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EFFECT OF TEMPERATURE ON THE TIMES TO HATCHING OF EGGS OF THE PLANT PARASITIC NEMATODE *LONGIDORUS ELONGATUS*

by
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There is little information on the effect of temperature on the rate of development and hatching of migratory plant parasitic nematode eggs and yet it is essential that this relationship is understood and the minimum threshold temperature for development determined if the population dynamics and epidemiology of the nematode in the field is to be understood and modelled. Flegg (1968; 1969) investigating the embryology of *Xiphinema diversicaudatum* (Micoletzky) Thorne found 25 °C to be the optimum temperature for egg development while no development occurred at 5 °C, and 30 °C proved lethal. Wyss (1970; 1975) and Yassin (1969) found that *Longidorus elongatus* (de Man) Thomas *et* Swanger completed its life cycle in nine weeks at 30 °C while no egg development was observed at 10 °C. Investigations into the effects of temperature on the development and hatching of *L. elongatus* eggs and calculations on the minimum threshold temperature for development are reported in this paper.

Materials and Methods

Nematodes were extracted using a sieving and decanting technique (Boag, 1974) and from those collected gravid *L. elongatus* were taken and added to the roots of *Lolium perenne* L. seedlings growing in 0.75% agar in sealed petri dishes. These were examined every 24 h and eggs which had been expelled from the females were collected

and added to micro-containers (Fig. 1). These micro-containers, which were similar in concept to the sieves produced by Moriarty (1963) and Yeates (1968) were produced from rings 5 mm deep cut from 15 mm diameter plastic sample tubes and their tops. The 15 μm diameter nylon mesh used as a base was stretched between the two rings. Ten eggs were placed in each of nine micro-containers which were maintained in sealed petri dishes containing a piece of filter paper and just sufficient water to cover the eggs. These petri dishes were then placed in cooled incubators held at intervals from 5 to 35 °C. The eggs were examined daily for seventy days under a low powered binocular microscope and their development stage recorded. Every three days the micro-containers were placed on dry filter paper which removed the water by capillary action. Fresh, aerated distilled water at incubator temperature was then added to the micro-containers and the petri dishes, which were resealed to reduce evaporation of the water, were returned to their respective incubators.

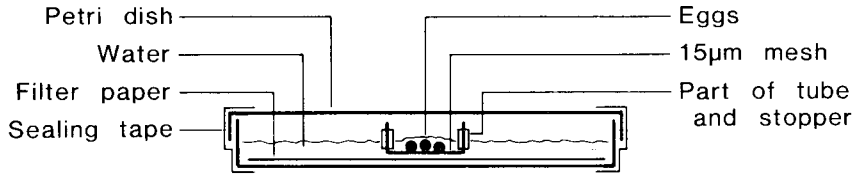

Fig. 1 - Transverse section through petri dish and micro-container containing nematode eggs.

To investigate the effect of a regime of fluctuating temperature, 10 eggs were exposed to a 12 h diurnal rhythm of 10 °C and 20 °C. The eggs were examined every 24 h and their developmental stage recorded. The effect of temperature on the hatching of *L. elongatus* eggs was analysed using the Maximum Likelihood Program (MPL) (Ross, 1980).

Results

The results indicated that eggs developed and hatched successfully in the nylon based micro-containers. The percentage of eggs finally hatching varied with temperature. There was a direct rela-

tionship between temperature and hatching time (Fig. 2). The equation best fitting the data and accounting for 98.86% of the variability was the rectangular hyperbola $Y\ (\text{days}) = \frac{162.73}{X\ (\text{temperature})} - 8.28$.

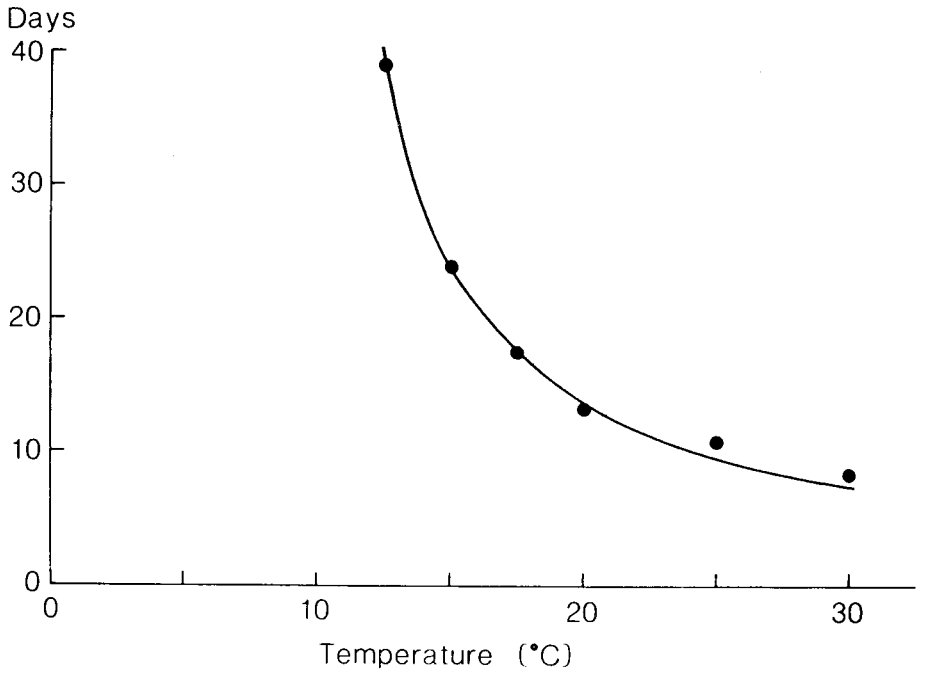

Fig. 2 - Effect of temperature on the times to hatching of *Longidorus elongatus* eggs.

The minimum threshold temperature for development and accumulated day degrees above the threshold for development to hatching were calculated to be 8.28 °C and 162.73 days respectively. The support limits (which are similar to the 95% confidence limits) were found to range from 7.92 - 8.61 °C for the minimum threshold temperature and for the accumulated day degrees 153.10 - 173.04 days.

Egg development under the fluctuating temperature regime (10 and 20 °C) was similar to that at a constant 15 °C.

Table I - *The effect of temperature on the percentage hatching success of* Longidorus elongatus *eggs.*

	Temperature (°C)								
	5	10	12.5	15	17.5	20	25	30	35
Percentage of eggs hatching	0	0	80	70	80	100	90	30	0

Discussion

The use of micro-containers for observing embryo development and hatching of *L. elongatus* eggs has the following advantages over the hanging drop technique (Taylor, 1961): it allows several eggs to be observed simultaneously, the depth of water in which the eggs develop can be controlled and the water can be changed without the risk of eggs being lost.

The effects of temperature on the hatching of animal parasitic nematode eggs has recently been shown to follow a delayed gamma distribution and that an arrhenius equation well describes the relationship between temperature and hatching time (Le Jambre and Whitlock, 1973; Young *et al.*, 1980). Although less is known about the relationship between temperature and the hatching of eggs of migratory plant parasitic nematodes the results here show that a rectangular hyperbola satisfactorily explained the effect of temperature on the hatching of *L. elongatus*, accounting for 98.98% of the observed variability. The direct relationship between hatching time and temperature permits accumulated day degrees to be used to model the influence of temperature and to estimate the lower threshold temperature below which development does not occur. The calculated threshold. temperature for *L. elongatus* is 8.3 °C, which is higher than the 5 °C base temperature used by Griffiths and Trudgill (1983) but lower than the temperature 10 °C at which no hatching was observed during the present experiment or by Wyss (1970). The reason for the discrepancy between the calculated threshold temperature and the observed non-development and hatching of the eggs at 10 °C is not known.

The results also showed that the upper threshold temperature of hatching was between 30-35 °C and that at these high temperatures mortality was high. The optimum temperature range for both sur-

vival and development was 20-25 °C when 90-100% of the eggs hatched. This percentage hatch was greater than the maximum of 60% reported by Flegg (1969) for *X. diversicaudatum*. However, Flegg (1969) used eggs excised from uteri which may have been immature, whereas naturally delivered full term eggs were used in this study.

Modelling nematode populations, especially of migratory plant parasitic nematodes, is in its infancy. However, the close relationship between temperature and the time taken for *L. elongatus* eggs to hatch as demonstrated in this study suggests that the concept of accumulated day degrees (Jones, 1975; 1977) can be extended to the hatching of migratory plant parasitic nematodes.

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SUMMARY

Studies of the effect of temperature on the hatching time of *Longidorus elongatus* eggs is a necessary prerequisite for detailed investigations of the life cycle and population dynamics of this nematode. A technique was developed which enabled the development and hatching of many eggs to be observed concurrently. The results indicate that the relationship between temperature and hatching time of *L. elongatus* eggs could adequately be described by a rectangular hyperbolic equation. The basic threshold temperature for the development of eggs of *L. elongatus* was calculated to be 8.3°C and the accumulated day degrees 162.7 above the threshold for development to hatching.

LITERATURE CITED

BOAG B., 1974 - Nematodes associated with forest and woodland trees in Scotland. *Ann. appl. Biol.*, 77: 41-50.

FLEGG J. J. M., 1968 - Embryogenic studies on some *Xiphinema* and *Longidorus* species. *Nematologica, 14*: 137-145.

FLEGG J. J. M., 1969 - The effect of temperature on the embryogeny of *Xiphinema diversicaudatum*. *Nematologica, 15*: 285-286.

GRIFFITHS B. S. and TRUDGILL D. L., 1983 - A comparison of the generation times and gall formation of *Xiphinema diversicaudatum* and *Longidorus elongatus* on a good and poor host. *Nematologica, 29*: 78-87.

JONES F. G. W., 1975 - Accumulated temperature and rainfall as measures of nematode development and activity. *Nematologica, 21*: 62-70.

JONES F. G. W., 1977 - Temperature and the development of *Mononchus aquaticus*. *Nematologica, 23*: 123-125.

LE JAMBRE L. F. and WHITLOCK J. H., 1973 - Optimum temperature for egg development of phenotypes in *Haemonchus contortus cayugensis* as determined by Arrhenius diagrams and Sacher's entropy function. *Int. J. Parasitol., 3*: 299-310.

MORIARTY F., 1963 - A nylon sieve for hatching *Heterodera* larvae. *Nematologica, 9*: 157-158.

ROSS G. J. S., 1980 - Ulser Models. *In*: MLP Maximum Likelihood Program. Rothamsted Experimental Station, Harpenden.

TAYLOR D. P., 1961 - Biology and host-parasite relationships of the spiral nematode *Helicotylenchus microlobus. Proc. helminth. Soc. Wash., 28*: 60-66.

WYSS U., 1970 - Untersuchungen zur populationsdynamik von *Longidorus elongatus. Nematologica, 16*: 74-84.

WYSS U., 1975 - Embryology and hatching of *Trichodorus similis* and *Longidorus elongatus. In*: Nematode Vectors of Plant Viruses (Eds. F. Lamberti, C. E. Taylor and J. W. Seinhorst) Plenum Press, London and New York, pp. 153-154.

YASSIN A. M., 1969 - Glass-house and laboratory studies on the biology of the needle nematode *Longidorus elongatus. Nematologica, 15*: 169-178.

YEATES G. W., 1968 - A simple method of making sieves using nylon gauze and P. V. C. tubing. *Nematologica, 14*: 456-457.

YOUNG R. R., ANDERSON N., OVEREND D., TWEEDIE R. L., MALAFANT K. W. J. and PRESTON G. A. N., 1980 - The effect of temperature on times to hatching of eggs of the nematode *Ostertagia circumuncta. Parasitology, 81*: 477-491.

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