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**Northeastern
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Gypsy Moth Research Review Progress Reports

1985 Field Season

Gypsy Moth Program

Final Report

June 14, 1985

Title: Development of adequate larval and pupal sampling procedures

Investigator and Organization: Clive G. Jones, Institute of Ecosystem Studies, The New York Botanical Garden, Mary Flagler Cary Arboretum, Millbrook, NY 12545

Cooperative Agreement No.: 23-899

Accomplishments:

I. Implemented a comprehensive sampling design to quantify gypsy moth distribution, abundance and associated habitat characteristics at 4 Northeastern sites (as described in January 1984 Progress Report).

II. Produced recommendations for estimating larval density using burlap bands.

1. Sampling late instar larvae (4th-6th instars) should be done at least 5-7 days after 4th instars begin to appear under bands to obtain the most reliable point estimate of density.

2. Habitat differences contributed significantly to variation in larval density, but no single plot or group of plots (e.g. "susceptible" or "resistant") accounted for more of the variation in density. For this reason, we suggest that sampling be distributed to include diverse habitats rather than being restricted to homogeneous areas.

3. A broad range of tree species and sizes (DBH) should be sampled to obtain the best estimate of density. From NY data, we found that there was a continuum of mean larval density ranging from highest values for oak and beech species ($\bar{X}$=4-6 larvae) to low values for ash and dogwood ($\bar{X}$<1 larva).

III. Examined the effects of burlap banding on gypsy moth densities.

Plots without bands were established between banded plots in NY to compare changes in egg mass densities for 1983 and 1984 oviposition. Egg mass density increased on banded plots by

14-fold in comparison to unbanded plots. Whether or not banding affects the overall population dynamics must await density data for the next generation.

IV. Validated a field method for determining fecundity based on egg mass geometry.

A simple, reliable method for estimating the number of eggs per mass from length and width dimensions of the mass was developed, tested and validated.

V. Developed a method for estimating field larval hatch from masses collected after hatch.

This method enables us to determine field hatch success from masses collected after hatch. A sample of masses is measured and the number of eggs per mass is estimated (see IV). Parasitized eggs are distinguished from eggs with larval emergence on the basis of exit hole size. The parasitized eggs and remaining intact eggs are counted and this number is subtracted from the estimated total number of eggs per mass to arrive at an estimate of hatch.

VI. Constructed life tables for each site.

These data will be used to calculate the rates of change in each population from 1984 to 1985, in relation to habitat.

VII. Tested and refined a photographic method for quantifying canopy cover.

A two-dimensional density estimate of canopy cover was obtained for each plot on all sites using a fisheye lens system to photograph the canopy. A radial dot-grid was used to determine percentages of foliage and open sky. Since insect damage was negligible in 1984, we can use these data as a baseline to compare with subsequent defoliation.

VIII. No differences in insect population dynamics were detected between areas classified as "susceptible" and "resistant."

Sample sizes were too small at the gradient sites (NY, VT) to draw any conclusions from comparisons between plots that could be characterized as "susceptible" or "resistant." Since densities are rising at both sites and unbanded plots have been established to quantify the effects of the banding method on insect density, we will be in a position to compare rates of change in population dynamics in various habitats at the end of the 1985 field season.

Gypsy Moth Program

Progress Report

(January 4, 1985)

Title: Development of adequate larval and pupal sampling procedures

Investigator: Clive G. Jones

Performing Organization: Institute of Ecosystem Studies, The New York Botanical Garden, Mary Flagler Cary Arboretum, Millbrook, NY 12545 (914-677-5343)

Coop. No.: 23-899
Start: 4/15/84
End: 4/15/85
RWU: 2201
Cooperating Scientist: William E. Wallner

Objectives:

1. Design and implement a sampling regimen at 4 Northeastern sites to quantify the distribution, abundance and survivorship of selected gypsy moth life stages at low densities.

2. Evaluate sampling and estimation techniques for larval, pupal and egg stages in low level populations using artificial refugia (burlap bands).

3. Characterize insect distribution, abundance and survivorship in relation to vegetation including 'susceptible' and 'resistant' points on a vegetation gradient.

General Approach:

It is important to know whether or not 'focal areas' exist and if they can serve as sources of outbreaks. We define focus as a habitat that perennially supports gypsy moth populations at sufficient densities to initiate future outbreaks. The specificity with which such critical habitats can be described, and hence their distribution and abundance in forests, is crucial to evaluating the potential of habitat manipulation as a pest management tool. For example, if such habitats are rare in forests, easily identified and defined, and are crucial to outbreak dynamics, then alteration of these small areas of critical habitat would have a major effect on outbreaks.

Our ability to answer these questions required that we determine the distribution, abundance and survivorship of gypsy moth between outbreaks, i.e., at low densities, over time, in a wide range of habitats that appear to vary in their suitablility to the insect. This in turn required development of sampling and estimation techniques effective at low densities. Our approach was to develop a comprehensive, multivariate analysis of these relationships with the associated vegetation as the major ordinating habitat component. Sites of divergent habitats in four states (NY, CT, VT, MA) were sampled, including those classified as 'susceptible' and 'resistant' found on elevational gradients at two sites (NY, VT). Burlap bands placed at a fixed height on overstory trees were used as a sampling tool to promote aggregation of larvae, pupae and egg masses and permit rapid sampling of these life stages. Although egg masses are the most persistent and easily sampled life stage, survivorship of different life stages is necessary to reconstruct the population dynamics.

Accomplishments:

A design for sampling distribution, abundance and survivorship of low density gypsy moth populations was implemented at four Northeastern sites (NY, CT, VT, MA), with the aid of site cooperators. Fixed area plots (15-50 measuring 176.7 m^2) were layed out on a hectare grid, which included an elevational gradient at two sites (NY,VT). Trees ($\geq$7 cm dbh) in plots were numbered and species, height, canopy height, dbh and canopy density data recorded. Burlap bands on all numbered trees (except some unbanded plots in NY) were used to monitor larval density and mortality of fourth, fifth and sixth instars at approximately bi-weekly intervals for six weeks. Pupal density, fate, sex and dimensions were recorded under bands after eclosion. Egg masses oviposited in 1984 below 2 meters on tree boles and on other substrates including rock, litter and wood debris, were counted, tagged and dimensions recorded. Variable-radius prism plot sampling was also done on two sites (NY, MA) to compare methods of estimating egg mass density. To reconstruct prior population history, selected egg mass variables were recorded using techniques developed from the Cary intensive plot system. From a subsample of post-hatch masses, the number of eggs per mass, larval hatch, fecundity and parasitism were quantified for eggs oviposited prior to and including 1982 and 1983. Similar data for the 1984 oviposition will be collected after larval hatch in 1985.

Data sets for larvae, pupae, egg masses and vegetation have been entered in the computer (IBM 4341, CMS), checked for errors, and statistical summary data is now being distributed to the respective site cooperators. The following data summaries and discussions serve to exemplify the analyses currently underway.

I. Egg Mass Abundance and Distribution

Egg mass densities increased on all sites from 1983 to 1984, but the rise in number is probably associated with burlap banding (Table 1), except in MA where there appears to be a real increase in density. This can be more clearly seen in NY (Table 2) where adjacent unbanded plots have similar densities for all substrates in 1983 and 1984, with the exception of trees in 1984. Of the 18 masses on banded trees, 16 masses were associated with the bands, which would suggest local density increases due to banding. Distribution of masses on substrates other than trees (Table 2) indicates the importance of other substrates, particularly rocks and woody debris, and the potential role of these substrates as competitors with bands.

TABLE 1: Egg Mass Densities for 4 Northeastern Sites (for all substrates)

Year of Oviposition	Site NY	CT	VT	MA
1983	4	144	9	11
1984 (assoc. w/bands)	15	303	17	299
1984 (not assoc. w/bands)	4	143	6	98

TABLE 2: Comparison of Egg Mass Counts on NY Plots, by year of oviposition

Substrate	Banded Plots (n=15)		Unbanded Plots (n=35)	
	≤83	84	≤83	84
Trees ≥ 7 cm DBH	34	18	42	0
Trees < 7 cm DBH, > 2 m ht	1	0	0	1
Snags	6	0	10	0
Fallen tree/limbs	36	0	87	2
Rocks	83	1	114	0
Litter	4	0	1	0

II. Egg Mass Quality

Subsamples of 1983 egg masses were collected for lab determination of potential productivity, hatch success and parasitism. A summary of data from 1983 oviposition in Connecticut are shown in Table 3. The numbers of eggs per mass along with levels of parasitism and viability indicate low productivity for this site. Variation in these egg mass parameters is not excessive, as evidenced by low coefficients of variation.

Table 3: Egg Mass Quality Summary for N. Stonington, CT 1983 Oviposition

For all plots (n=39 masses)	Minimum	Maximum	Mean	Coeffici[cut off] of Variat[cut off]
Number of eggs per mass	16	399	128	63%
% Viable eggs per mass*	4	78	39	55%
% Parasitized eggs per mass**	0	91	55	47%

* % Viability=# hatched eggs/(Total # eggs-# parasitized eggsx100.
** % Parasitism= (# parasitized eggs/Total # eggs) x 100.

III. Larval Distribution in 1984 and Previous Egg Mass Densities

A comparison between mean larval density under burlap bands for all instars averaged over time and the density of relict egg masses oviposited in 1982 and earlier was made (Table 4). Egg mass densities in 1983 and 1984 were too sparse in NY to warrant a similar comparison for these years. Over the period of larval development from fourth through sixth instar, larvae are ubiquitous across an elevation gradient. The coefficient of determination (r^2) for number of egg masses regressed with mean number of larvae is 0.79 for plots #1-9. The r^2 for plots #10-15 is 0.15, and the overall r^2 for all plots (1-15) is 0.31, suggesting that the strength of the relationship between previous egg mass densities and subsequent larval distribution is greater for some classes of habitat than others. This also suggests that other factors, such as habitat-specific survivorship may be important. In this example, the most variation is accounted for by those plots on the 'susceptible' end of the gradient. Variation in larval density appears to be influenced by time, locale and vegetation (ANOVA $p>0.001$), and further analyses are in progress.

Table 4: Comparison or ≤1982 Oviposition with Subsequent 1984 Larval Density at Black Rock, NY

Plot	# Egg Masses	Frequency (%) of Trees with Larval Count>0	Mean # of Larvae per Plot *	
4	39	92	8.1	Xeric
5	12	100	2.5	
6	23	100	5.7	
1	22	100	6.0	Moderately Xeric
2	4	100	2.0	
3	13	100	5.2	
7	3	93	2.1	Transitional
8	7	93	3.4	
9	9	100	3.0	
10	2	100	4.2	Mesic
11	10	100	2.0	
12	7	94	5.2	
13	0	100	5.7	Mesic Cut Woodland
14	0	92	2.6	
15	2	83	5.6	

* Means derived from the sum of all instars for all observations/number of observations, on a by tree basis.

Final Products: In cooperation with other research studies -

1. Provide evidence to support or refute the existence of focal areas, their role in gypsy moth outbreaks, and the potential for manipulating habitat structure and insect outbreaks.

2. Provide a quantitative basis for classifying habitat susceptibility to gypsy moth, in order to develop and improve existing risk rating techniques.

3. Evaluate the efficacy of sampling and estimation techniques for gypsy moth life stages at low densities, with emphasis on larval, pupal and egg mass sampling with burlap bands, comparison of fixed area and variable radius plot sampling, and reconstruction of population histories using egg mass data.

4. Provide, as produced, equations for use in the gypsy moth life stage model.

5. Provide a multivariate data base for use by other researchers in aiding the interpretation of their data and testing models.

Cooperators:

Harvard Black Rock Forest, Cornwall, NY. Dr. John Torrey, Director, Mr. Jack Karnig, Forest Manager.
Pachaug State Forest, North Stonington, CT.
USFS Green Mountain National Forest, Bryant Mountain and adjacent properties, Ripton, VT.
Otis Methods Development Lab, Massachusetts Military Reservation, Falmouth, MA. Dr. Charles Schwalbe, Director.
Dr. William Wallner and staff, USDA NEFES Hamden, CT.
Dr. Bruce Parker and staff, University of Vermont, Burlington, VT.
Dr. Joseph Elkinton and staff, University of Massachusetts, Amherst, MA.