Evaluation of a Nonconventional Insecticide and Appropriate Application Timing for Destruction of Gypsy Moth (Lepidoptera: Lymantriidae) Egg Masses

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ABSTRACT Two field studies were conducted in 2001–2002 and 2003 to evaluate the effectiveness and appropriate application timing of Golden Pest Spray Oil (GPSO) for destruction of gypsy moth, *Lymantria dispar* (L.) (Lepidoptera: Lymantriidae), egg masses in Wisconsin. GPSO is a commercially available, registered pesticide that is predominantly comprised of a soybean-oil base (93%); its primary mode of action is by means of suffocation. Because gypsy moth spends the majority (>75%) of its life cycle in the egg stage (August–April), the potential utility of this product by arborists, city foresters, landscapers, and homeowners is high, especially because GPSO is a United States Environmental Protection Agency registered, nonconventional pesticide that is considered relatively nontoxic. When GPSO was applied at a 1:1 ratio with water, >96% control of gypsy moth egg masses was achieved, regardless of application timing (October, 3 d before egg hatch).

KEY WORDS ovicide, ornamental pest, gypsy moth

THE GYPSY MOTH, *Lymantria dispar* (L.), is one of the most important pests of hardwood trees in the eastern United States, it defoliated nearly 13 million acres in 1981, this area is larger than Rhode Island, Massachusetts, and Connecticut combined (McManus et al. 1989). Gypsy moth is equally as serious of a pest of shade trees in urban communities (Webb et al. 1994). Gypsy moth has been reported to feed on >300 species of plants (Liebhold et al. 1995), including numerous woody ornamental plants that are regarded as highly valuable specimen plants in the urban landscape.

The larval stage is the damaging life stage. Gypsy moth larvae defoliate hosts by entirely consuming leaf tissue (Campbell and Valentine 1972, Witter et al. 1992, Hicks et al. 1993), resulting in weakened trees and unacceptable esthetic injury. Highly valuable specimen plants such as oak, crab apple, paper birch, linden, as well as other woody ornamental plants are among the preferred hosts of gypsy moth. Sustained, year-after-year defoliation of plant material may result in tree decline and ultimate death (Witter et al. 1992. Gottschalk 1993). Additionally, trees weakened by consecutive defoliations are vulnerable to attack by disease organisms and other insects such as the two-lined chestnut borer, *Agrilus bilineatus* (Weber) (McManus et al. 1989).

Payne et al. (1973) reported that landscape trees in Massachusetts add an estimated 7% to the property value of homes. Subsequently, homeowners regularly choose to protect individual landscape trees, especially because the replacement cost of a comparatively smaller landscape tree with a diameter of 18 cm is estimated at $500–600, not including cost of removing the preceding tree.

Moreover, all other gypsy moth life stages, including the pupal, adult, and egg, are considered to be a nuisance or esthetically unpleasing. Occasionally, human health is impacted due to allergens associated with larvae, pupae, egg masses, as well as adults. As larvae reach physiological maturity and pupation occurs, pupal cases frequently create unsightly eyesores and occasionally interfere with human activity, especially in high-traffic areas such as picnic, entertainment, and other recreational areas. During the short-lived adult life stage (July–August), adult gypsy moths are often perceived as annoying; males, in abundant numbers, aggressively orient and fly to females. The egg stage also is considered a serious nuisance because gypsy moth egg masses are frequently deposited on the outer bark of trees, siding of homes and buildings, lawn furniture and ornaments, as well as on numerous other recreational equipment. Gypsy moth eggs are laid in masses that contain between 300 and 1000 eggs (Moore and Jones 1987) per egg mass. Although adult gypsy moth females have wings, they are incapable of flying; thus, they typically mate and lay their eggs in proximity to their respective pupation site. For this reason, gypsy moth egg masses often occur in large numbers in relatively close proximity. Gypsy moth is an univoltine insect that spends >75% of its life cycle in the egg stage; thus, gypsy moth egg masses are visible for >9 mo (August– early May). This biological information coupled with related efficacy data re-

Table 1. Mean number of *L. dispar* moth eggs and mean percentage of survival (±SEM) in 2001–2002 under 11 application timings of Golden Pest Spray Oil applied to gypsy moth egg masses

Treatment application		Mean no., total eggs	Mean no., eggs hatched	Mean % survival[a]
Date	DBEH			
16 Oct. 2001	203	535.3 ± 40.1	4.8 ± 1.3a	0.9 ± 0.7a
19 Nov. 2001	169	587.8 ± 57.4	0.7 ± 0.3a	0.1 ± 0.1a
20 Dec. 2001	138	656.8 ± 85.2	5.0 ± 3.1a	0.8 ± 0.7a
18 Jan. 2002	109	523.8 ± 56.9	2.3 ± 1.5a	0.4 ± 0.4a
25 Feb. 2002	71	499.3 ± 78.2	1.5 ± 0.7a	0.3 ± 0.1a
26 Mar. 2002	42	532.0 ± 45.3	1.3 ± 0.6a	0.2 ± 0.1a
9 April 2002	28	480.7 ± 20.3	5.2 ± 1.3a	1.1 ± 0.6a
16 April 2002	21	467.8 ± 44.6	5.2 ± 1.3a	1.1 ± 0.8a
23 April 2002	14	453.3 ± 51.7	4.8 ± 1.1a	1.1 ± 0.4a
30 April 2002	7	371.7 ± 23.3	5.8 ± 1.2a	1.6 ± 0.5a
Control		551.4 ± 53.5	502.8 ± 53.9b	91.2 ± 10.1b

Means followed by the same letter are not significantly different by Tukey's HSD test ($P = 0.05$). DBEH, days before egg hatch.
[a] Mean percentage of survival was calculated by 100 * (no. of gypsy moth eggs hatched by total no. eggs).

ported by Culin et al. (1993) that suggests lightweight oil is a viable pesticide that causes larval mortality rendered the rational for conducting a study to determine the effectiveness of an ovicide for control of gypsy moth.

A field experiment was conducted to evaluate the effectiveness and application timing of a commercially available insecticide, Golden Pest Spray Oil (GPSO, Stoller Enterprises, Houston, TX), containing a soybean-oil base to control gypsy moth. The potential utility by arborists, landscapers, and homeowners is high, especially because this vegetable oil-based product is a biologically based, nonconventional insecticide that is relatively nontoxic.

Materials and Methods

Two field sites were selected based on an adequate endemic infestation of healthy gypsy moth egg masses. At each field site, six trees were randomly selected, respective trees were located ≈20 m apart. Colored push-pins were inserted into the bark within 1.3 cm of a respective gypsy moth egg mass. A color code using the colors of the rainbow (i.e., red, orange, yellow, green, blue, indigo, and violet) were used to identify the respective application timing of a 1:1 ratio of GPSO (Stoller Enterprises, Houston, TX) and water. GPSO is a soybean-oil based product; similarly to other vegetable oils, its mode of action is by suffocation (Davidson et al. 1991). GPSO contains 93% soybean oil and 7% surfactant/penetrant; it is a commercially available, registered pesticide labeled for control of gypsy moth eggs. A hand-held, 0.5-liter plastic container equipped with an adjustable spray nozzle was used to treat the gypsy moth egg masses. Five squirts containing ≈6.2 ml of GPSO and water were applied to each egg mass, until saturation was achieved, at an approximate range of 20–30 cm from the egg mass. A growing degree-day model as reported by Johnson et al. (1983) was used to predict egg hatch; as egg hatch was anticipated, egg masses were monitored daily in the field. Once egg hatch occurred, all egg masses were immediately collected by scraping them from the trees and returned to the laboratory to determine larval survival. Two field trials were conducted, Madison, WI (2001–2002) and Oconomowoc, WI (2003), trials 1 and 2, respectively.

Trial 1. Madison, WI, 2001–2002. A study site was selected at the University of Wisconsin-Madison campus that consisted of white oak, *Quercus alba* (L.), trees infested with an estimated 350 healthy egg masses per hectare. Six gypsy moth egg masses were treated with GPSO on the following dates in 2001–2002: 16 October 2001, 19 November 2001, 20 December 2001, 18 January 2002, 25 February 2002, 26 March 2002, 9 April (28 d before egg hatch [DBEH], 16 April 2002 (21 DBEH), 23 April (14 DBEH), 30 April (7 DBEH), and six untreated egg masses. The untreated egg masses were used to compare the respective treatment effects.

Trial 2. Oconomowoc, WI, 2003. A study site was identified in Oconomowoc, Waukesha County, on an urban residential property that had numerous relatively large diameter white oak trees infested with an estimated 800 healthy egg masses per hectare. GPSO treatments were applied to six gypsy moth egg masses on the following dates in 2003: 11 April (28 DBEH), 18 April (21 DBEH), 25 April (14 DBEH), 2 May (7 DBEH), 6 May (3 DBEH), and six untreated egg masses. As in trial 1, the untreated egg masses were used to compare the treatment effect.

In both trials, the total number of eggs hatched in respective treated gypsy moth egg masses were counted and compared with the untreated egg mass. All percent data were arcsine square root-transformed before statistical analysis. If treatment means were determined to be significantly different by one-way analysis of variance (ANOVA), they were separated by Tukey's honestly significant difference (HSD) test by using Statistica 6.1 (StatSoft Inc., 2003).

Results and Discussion

Trial 1. Madison, WI, 2001–2002. Regardless of the time of application (16 October–7 DBEH), all egg masses treated with GPSO exhibited >98% mortality (Table 1). No significant difference was observed among any of the GPSO treatments (Table 1). The

Table 2. Mean no. of *L. dispar* eggs and mean percentage of survival (±SEM) in 2003 under six application timings of Golden Pest Spray Oil applied to gypsy moth egg masses

Treatment application		Mean no., total eggs	Mean no., eggs hatched	Mean % survival[a]
Date	DBEH			
11 April 2003	28	416.2 ± 58.3	16.2 ± 3.1a	3.9 ± 1.6a
18 April 2003	21	327.7 ± 36.9	4.0 ± 1.0a	1.2 ± 0.5a
25 April 2003	14	354.7 ± 20.5	7.5 ± 2.0a	2.1 ± 1.0a
2 May 2003	7	441.5 ± 50.5	10.7 ± 2.1a	2.4 ± 1.1a
6 May 2003	3	371.5 ± 24.9	8.2 ± 2.3a	2.2 ± 1.2a
Control		426.7 ± 46.4	383.3 ± 41.9b	89.8 ± 9.2b

Means followed by the same letter are not significantly different by Tukey's HSD test ($P = 0.05$). DBEH, days before egg hatch.
[a] Mean percentage of survival was calculated by 100 * (no. of gypsy moth eggs hatched by total no. eggs).

results of this study suggest that GPSO is an effective gypsy moth egg mass control strategy. Moreover, GPSO can effectively be applied to gypsy moth egg masses from October through 7 d before egg hatch.

Trial 2. Oconomowoc, WI, 2003. Similarly to the results in trial 1, all gypsy moth egg masses treated with GPSO had >96% mortality when applied 28–3 d before egg hatch, regardless of the treatment timing (Table 2). No significant difference was observed among any of the GPSO-treated egg masses (Table 2). Again, the results of this trial suggest that GPSO can effectively be applied up to 3 d before egg hatch.

Mean larval survival in the untreated gypsy moth egg masses was 91.2 and 89.8%, trials 1 and 2, respectively. These results were comparable to work by Webb et al. (1994) where >90% survival occurred in the untreated egg masses. The results of this study suggest that GPSO can effectively be applied to gypsy moth egg masses from October through 3 d before egg hatch. These results further support the work of Webb et al. (1994) that reported "it is reasonable to conclude that Golden Natur'l Spray Oil (currently registered as GPSO) would likely be effective throughout the gypsy moth egg stage."

This information is highly valuable to arborists, city foresters, landscapers, nursery growers, and homeowners, because gypsy moth spends the majority (>75%) of its life cycle in the egg stage. Subsequently, ample time is available to pest managers for GPSO treatments to be applied, especially in the traditionally less busy winter months (November–March). Moreover, in the early spring, as homeowners begin gardening and yardwork activities, they are more likely to observe gypsy moth egg masses. Thus, they have a viable alternative gypsy moth control strategy with the use of GPSO. Furthermore, due to the ever-growing public concern over the use of conventional pesticides, registered, relatively nontoxic control products are highly valued and demanded. Although not quantitatively measured, empirical observations revealed that when GPSO was applied according to the manufacturers' labeled guidelines, no apparent staining or damage occurred to the tree bark. For the aforementioned reasons and on the basis of this research, GPSO is a viable control agent that should be viewed favorably and used by many as an alternative to conventional insecticides.

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