was the temperature 30°C at which the differences appeared not to be statistically significant.

F i s c h e r's (1969) studies on the length of life of *Aphelenchus avenae* indicate that females reared at 20°C lived 48 days, and at 30°C – 22 days. *Ditylenchus triformis* reared at 24–26°C lived much longer, the average length of life of a female being 63 days, that of a male 74 days.

T h o m a s (1965) has reported that the females of *Acrobeles complexus* Thorne 1937 may live even for 6 months, whereas some of the females of *Rhabditis oxycerca* lived 7 months (K ä m p f e and S c h m i d t 1966). The average length of life of *R. oxycerca* females was 100–150 days, that of males 150–200 days.

By comparison with this data the life of the *P. rigidus* studied during the present research was exceptionally short.

4. SUMMARY

The biology of *Panagrolaimus rigidus* (Schneider 1866) Thorne 1937, a parasaprobiotic nematode species, was studied under laboratory conditions at the following temperatures: 10, 20 and 30°C. The longest development period was recorded for eggs kept at 10°C, and the shortest for those at 30°C (Fig. 1). However, at 30°C larvae hatched only from 69% of eggs, at 20°C – from 84% of eggs, and at 10°C – from all the eggs laid.

The longest life cycle was seen in the nematodes reared at 10°C, a much shorter one at 20°C, and the shortest at 30°C (Table I).

The females remained fecund for the longest time at 20°C, and it was at this temperature that they laid the largest numbers of eggs. One egg laying peak occurred on the 15th and another on the 26th day of a female's life (Fig. 2). Much fewer eggs were laid by females reared at 30°C. At this temperature the maximum egg laying occurred on the 11th day. Least fecund were females reared at 10°C.

Statistically significant differences in the length of life were found among the nematodes reared at different temperatures (the longest life time was recorded for individuals reared at 10°C, and the shortest for those reared at 30°C). Significant differences were also found between the length of life of the females and males (except at 30°C) (Table II).

5. POLISH SUMMARY (STRESZCZENIE)

Badano w warunkach laboratoryjnych w temperaturze: 10, 20 i 30°C biologię parasaprobiotycznego nicienia *Panagrolaimus rigidus* (Schneider 1866) Thorne 1937. W temperaturze 10°C jaja złożone przez samice rozwijały się najdłużej, najkrócej w temperaturze 30°C (fig. 1). Jednak w temperaturze 30°C larwy wylęgły się tylko z 69% złożonych jaj, w temperaturze 20°C z 84% jaj, a w temperaturze 10°C rozwijały się wszystkie złożone jaja.

Najdłuższy cykl rozwojowy *P. rigidus* obserwowano u nicieni hodowanych w temperaturze 10°C, znacznie krótszy w temperaturze 20°C, a najkrótszy w temperaturze 30°C (tab. I). Samice były najdłużej płodne w temperaturze 20°C i w tej temperaturze składały najwięcej jaj. Szczyt składania jaj przypadał na 15 i 26 dzień życia samicy (fig. 2). Znacznie mniej jaj składały nicienie w temperaturze 30°C; szczyt składania jaj w tej temperaturze obserwowano 11 dnia. Najmniej płodne były samice hodowane w temperaturze 10°C.

Stwierdzono statystycznie istotne różnice między długością życia nicieni hodowanych w różnych temperaturach (najdłużej żyły osobniki hodowane w temp. 10°C, najkrócej – hodowane w temp. 30°C). Również istotne różnice stwierdzono między długością życia samic i samców (z wyjątkiem temperatury 30°C); (tab. II).

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Paper prepared by J. Stachowiak

AUTHOR'S ADDRESS:
Mgr Ewa Mianowska
Instytut Ekologii PAN
Dziekanów Leśny k. Warszawy
05–150 Łomianki
Poland