NOTA DE INVESTIGACIÓN - RESEARCH NOTE

SEASONAL CHANGES IN CITRUS FIBROUS ROOT STARCH CONCENTRATION AND BODY LENGTH OF FEMALE *PRATYLENCHUS COFFEAE*[†]

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RESUMEN

Duncan, L. W., R. N. Inserra y D. Dunn. 1999. Cambios estaciónales en la concentración de almidón fibroso en las raíces de cítrico y su influencia sobre la longitud del cuerpo en hembras de *Pratylenchus coffeae*. Nematrópica 28:263-266.

Se determinó que los efectos de variación estacional sobre el promedio del largo del cuerpo en hembras *Pratylenchus coffeae* recolectados en un herto de cítricos en Florida se correlacionó con el contenido de almidón fibroso en las raíces. Durante 2.5 años, la relación entre el largo de *P. coffeae* y contenido de almidón en las raíces era maás estrecha en invierno y verano, pero que la longitud promedio aumentaba independientemente del contenido de almidón en otoño. Especulamos que el largo de la hembra es proporcional a la edad, y proponermos que la estructura de la edad de la hembras en una población probablemente interactúa con la disponibilidad de alimento (almidón), resultando en una marcada estacionalidad del largo del cuerpo. El rango del promedio del la longitud del cuerpo fue de 21% (628-760 m), similar al rango estimado para un aislado de *P. penetrans* (20%), auque mayor que el rango descrito para varios aislados de *P. vulnus*.

Palabras claves: Almidón, carbohidratos, morfometría, nutrición, *Pratylenchus coffeae*.

The use of morphometry in nematode taxonomy requires knowledge of the variability of morphometric characters within a taxon. Without independent phylogenetic information, questions about character variability can be circuitous, because most taxonomic designations are based partly on anatomical measurements. A first approach to understanding morphometric variation within a species is to study variation within populations as representative of the minimum expected size ranges (Roman and Hirschmann, 1968). The influence of the environment on morphometry is an important consideration to reveal the fullest possible variation within a population (Bird and Mai, 1967; Tarte and Mai, 1976).

Significant variation was reported in the average sizes of morphometric characters among populations of female *Pratylenchus coffeae* from citrus roots in three Florida orchards and among cohorts of females collected from the same orchard at different times (Inserra *et al.*, 1996). We speculated that the intra population variability resulted partly from changes in the average age of females in the population and/or from nematode growth responses to unknown environmental variables. To

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study possible environmental effects, we conducted a survey during approximately 2.5 years in an orchard in which we: 1) estimated temporal variability in the average body length of female *P. coffeae* and 2) determined relationships between female body length and seasonal changes in temperature, nematode population density, and starch concentration in citrus fibrous roots. Our primary hypothesis was that seasonal change in the starch concentration in fibrous roots would directly influence the size of female *P. coffeae*. We chose body length as a character to investigate seasonal variation, because the sizes of other characters often exhibit allometry with body length (Bird and Mai, 1967) and because high variability in body length within *Pratylenchus* spp. requires great caution when using the character for taxonomic purposes (Geraert, 1990; Loof, 1991).

The survey was conducted near Avon Park in an orchard of Valencia orange (*Citrus sinensis* (L.) Osbeck) trees on rough lemon (*C. jambhiri* L.) rootstock. Samples were collected 25 times at 1-2 month intervals during 33 months beginning in October 1994. A single sample of approximately 100 g (fw) fibrous roots from 3-15 cm depth was collected from 8 to10 trees in the same general vicinity during each sampling event. Roots were rinsed, cut into 2-cm segments, and a 5 g subsample was removed and dried at 40°C. The remaining root sample was weighed and incubated in a plastic bag at 25°C. Nematodes on the exterior of roots after 48 hrs were rinsed from the bag. During the final 13 sampling events, nematodes were counted and expressed per gram of fibrous root. Twenty female nematodes were mounted on water agar (Esser, 1986), heat killed, and an ocular micrometer was used to measure body length at 400× magnification. Dried roots were processed to determine the concentration of soluble and insoluble starch (Duncan and Eissenstat, 1993). Simple and multiple linear regression analyses were used to determine relationships between female body length, and starch concentrations in roots, ambient temperature, or nematode population density in roots. Regressions were performed with data collected during the same month, and also for body lengths measured in the succeeding sampling period from the other variables to consider the possibility of longer time lags in the response. We calculated a range index (RI) = (H-L)/L × 100%, where H and L are respectively the highest and lowest mean length estimate, to compare the magnitude of the range of mean length estimates in this orchard with those of published studies.

The starch concentration in fibrous roots exhibited typical seasonality, increasing during the winter each year and declining in early-late spring (Fig. 1). Starch concentration in roots in early summer ranged from low (ca. 2%) to high (ca. 6%) in alternate years, a pattern reported previously (Duncan *et al.*, 1993). Relatively low starch concentration in roots during the winter of 1996-97 probably resulted from unusually high ambient temperatures. Female body length and starch concentration in roots were positively correlated (Fig. 2). Twenty-four percent ($P < 0.01$) of the variation in body length was explained by the relationship with starch concentration. Between 1994-96, female body length was roughly proportional to starch concentration in roots during the winter through summer periods. However, body length tended to increase independently of starch concentrations each autumn. No significant correlation existed between female body length and soil temperature. Female body length was inversely related to nematode population density in roots ($P = 0.06$, data not shown), but only root starch con-

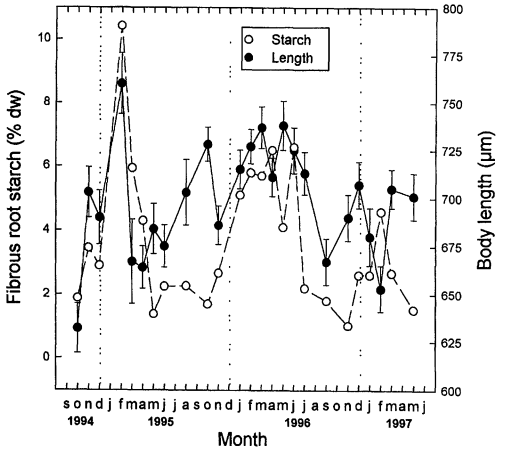

Fig. 1. Variability of fibrous root starch concentration and body length of female *Pratylenchus coffeae* during 34 months in a Florida citrus orchard. Nematode data are means and standard errors (n = 20).

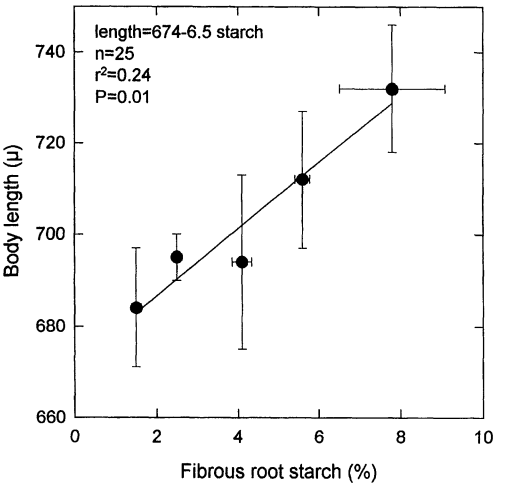

Fig. 2. Relationship between fibrous root starch concentration and body length of female *Pratylenchus coffeae* during 34 months in a Florida citrus orchard. Data (means and standard errors) were pooled by 0.5 increments of starch concentration.

centration was significant when both independent variables were included in the regression analysis.

The plausibility that seasonal starch (food) availability directly influences nematode body length is supported by other studies. Stephenson (1942) reported that the length and width of *Rhabditis terrestris* increased with increased food availability. All morphometric characters examined on *Paratrichodorus* minor were altered by pruning shoots to change the physiology of red clover plants (Bird and Mai, 1967). Nguyen and Smart (1995) speculated that a negative correlation between body length and time of harvesting *Steinernema* spp. from infected insect cadavers resulted from diminishing food. Moreover, seasonality of carbon allocation to the roots of perennial crops appears to be important for other aspects of the biology and ecology of at least some phytoparasites in the rhizosphere. Starch concentration in roots of citrus trees whose physiology was altered by fruit removal was found to be directly related to the fecundity of female *Tylenchulus semipenetrans* (Duncan and Eissenstat, 1993). The population densities of *T. semipenetrans* and of the fungus parasite *Phytophthora nicotianae* were directly related to seasonal changes in fibrous root starch and ketone sugars, respectively (Duncan *et al.*, 1993).

Unknown factors in this study apparently influenced body size to a greater degree than starch. We did not estimate absolute population size nor ages of the females. Seasonal changes in population growth rate will alter the average ages of individuals in each developmental stage. If adult female nematodes continue to grow, temporal variation in average female age may have been a factor contributing to unexplained variation in the relationship between female body length and root starch concentration.

All of our periodic estimates of mean female *P. coffeae* body length from this orchard exceed reported mean values for the species which range from 470 to 600 m (Mizukubo, 1992; Roman and Hirschmann, 1969; Sher and Allen, 1953). The mean and standard deviation of the

coefficients of variation of the female body lengths measured on each sampling date (0.083 ± 0.02) were similar to those (0.086 ± 0.01) reported for four other *Pratylenchus* species (Taylor and Jenkins, 1957). The RI for average body length of *P. coffeae* females during the survey was 21% (628-760 µm). These temporal changes in mean body length were similar to a 20.4% RI for lengths of a *P. penetrans* population grown on different host plants (Tarte and Mai, 1976), but were nearly double the RI of 12% for mean body length of 6 geographically separated populations of *P. vulnus* from Europe and America (Doucet *et al.*, 1996). These comparisons suggest higher variability of body length among *P. coffeae* than *P. vulnus*. Moreover, our unpublished measurements of 14 populations of *P. coffeae* from worldwide sources indicates a body length RI of at least 47% (517-760 µm). Nevertheless, the variability among our isolates of *P. coffeae* worldwide does not appear high when compared with RI's reported for single isolates of *Steinernema feltiae* (RI = 45%) and *S. riobravis* (RI = 39%), reared either *in vitro* or *in vivo* (Nguyen and Smart, 1995).

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