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Evaluation of the effectiveness of integrated management and mating disruption in controlling gypsy moth *Lymantria dispar* (Lepidoptera: Lymantriidae) populations

GOODARZ HAJIZADEH♥, MOHAMMAD REZA KAVOSI
Department of Forest Sciences, Gorgan University of Agricultural Sciences and Natural Resources, Beheshti St. 386, Gorgan, Golestan, Iran.
Tel./Fax. +98 171 2227867, ♥email: Goodarzhajizadeh@gmail.com

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Abstract. *Hajizadeh G, Kavosi MR. 2012. Evaluation of the effectiveness of integrated management and mating disruption in controlling gypsy moth* Lymantria dispar *(Lepidoptera: Lymantriidae) populations. Nusantara Bioscience 4: 27-31.* This study was conducted during 2008 and 2009 in Daland National Park (north of Iran) to compare the effectiveness of mechanical control used in combination with mating disruption (integrated management) and only mating disruption in controlling gypsy moth, Lymantria dispar (L.) (Lepidoptera: Lymantriidae). Male moths and egg mass counts were taken before (2008) and after (2009) the two treatments were applied. In sites with integrated management and with mating disruption only, 1,828 and 1,793 egg masses/tree, and 412.75 and 207.75 male moths/trap were observed, respectively. Both the numbers of egg masses/tree and of male moths/trap were significantly lower in sites with integrated management than in sites with only mating disruption. This study shows that integrated management was more effective than mating disruption in reducing infestation levels in the study site.

Key words: egg masses, integrated management, Lymantria dispar, mating disruption, mechanical method, pheromone traps

Abstrak. *Hajizadeh G, Kavosi MR. 2012. Evaluasi tentang efektifitas manajemen terpadu dan gangguan perkawinan dalam mengontrol populasi ngengat gipsi* Lymantria dispar *(Lepidoptera: Lymantriidae). Nusantara Bioscience 4: 27-31.* Penelitian ini dilakukan selama tahun 2008 dan 2009 di Taman Nasional Daland (bagian utara Iran) untuk membandingkan efektivitas pengendalian mekanis yang digunakan dikombinasi dengan gangguan perkawinan (manajemen terpadu) dan hanya gangguan perkawinan saja dalam pengendalian ngengat gipsi, Lymantria dispar (L.) (Lepidoptera: Lymantriidae). Penghitungan ngengat jantan dan jumlah massa telur dilakukan sebelum (2008) dan setelah (2009) dua perlakuan diterapkan. Di lokasi dengan manajemen terpadu dan dengan gangguan perkawinan saja, terdapat 1.828 dan 1.793 massa telur/pohon, serta 412,75 dan 207,75 ngengat jantan/perangkap. Jumlah massa telur/pohon dan ngengat jantan/perangkap secara signifikan jauh lebih rendah pada lokasi dengan manajemen terpadu daripada di lokasi dengan gangguan perkawinan saja. Studi ini menunjukkan bahwa manajemen terpadu lebih efektif daripada gangguan perkawinan dalam mengurangi tingkat serangan hama di lokasi penelitian.

Kata kunci: massa telur, manajemen terpadu, *Lymantria dispar*, gangguan perkawinan, cara mekanik, perangkap feromon

INTRODUCTION

The gypsy moth, *Lymantria dispar* (L.) (Figure 1), is probably the most important forest defoliating pest in the northeastern United States. Defoliation and tree mortality associated with gypsy moth outbreaks can cause a multitude of ecological and economic effects (Twery 1991; Gottschalk 1993). In Iran, gypsy moth was observed for the first time in oak forests at Guilan state region, north Iran in 1937 (Kavosi 2008). The activity of this pest in central parts, western and southwestern forests of Iran has been admitted outside these regions (Hajizadeh and Kavosi 2011). The largest outbreaks of gypsy moth occurred in Talesh forest in Guilan state region in 1975 (Kavosi 2008).

In the 1960s and 1970s, most treatments for controlling this pest were conducted using conventional synthetic pesticides like carbaryl (sevin) and dylox (trichlorfon). Since 1983, these have been increasingly replaced by biorational compounds like *Bacillus thuringiensis* variety *kurstaki* (Berliner) and dimilin (Diflubenzuron) (Liebhold and McManus 1999). Starting in 1971, the management of gypsy moth using mating disruption has been the subject of considerable research efforts (Doane and McManus 1981; Reardon et al. 1998).

Application of the synthetic gypsy moth pheromone, disparlure, in a slow-release formulation interferes with the male mate-search behavior and subsequently decreases the number of fertilized eggs laid by females (Leonhardt et al. 1996; Reardon et al. 1998). Initially, this method applied to high-density gypsy moth populations got poor results (Cameron 1981). Later experiments in medium and low-density populations have proven that disparlure can substantially reduce gypsy moth abundance (Reardon et al. 1998). In recent years, the operational use of disparlure has increased (Sharov et al. 2002). Its effectiveness is inversely related to population density (Schwalbe et al. 1983; Webb et al. 1988, 1990).

Figure 1. The morphology of *Lymantria dispar*; A. larva, B. pupa, C. imago, D. antennae (photo: from several sources).

Historically, most treatments of gypsy moth populations have been conducted to prevent defoliation in the current year. Treatments are typically scheduled based on counts of overwintering egg mass populations, which can be used to predict defoliation (Gansner et al. 1985; Liebhold et al. 1993). Operational treatments of outbreak populations usually provide at least partial foliage protection, but they may have limited effects on densities in subsequent years or on the probability of defoliation in the future (Liebhold et al. 1996). The success of treatments targeted against outbreak populations of the gypsy moth is traditionally evaluated by the reduction in egg mass counts and defoliation in treated versus untreated blocks (Twardus and Machesky 1990; Liebhold et al. 1996). However, these methods are not applicable in low-density populations because egg mass densities cannot be estimated with any accuracy and populations are too low to cause noticeable defoliation. Thus, evaluation of preventive treatments has to be based on alternative methods. Larval counts under burlap bands are a sensitive sampling method at moderate population densities (Reardon et al. 1998; Wallner et al. 1990); and at extremely low densities, the only viable sampling method is the use of male moth counts in pheromone traps because they are most sensitive to variations at very low population levels. Another advantage of using pheromone traps for treatment evaluation is that they are less expensive and thus can be used on an operational basis rather than just in experiments. Liebhold et al. (1995) and Carter et al. (1992) found that the correlation between moths counts in pheromone traps and defoliation was weak in continuously infested areas of high-density populations. However, at these densities many traps become saturated and this may obscure correlations of trap counts with population density (Elkinton 1987). Granett (1974) avoided trap saturation by frequent moth removal and recorded a high correlation between trap catches and population numbers.

The objective of this study was to evaluate the effectiveness of integrated management and mating disruption in controlling gypsy moth, *Lymantria dispar* (L.) populations in Daland National Park (north of Iran).

MATERIALS AND METHODS

Study site

The experiment was conducted in Daland National Park, which is part of the larger Golestan forest in Hyrcanian, north Iran (latitude 36º2′ S -36º4′ S, longitude 36º3′ E-41º5′ E). This area is approximately 3750 m long and 2900 m wide and has a total area of 608 ha. The study region has an average temperature of 16.5°C, a total annual rainfall of 660 mm and an altitudinal range of 75-119 m above sea level. The park consists almost entirely of *Parrotia persica*, *Quercus castaneifolia*, *Zelkova carpinifolia,* and *Carpinus betulus*, with a few small areas of other species such as *Populus alba, Ficus carica, Morus alba, Cupressus sempervirens* var. *horizontalis*, *Pinus eldarica, Thuja orientalis,* and *Acer insigne* (Anon 2005). The study site was newly infested with the gypsy moth. This area was considered to be part of the eastern infestation front.

Description of treatments

Integrated management and mating disruption only treatments were applied in 2008. For the evaluation of these treatments egg masses and male moth, counts were taken during the year treatment was applied (2008) and in the following year (2009). Egg masses counts were taken from burlap bands placed around the boles of trees in the study areas. This allows for evaluating gypsy moth population levels even at low densities and other egg masses sampling methods yield mostly zero counts (Bellinger et al. 1990).

The use of pheromone traps is one of the suitable methods for monitoring and control of *L. dispar*. Sampling was carried from early July to the end of August through the use of delta type traps (4 for each treatment-total of 8) installed at 1.5-2 m height with spacing of 100-200 m between each other. Adults captured were counted daily. The delta trap did not contain any sticky material. A small piece of brown paper was placed inside to provide a surface on which the female could cling. The delta trap was suspended from a coat hanger stapled to the side of the tree bole.

Integrated management

Integrated management consisted of burning of egg masses (mechanical method) combined with mating disruption. This treatment was applied to the western part of study site. A gas instrument was designed and used to mechanical control egg masses in defoliated trees. This instrument was so designed that enough gas could exit to burn the entire egg mass while keeping the bole of the trees undamaged. This was the first time gypsy moth mating disruption was carried out in Iran. The pheromone traps described previously for the evaluation gypsy moth population densities were used for the mating disruption. This treatment was applied to the eastern part of study site.

RESULTS AND DISCUSSION

During the year the treatments were applied, 1.793 egg masses/tree and 207.75 males/trap, and 1.828 egg masses/tree and 412.75 males/trap were collected in sites with integrated management and in site with mating disruption only, respectively. The numbers of egg masses and male moths captured in the sites with integrated management were significantly lower than in sites with mating disruption only (Table 1 and 2). In the year following treatment application, the number of egg masses in the sites with integrated management was significantly different from that in the sites with mating disruption only, which were 0.93 egg masses/tree and 1.362 egg masses/tree, respectively (Table 3). Combining both treatments, the number of egg masses decreased significantly from the year of treatment application (2008) to the following year (2009)(Table 4).

Table 1. Number of egg masses collected during the year the control treatments were carried out in sites with integrated management and sites with mating disruption only.

Treatment	No. of egg masses collected	Egg masses/tree
Integrated management	631	1.828a
Only pheromone traps	443	1.793b

Note: Treatments with the same letter are not significantly different at the 0.05 experiment-wise error rate.

Table 2. Comparison of male counts in pheromone traps in sites with integrated management and sites with mating disruption only

Treatment	Number of pheromone traps	Males/trap
Integrated management	4	207.75b
Only pheromone traps	4	412.75a

Note: Treatments with the same letter are not significantly different at the 0.05 experiment-wise error rate.

Table 3. Comparison of number gypsy moth egg masses in sites with integrated management and sites with mating disruption only, the year following the application of the control treatments (2009).

Treatment	No. of egg masses collected	Egg masses/tree
Integrated management	15	0.930b
Only pheromone traps	79	1.362a

Treatments with the same letter are not significantly different at the 0.05 experiment-wise error rate.

Table 4. Evaluation of the number of egg masses collected during (2008) and after (2009) carrying out the control treatments.

Year	No. of egg masses collected	Egg masses/tree
2008	1074	1.81a
2009	94	1.30b

Note: Treatments with the same letter are not significantly different at the 0.05 experiment-wise error rate.

Discussion

In this research, we found that integrated management was more effective than mating disruption in controlling gypsy moth populations, as it can be attested by the significantly lower numbers of egg masses and male moths. Gypsy moth populations are mainly monitored using aerial maps of forest defoliation, counts of overwintering egg masses (Kolodny-Hirsch 1986), and counts of male moths in pheromone-baited traps (Talerico 1981; Ravlin et al. 1987). Particularly, egg mass counts are the most reliable method for assessing decisions (Ravlin et al. 1987). Methods such as collection and destruction of egg masses, use of sticky bands to prevent larvae from climbing trees, removal of larvae that congregate under burlap skirts wrapped around tree trunks, and pheromone traps are often recommended as alternative approaches to managing gypsy moth (Campbell 1983; Thorpe et al. 1995; Thorpe et al. 2007). However, Campbell (1983) and Thorpe et al. (1995) have shown that these tactics are not capable of protecting trees from defoliation during outbreaks, even when used in combination. Collection and destruction of egg masses is ineffective because most egg masses are well hidden or high in the tree where they are inaccessible. Even thorough searches by experts detect only a proportion of those present. Burlap bands wrapped around the lower trunk of trees can attract large numbers of gypsy moth larvae, which hide under them during the day when they are not feeding. This tactic can be useful for detecting the presence of low gypsy moth populations, and may be useful for protecting small, isolated trees from defoliation. However, research and experience have demonstrated that trunk banding is ineffective in preventing defoliation of even moderate size trees. The use of pheromone traps to decrease gypsy moth populations is sometimes recommended, but is also futile. Only males are attracted to the traps, which are quickly saturated even when populations are very low (Herms 2003). Pheromone traps are very useful for delineating the distribution of gypsy moth populations, and are used effectively in monitoring programs. Application of gypsy moth sex pheromone over large areas has been used successfully to suppress populations through disruption of mating (Leonhardt et al. 1996). Widespread application of pheromone (usually by aircraft) saturates the environment, preventing males from detecting pheromones produced by individual females. Mating disruption is most effective when gypsy moth populations are low but starting to increase. When Populations are high, the day-flying males can easily locate mates visually. In areas infested by gypsy moth for many years, there is little or no relationship between male moth counts and subsequent defoliation at the same location (Carter et al. 1992; Liebhold et al. 1995). However, in the area along the expanding gypsy moth front, the relationship among male moth counts, egg mass density, and defoliation may be quite different because of the strong population density gradient (Ravlin et al. 1991). Egg mass counts are the most reliable cause method in medium and high-density population, and thus they are widely used for making decision concerning aerial suppression of outbreak population (Schwalbe 1981; Ravlin et al. 1987). In the uninfected and transition zones, moth trapping remains the only reliable monitoring method. Thus, the analysis of the spatial distribution of moth counts is justified. Mating success may be the most important density-dependent factor that affects sparse gypsy moth populations. Mating failure can cause instability in isolated populations because the proportion of non-mated females will increase as population density decreases. The relationship between pheromone trap catch and mating success has never been measured accurately. Knowledge of this relationship will be useful for distinguishing between unstable and establish populations (Sharov et al. 1995a). There are several factors affecting the relationship between pheromone trap capture and female mating probability. One group of factors is related to pheromone source and trap design. Another group of factors affecting the mating trap capture relationship is associated with male moth behavior. The 3rd group of factors is associated with the female calling period (Sharov et al. 1995b).

CONCLUSION

In this paper, we have developed a new method for evaluating treatments of low density, isolated gypsy moth populations that is based on male moth count and egg mass counts. It is recommended that field studies of contamination measure in other areas, especially in the northern forests, be conducted so that we could use the knowledge in the management and population control programs. Also, the use of integrated methods to control pest gypsy moth areas is recommended. Finally, the methods of pest control training in gypsy moth to executive departments should be effective.

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