Noctuidonema guyanense (Nematoda: Aphelenchoididae): Population Profiles on Male and Female Fall Armyworm Moths[1,2]

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ABSTRACT The distribution of *Noctuidonema guyanense* Remillet and Silvain (Nematoda: Aphelenchoididae) populations on wild female, laboratory-reared female, and wild male moths of *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) was determined. Populations of all life stages of *N. guyanense* were aggregated ($P < 0.05$) on abdominal segments 7-10 of wild female and moderately infested (<100 nematodes), laboratory-reared female moths. Nematodes also aggregated on abdominal segments 7-10 on heavily infested (>300 nematodes), laboratory-reared female moths, but larger populations of all mobile life stages migrated from posterior to anterior abdominal segments of a host. On wild male moths, *N. guyanense* populations tended to disperse along the host's abdomen, with significant aggregates of eggs and neonates on abdominal segments 8-10 and smaller aggregates of adults and juveniles on abdominal segments 1-2. Nematodes avoided colonization of the head of nearly all hosts of either sex.

KEY WORDS *Spodoptera frugiperda,* Fall armyworm, Entomogenous nematode, Biological control, *Noctuidonema guyanense.*

Noctuidonema guyanense Remillet and Silvain parasitizes adults of the fall armyworm, *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) throughout the tropical Americas (Rogers et al. 1991). Its obligatory parasitic relationship with hosts, its host specificity, and its insidious pathogenicity to hosts (Marti et al. 1990) make *N. guyanense* a candidate for biological control of the fall armyworm. Also, infested moths autodisseminate *N. guyanense* as they migrate from overwintering and other habitats to disperse into new habitats (Simmons and Rogers 1991). *Noctuidonema guyanense* is an obligate ectoparasite of moths and has no free-living infective stage. Hence, *N. guyanense* must be transmitted to new hosts as infested moths copulate with uninfested moths (Simmons and Rogers 1990). The mechanics of its transmission and redistribution on new hosts were reported by Rogers and Marti (1992). The nematode appears to redistribute itself on hosts based on sex of the host. This paper delineates observed differences in the distribution pattern of *N. guyanense* on male and female fall armyworm moths.

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[2] The results reported in this paper are for research purposes only. The mention of a trade name or proprietary product does not imply an endorsement by either the USDA or the Agricultural Research Service..

Materials and Methods

Wild *S. frugiperda* females were captured by hand from the foliage of corn and grain sorghum in Tift County, GA, in 1989 and 1990. Wild males were captured in Universal® moth traps (International Pheromone Systems) baited with rubber septa impregnated with a commercially prepared sex pheromone (Raylo Chemicals Ltd., Edmonton, Canada) placed near the fields in which females were captured. Captured moths were taken immediately to the laboratory and killed by lightly crushing their thorax. Wings and legs of immobilized moths were removed, and the moths were pinned through the thorax to the bottom of a wax-lined dish. Body segments were removed from the moths by gently stretching the abdomen posteriad with forceps and cutting through intersegmental membranes with dissecting scissors. Excised segments (including the head and thorax) were preserved individually in vials containing 10% buffered formalin and a few drops of Tween 80® to aid in wetting the cuticle. Abdominal segments 1-2 and 8-10 from females and 1-2 and 9-10 from males were preserved as intact units in separate vials.

Laboratory-reared female moths were mated with wild male moths and held in an environmental chamber from 0.25 to 168 hours at 27.8°C, 80% R.H., and 14:10 L:D photoperiod. At the end of the incubation period, infested female moths were killed and preserved as described for wild females. The distribution of *N. guyanense* populations on moderately infested (<100 nematodes/host), laboratory-reared female moths, and heavily infested (>300 nematodes/host), laboratory-reared female moths were compared with distribution of nematode populations on wild female (<100 nematodes/host) and male (<100 nematodes/host) moths. For the purpose of this study, the distribution of *N. guyanense* on intermediately infested (100-300 nematodes/host) moths was not determined.

Nematodes were removed from preserved moth segments by gently scraping the scales with forceps and then examined through a stereoscopic microscope, sorted by stage and gender, and counted. Nematodes from 10 infested moths from each group of hosts were used to analyze their distribution, developmental stage, and number per host segment. The number of nematodes was transformed to $\sqrt{\text{value} + 1}$, and analyzed by the General Linear Models (GLM) procedure of SAS (SAS Institute 1985). Significantly different means were separated by LSDs and back-transformed by $\text{value}^2\text{-}1$.

Results and Discussion

A population curve for *N. guyanense* on wild fall armyworm females showed aggregation of nematodes on the posterior abdominal segments of hosts (Fig. 1). Significantly more ($P<0.05$) nematodes of all stages occurred on abdominal segments 6-10 than on segments anterior to the sixth segment. Few nematodes occurred anterior to the 6th abdominal segment on wild female moths; only juveniles were observed on the thorax. No nematodes were found on the head of any wild female moth, nor on the wings of any moth. The distribution of *N. guyanense* on moderately infested, laboratory-reared female moths (Fig. 2) resembled its distribution on wild females. Male and female nematodes were most numerous ($P<0.05$) on abdominal segments 8-10, neonates and eggs were

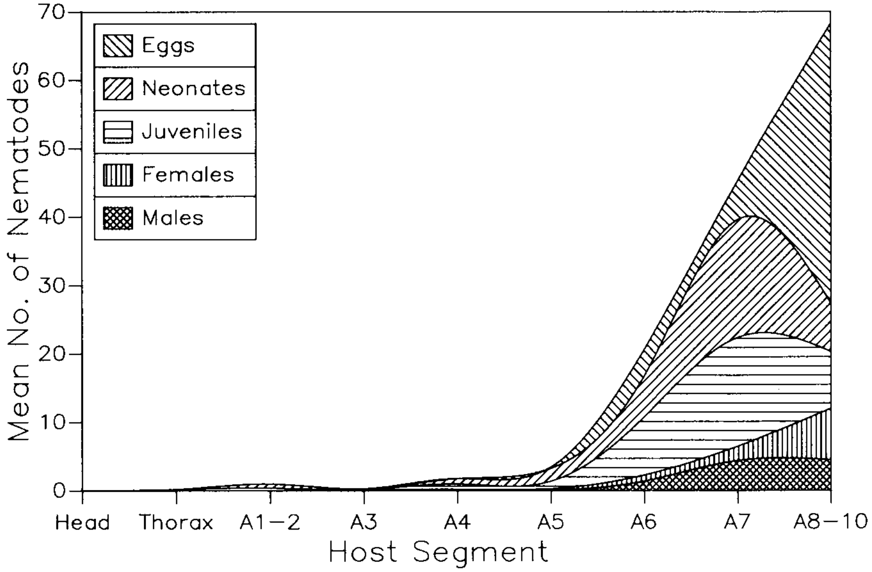

Fig. 1. Distribution of *N. guyanense* on wild fall armyworm females (A = abdominal.

concentrated on segments 6-10, and juveniles were concentrated on the seventh abdominal segment. As on wild female hosts, juvenile nematodes on moderately infested laboratory reared female moths significantly outnumbered other stages anterior of the host's sixth abdominal segment.

The distribution of *N. quyanense* on heavily infested, laboratory-reared female hosts was similar to the distribution on moderately infested moths, except that the number of nematodes of a given stage per host segment was significantly greater (Table 1). As populations of *N. guyanense* increased on a moth, nematodes became more numerous on anterior segments of the host's abdomen. However, in dense populations nematodes colonized the thorax and head of female moths. Adult nematodes were not found on the head of hosts. Primarily neonates and juveniles occurred anterior to the host's sixth abdominal segment on heavily infested female hosts. At the highest population density, about 7% of the nematodes were adults, compared with 20% and 16% adults on wild and moderately infested, laboratory-reared female hosts, respectively. Male and female nematodes and their eggs were most numerous on abdominal segments 7-10 of female hosts, while neonates and juveniles were most numerous on segments 6-7 and 7-10, respectively. Analyses of our data confirmed that *N. guyanense* aggregate on the posterior abdominal segments of female fall armyworms.

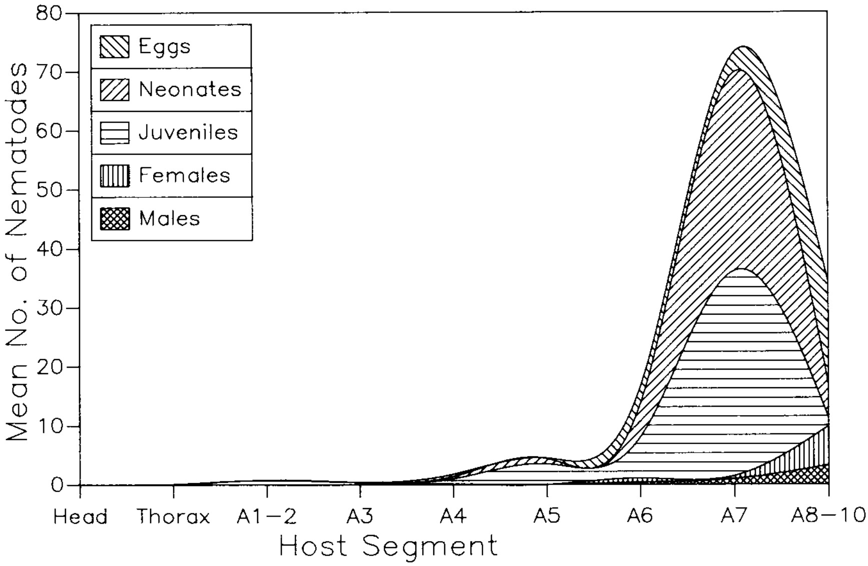

Fig. 2. Distribution of N. guyanense on moderately infested (<100 nematodes), laboratory-reared fall armyworm females (A = abdominal).

Populations of *N. guyanense* were more evenly distributed along the abdomen and thorax of wild male fall armyworms (Table 2). The only significant aggregation ($P<0.05$) of nematodes on male hosts involved eggs on abdominal segments 8-10 and neonates on the eighth abdominal segment. Also, more male nematodes occurred on the first and second abdominal segments than on the third abdominal segment of male hosts. Analyses of within-segment populations on male hosts showed fewer ($P<0.05$) males than juveniles on abdominal segments 3 and 6-7, and more eggs than other stages on abdominal segments 8-10. As on female hosts, nematodes mostly avoided colonizing the head of male fall armyworms.

Host factors which may cause a dissimilar distribution of *N. guyanense* on female and male fall-armyworm moths are unclear. We know that nematodes attach themselves and penetrate the host cuticle via a relatively long stylet (Rogers et al. 1991, Remillet and Silvain 1988), and that infestation of moths produces microscopic evidence of insidious pathologic effects on a host (Marti et al. 1990). Host tissues and/or body fluids imbibed by *N. guyanense* remain unidentified. However, the hue of mature nematodes approximates the hue of host hemolymph, and changes as adult moths feed on dyed sugar water (unpublished data). Nevertheless, *N. quyanense* prefers to aggregate on abdominal segments 8-10 in female moths.

Table 1. Distribution of *Noctuidonema guyanense* from three populations of infested fall armyworm females.

	$\bar{X}$ No. nematodes per host segment*		
		Laboratory infestation	
Host segment	Wild	Moderate†	Heavy‡
Head	0 a,e	0 a,e	0.2 a,g
Thorax	0.2 b,e	0.1 b,e	4.1 a,fg
Abdomen			
1-2	0.6 b,e	0.5 b,e	3.8 a,fg
3	0.3 b,e	0.3 b,e	3.0 a,fg
4	1.3 b,e	0.7 b,e	6.0 a,fg
5	2.4 b,e	2.3 b,e	15.7 a,f
6	16.2 b,d	12.9 b,d	104.7 a,e
7	31.5 b,cd	56.8 b,c	333.9 a,c
8-10	54.8 b,c	26.4 b,d	187.0 a,d

* Means across columns (within segments) followed by different letters (a or b) or within columns (across segments) followed by different letters (c-g) are significantly different at $P < 0.05$ (SAS Institute 1985).

† $\bar{X}$ of < 100 nematodes/host.

‡ $\bar{X}$ of > 300 nematodes/host.

The aggregation of *N. guyanense* on the apex of female moth abdomens may be an artifact of host mating behavior, since moths copulate in tandem with their heads pointing in opposite directions (Rogers and Marti 1992). However, the tendency for immature *N. guyanese* to migrate anteriorly on male moths indicates that physiological differences between the sex of hosts also may influence its dissimilar distribution on male and female moths. Recent laboratory feeding studies indicate that nematodes feeding on gravid female hosts reduce viability of their eggs (unpublished data). Also, at an unknown population threshold, *N. guyanense* obviously interferes with flight of hosts. Populations of *N. guyanense* on male moths captured in pheromone traps average from 35 to 50 nematodes per host: yet in the laboratory, moths frequently support more than 1,000 nematodes (Rogers et al. 1992). Our preliminary results favorably suggest that *N. guyanense* offers unique opportunities as an augmentative biological control agent for assisting in the management of the fall armyworm. Our objective for the near future is to document this potential.

Table 2. Distribution of *Noctuidonema guyanense* on wild males of the fall armyworm.

Host segment	$\bar{X}$ No. nematodes per stage and gender per host segment*				
	Male	Female	Juvenile	Neonate	Egg
Head	0 a,e	0 a,e	0.1 a,d	0 a,e	0 a,d
Thorax	0.1 a,e	0.1 a,e	2.0 a,cd	1.0 a,de	0.3 a,d
Abdomen					
1-2	2.6 a,c	2.5 a,cd	11.4 a,c	2.1 a,de	3.5 a,d
3	0.5 b,c	1.2 ab,de	7.1 a,cd	2.3 ab,de	4.2 ab,d
4	1.3 a,cde	1.8 a,cde	9.1 a,c	3.7 a,de	4.2 a,d
5	1.9 a,cd	1.5 a,cde	7.6 a,cd	1.4 a,de	3.0 a,d
6	1.1 b,cde	1.4 ab,cde	7.5 a,cd	3.0 ab,de	3.7 ab,d
7	0.9 b,cde	1.0 b,de	5.8 a,cd	4.7 ab,d	3.1 ab,d
8	2.5 b,c	3.9 b,c	9.4 b,c	13.9 ab,c	28.0 a,c
9-10	2.7 b,c	2.7 b,cd	3.2 b,cd	4.2 b,de	22.9 a,c

*Means across columns (within segments) followed by different letters (a or b), and within columns (across segments) followed by different letters (c-f) are significantly different at $P < 0.05$ (SAS Institute 1985).

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