

Effects of Temperature on Rate of Feeding of the Plant Parasitic Nematodes *Rotylenchus robustus*, *Xiphinema diversicaudatum*, and *Hemicycliophora conida*

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Abstract: *Rotylenchus robustus*, *Xiphinema diversicaudatum*, and *Hemicycliophora conida* were observed feeding over a range of temperatures on perennial rye-grass (*Lolium perenne*) seedlings grown on agar plates. *R. robustus* fed between 0.5 and 42.5 C, *X. diversicaudatum* between 5.0 and 37.0 C and *H. conida* between 5.0 and 34.0 C. Between 10 and 25 C there was a direct relationship between temperature and rate of esophageal bulb contractions. Above 25 C the number of esophageal contractions/min did not increase at the same rate and eventually decreased. At the extremes of temperature range, abnormal feeding behaviour was observed. Rates of esophageal bulb contraction did not differ in the different nematode life stages and sexes, or at different feeding sites on the roots. **Key Words:** Perennial rye-grass, *Lolium perenne*, esophageal bulb contraction.

Although temperature is a major environmental factor influencing the behaviour of plant parasitic nematodes (4), information is lacking on its effect on many aspects of nematode activity. The feeding of a large range of plant-parasitic nematodes has been reviewed (2), but the effect of temperature on feeding has not been investigated. The present work outlines a technique for studying the effect of temperature on the feeding of plant-parasitic nematodes, and reports observations on this relationship in three taxonomically diverse species.

MATERIALS AND METHODS

Rotylenchus robustus (de Man) Filipjev used in this study was obtained from soil around the roots of young *Picea sitchensis* (Sitka spruce), *Xiphinema diversicaudatum* (Micoletzky) Thorne from mixed mature deciduous trees, and *Hemicycliophora conida* Thorne from *Lolium perenne* in a glasshouse culture. Nematodes were extracted with a sieving and decanting technique (1), and added to *Lolium perenne* seedlings growing in 0.75% agar on 75-mm-diameter coverslips, in sealed petri dishes. The observations took place in a constant-temperature room where the temperature was varied gradually (never more than 1 degree C/h) between 0 and 45 C. Nematode feeding was observed with a high powered light microscope and video recorder. Perma-

nent recordings of the rate of esophageal bulb contractions were produced with a light pen-and-chart recorder (10). Also recorded were nematode sex and developmental stage, and parts of the root on which the nematode was feeding. Statistical analysis was carried out after the number of contractions/minute had been transformed by $\log_e (Y + 1)$. This transformation was used to stabilize the variance of the contraction rate over the range of temperatures at which observations were made.

RESULTS

More than 100 recordings were made of the feeding of each of the nematode species between 0 and 42.5 C. The relation between the temperature at which nematodes fed and the rate of esophageal bulb contractions was represented best by three quadratic equations (Fig. 1) which accounted for 86% of the total variation. While this relationship appeared linear for each of the species over the temperature range 5 to 25 C, and the fitting of three independent straight lines accounted for 85% of the variation, the improvement by fitting the quadratic equations was highly significant (F. ratio 4.387; d.f. 4, 349; $p < 0.5\%$).

The rate of contraction of the esophageal bulb was consistently greater for *R. robustus* (245 contractions/min at 27 C) than for *X. diversicaudatum* (178 at 34 C) or *H. conida* (119 at 29 C). *R. robustus* also fed over a greater range of temperatures (0.5-42.5 C) than either *X. diversicaudatum* (5.0-36.0 C) or *H. conida* (5.0-34 C).

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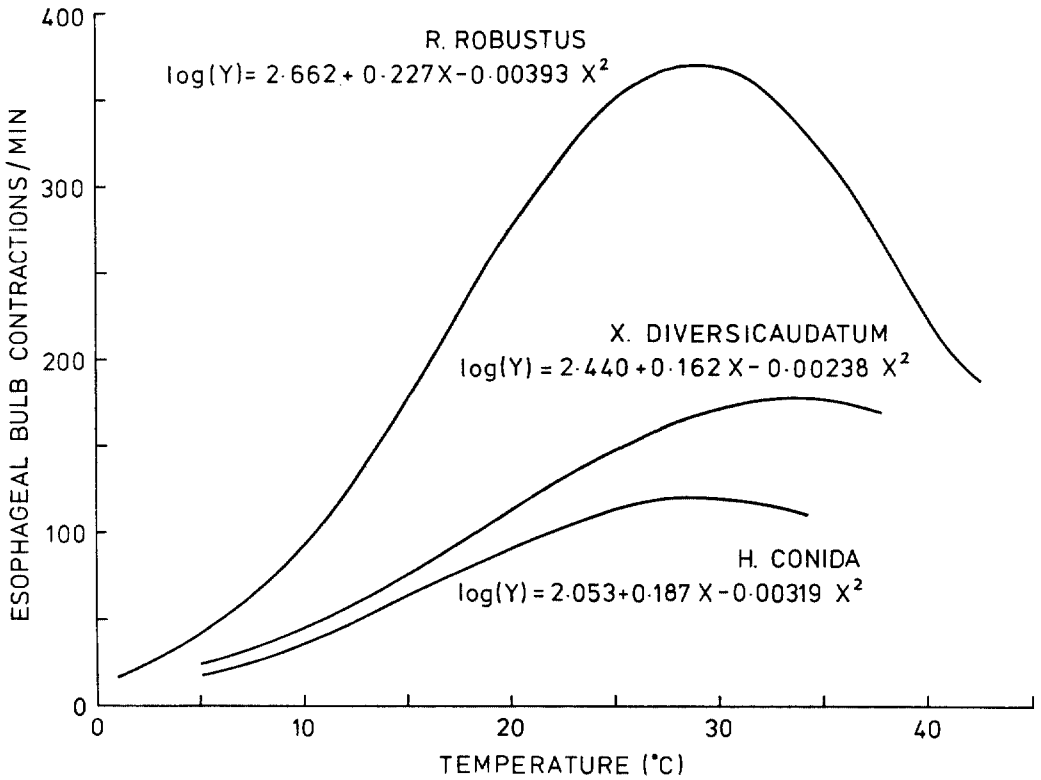


FIG. 1. Effect of temperature on esophageal bulb contractions.

Between 1 and 35 C the contractions of the esophageal bulb of *R. robustus* were regular (Fig. 2). At 0.5 C the muscles of the esophageal bulb sometimes twitched, but the valves failed to open. This was followed by a quiescent phase of 3-5 seconds without valve movement. Above 35 C some nematodes fed normally with a maximum of 440 contractions/min at 37 C, some had short periods of inactivity, and others had slower regular contractions. Above 30 C some aberrant feeding was observed with *X. diversicaudatum* and *H. conida*, the esophageal bulb trying to contract but the valve remaining closed. The proportion of all three species feeding was considerably less at the extremes of temperature than between 10 and 25 C.

X. diversicaudatum usually fed on the root-tip gall, *H. conida* aggregated and fed around lateral root buds, and *R. robustus* fed along the main root. Each species fed occasionally on other parts of the root, but the rate of esophageal bulb contractions was unaffected by feeding site. No differences in rate of contraction were found between male, female, or larvae in any of the species.

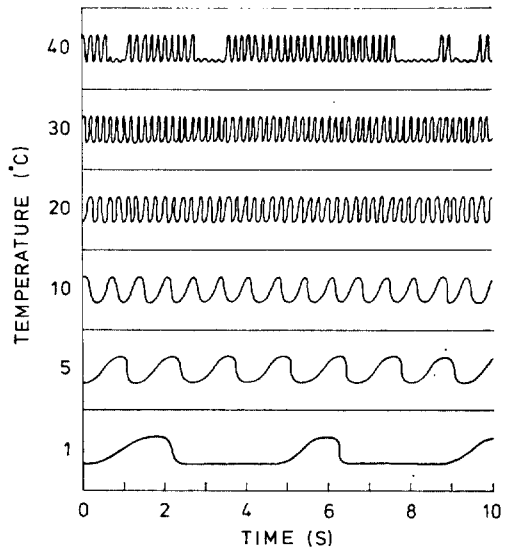


FIG. 2. Diagram from the chart recorder showing the characteristic rhythm of *R. robustus* esophageal bulb contractions for a range of temperatures.

DISCUSSION

Feeding of *R. robustus*, *X. diversicaudatum*, and *H. conida* has been observed

previously (5,6,11) but little attention has been given to the temperature at which feeding took place or to the rate of esophageal bulb contractions. The observations reported here show that temperature affects the rate of feeding of all three nematode species similarly. Since the rate of esophageal bulb contraction is related directly to temperature, these may serve as a measure of nematode activity.

The ability of *R. robustus* to feed over a greater range of temperatures than *X. diversicaudatum* or *H. conida* and its greater rate of esophageal bulb contractions may be explained by differences in the morphology of the nematode pharynx. It has been suggested that nematodes such as *R. robustus* with spherical bulbs are usually shorter nematodes and that these spherical bulbs are required to produce higher pressures than nematodes with elongate bulbs (7,8). *H. conida* is a tylenchid nematode, but it does not have a typical spherical bulb, and it has a long stylet comparable with that of *X. diversicaudatum*.

The higher temperature at which the maximum esophageal bulb contractions occur for *X. diversicaudatum* compared with the other two species may reflect an adaptation to survive in a warmer climate than the other two species (3).

This study indicates the importance of recording the temperature when studying various nematode activities. Tabular comparisons of feeding behaviour of different nematodes (2) would be of greater value if accompanied by information on temperatures at which observations took place.

The low temperature at which *R. robustus* feeds could help explain why the

tolerance of carrots to *R. robustus* decreases at low temperatures (9). The nematode may feed and damage the plant at temperatures below those necessary for growth of carrot roots.

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