A REPORT ON THE RELATIONSHIP BETWEEN *NOSEMA FUMIFERANAE* INFECTION IN FEMALE SPRUCE BUDWORM AND THAT OF THEIR OFFSPRING

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Nosema fumiferanae is a naturally occurring microsporidian parasite of the spruce budworm, *Choristoneura fumiferana* (Clem.), (Thomson 1955; Wilson 1977). It has been well established that this microsporidium is transovarially transmitted to offspring from infected females (Thomson 1958; Wilson 1982), but it has never been determined if a relationship exists between the intensity of infection (spores per insect) of the female and the intensity of infection in her offspring. This is an important consideration in understanding the role of this microsporidium in the natural regulation of spruce budworm populations, especially since dosage-mortality tests indicate that higher initial spore doses cause greater larval mortality (Wilson 1985).

Infected spruce budworm females were obtained by exposing laboratory reared, disease-free, early fourth-instar larvae to spores of *N. fumiferanae*. Larvae were reared in 28.4 mL plastic cups containing a synthetic diet (Grisdale 1973), the surface of which was treated with 200 µL of an aqueous suspension of 1 x 10^6 spores/mL. Approximately 8 larvae were placed in each of 25 cups. Insects were reared on the treated diet for 7 days, then placed on fresh untreated diet. A similar number of larvae were reared on untreated diet to provide healthy males. The cups were then checked every other day to ensure that the diet was free of fungal contamination. Upon adult emergence, individual matings were made using the method of Wilson (1984). All insects were maintained at room temperature (21-23°C) and 40-60% relative humidity. Spore counts, based on a method of Cantwell (1970), were performed individually on adults and their offspring just after hatching (first-instar), four weeks after hatching (second-instar), and in one case

after cold storage to complete diapause. Numbers examined are indicated in Table 1.

In a supplementary test, female spruce budworm pupae, naturally infected with *N. fumiferanae*, were collected from two field populations: Gargantua, an area of decreasing budworm infestation and high levels of *N. fumiferanae* infection (~60%), and Black Sturgeon Lake, an area of increasing budworm infestation with infection levels of about 30% (Wilson 1986). Because of the numbers involved, spore counts were performed on pooled samples of adults and their offspring from each area and the results were compared with the laboratory-reared insects.

Exploratory analysis of the data (Fig. 1, Tables 1 and 2) suggested a logarithmic relationship between spores per offspring and spores per adult. Linear regression analysis of the log-transformed data suggested a relationship of the form $y = Ax^b$, where y = spores per offspring, x = spores per adult, and A and b are constants. These constants were estimated by fitting this model to the data using non-linear regression (Dixon 1983). Although there is considerable scattering in the data, the model describes a general trend by which offspring spore counts increase at a declining rate as adult spore counts increase. Table 1 provides additional evidence indicating a tendency for offspring spore counts to increase with those of their mother even though statistical comparisons could not be made on field-collected spruce budworm because spore counts were made on pooled material. Infected females from the Gargantua plot had spore counts that averaged 12-fold higher than those from Black Sturgeon and 3-fold higher than the laboratory insects. Similarly, offspring from Gargantua females averaged 14-fold

more spores than offspring from Black Sturgeon and 13-fold more than offspring from the laboratory stock. The average number of spores per adult and larva for laboratory infected spruce budworm was marginally higher in both cases than for the Black Sturgeon insects.

There was a reduction in spores per larva when the insects molted from the first- to the second-instar (Table 1). This is probably a result of loss of the major site of spore production in the mid gut cells (Thomson 1955) when molting larvae empty their gut and also shed the fore and the hind portion of the alimentary canal with the cuticula. As expected, there was no change in mean spore count per larva for second-instars four weeks after hatching and for those coming out of the hibernacula after cold storage (unreported data).

Of a total of 1,283 offspring that were examined from 32 individual matings, 90% were infected (range 30 to 100% for individual families). Thus, if the mother is infected an average of 90% of her offspring will also be infected as demonstrated previously (Wilson 1982).

This study indicates that there is a direct relationship between microsporidian spore intensity in female spruce budworms and that of their offspring. Thus, as suggested by Wilson (1986), it is probable that the mortality of early instar spruce budworm larvae in the field is related to the quantity of *N. fumiferanae* passed from an infected female to her offspring. These findings and the fact that *N. fumiferanae* also affects the fecundity of infected females should increase our understanding of the importance of this microsporidium in the population dynamics of the spruce budworm.

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Table 1. Relationship between intensity of *Nosema fumiferanae* infection in female spruce budworm to that of their offspring. Number of individuals examined in parenthesis.

	Mean spores per adult	Mean spores per larva	
		I Instar	II Instar
Laboratory[a]	6.0×10^7 (8)	4.3×10^4* (96)	2.7×10^4* (96)
Gargantua[b]	2.0×10^8 (30)	5.8×10^5 (183)	-
Black Sturgeon[b]	1.6×10^7 (15)	4.0×10^4 (26)	-

[a] Individual spore counts performed on insects.

[b] Spore counts performed on insects as a group.

* Significantly different at 5% level.

Table 2. Parameters for the relationship between spores per adult and spores per offspring ($Y = A_x{}^b$). S = .211, standard error of the estimate = .711, sample size = 39 adults.

	Estimate	Asymptotic standard error	Coefficient of variation	t	P
A	0.84	0.147	0.175	5.724	< .001
b	0.39	0.132	0.341	2.932	< .01

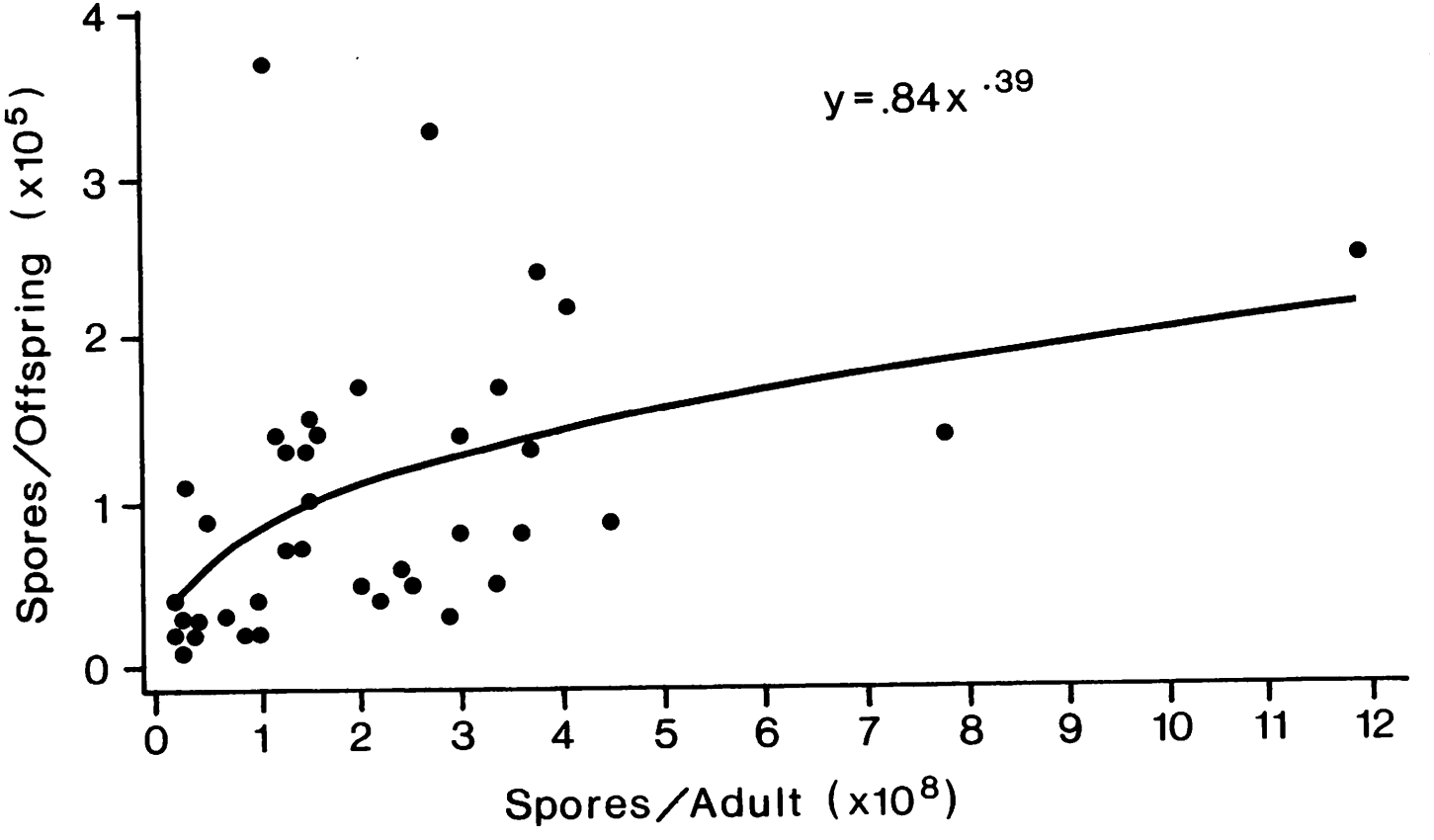

Fig. 1. The relationship between spores per spruce budworm female adult and the spores in her offspring.