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RESEARCH MEMORANDUM

RM 72-35

DEMOGRAPHIC STUDIES OF SAGEBRUSH INSECTS AS FUNCTIONS OF VARIOUS ENVIRONMENTAL FACTORS

Ting H. Hsiao

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1971 PROGRESS REPORT

DEMOGRAPHIC STUDIES OF SAGEBRUSH INSECTS AS FUNCTIONS OF VARIOUS ENVIRONMENTAL FACTORS

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ABSTRACT

Seasonal history, population density and natural mortality of the sagebrush defoliator have been investigated at the Curlew Valley study site. The defoliator has one generation a year and overwinters as 2nd or 3rd instar larvae. Activity of this species is limited from April to October. The population density at the study site was estimated to be 5-13 defoliators per plant or 1.6×10^5 to 3.9×10^5 defoliators per hectare. Biomass of the defoliator was calculated to be 1.183 kg. dry weight per hectare. Extrinsic factors accounted for 63% of mortality. The larval and pupal stages were attacked by 10 Hymenoptera parasites, one Coleoptera predator and one microbial pathogen. Intrinsic mortality of this species was apparently quite low, less than 10% of the overall mortality. Methods have been developed for accurate population sampling of the defoliator and estimation of impacts of defoliators on sagebrush defoliation. A limited study on the overwintering stage of the garden casebearer has been conducted at the Green Canyon site, near Logan, Utah.

INTRODUCTION

Field and laboratory studies were initiated in March, 1971. At the beginning of the season, the overwintering stage of the garden casebearer, *Apterona crenulella*, was investigated to determine the mortality factors and the timing of seasonal activities of this species. Since June, 1971, intensive study has been conducted on the sagebrush defoliator, *Aroga websteri*, at the Northern Curlew Valley study site. Results obtained on the various aspects of the ecology of these species are included in this report.

OBJECTIVES

The following objectives have been pursued in 1971.

1. To determine the seasonal history and natural mortality of these species.
2. To determine the procedure of population sampling of these species.
3. To investigate the quantitative relationships between population size of insects and the degree of sagebrush defoliation.

METHODS

Growth rate and age structure of the sagebrush defoliator were recorded at weekly intervals until the end of the season. Population densities were measured by removing sagebrush foliage from randomly selected sagebrush plants occurring on a 200 meter transect. The numbers and growth stages of the insects in the samples were then determined. Insects obtained from each sample were reared in the laboratory and the incidence of parasitism was recorded. Life tables for the sagebrush defoliator and the casebearer were constructed according to the methods described by Harcourt (1966). The DSCODES for these methods are A3UHL01 and A3UHL02.

FINDINGS & DISCUSSION

The Sagebrush Defoliator, *Aroga Websteri*.

Seasonal history and biology. The Northern Curlew Valley study site was selected for the study of the sagebrush defoliator. Initial population sampling showed as many as 40-80 defoliator webs per sagebrush plant. Eighty percent of the webs contained defoliator larvae. In contrast, the Southern Curlew Valley study site had only 1-5 defoliators per plant.

Age structure of the defoliator as determined by weekly sampling is summarized in Table 1. At the study site, the sagebrush defoliator has one generation per year. The adults are found during late July and August with a life span of 2-3 weeks. During daylight hours, they are quiescent, hiding in cracks, bark, or on covered ground. Activity begins 2-3 hours following dusk and continues throughout the night as determined by light trapping. Eggs are laid during the month of August. They may be found singly or in pairs in bark cracks of the terminal stems. Larval hatching was observed from mid-August to September. Upon hatching, the larvae migrate to the new foliage and mine into a leaf or construct a web with several leaves. The larva feeds inside the leaf. As winter approaches the feeding activity is restricted only to warm days. Plant samples collected in late October revealed the presence of 1st, 2nd and 3rd instar larvae. It appears that the sagebrush defoliators are capable of overwintering in 2nd and 3rd larval stages, since samples collected in early June also revealed the presence of 2nd instar larvae (Table 1). Larvae resume feeding activity quite early in the spring. By early June most of the larvae reach 4th instar and construct webs enclosing 4-6 leaves. Most larvae reach the 5th instar before the end of June. At this stage the larval webs become quite large, up to 4 inches in length, and sometimes encompass whole sagebrush branches. The 5th instar larvae also cause the most leaf damage.

Table 1. Seasonal history and age structure of *Aroga websteri* at Curlew Valley Site.

Date of Sampling	Egg #	Egg %	Larva 1st #	Larva 1st %	Larva 2nd #	Larva 2nd %	Larva 3rd #	Larva 3rd %	Larva 4th #	Larva 4th %	Larva 5th #	Larva 5th %	Pupa #	Pupa %	Adult #	Adult %	Total
June 10					3	2.9	25	24.0	54	52.0	22	21.1					104
June 16					1	0.7	8	5.8	80	58.0	49	35.5					138
June 23									32	11.6	220	79.4	25	9.0			277
June 30									4	1.4	207	71.4	79	27.2			290
July 7											106	28.7	252	68.1	12	3.2	370
July 14											5	1.2	301	73.4	104	25.4	410
July 21													50	45.5	60	54.5	110
July 28													24	19.4	100	80.6	124
Aug. 4													3	2.6	111	97.4	114
Aug. 18	3	50.0	3	50.0													6
Sept. 8			1	25.0			3	75.0									4

Mature larvae pupate during late June to early July. Pupal stage lasts from 2 to 3 weeks. The adult emerges by breaking the pupal case along its anterior-ventral surface. Pupae obtained from field samples were reared in the laboratory to determine the adult sex ratio. Adults collected from Malaise traps in August were also included in the study for comparison. Of 600 specimens examined, a sex ratio of 1:1 was found in the population from Curlew Valley. As a whole, males emerge earlier than the females.

Adults obtained from pupae reared in the laboratory were placed in cages with sagebrush plants in a 16-hour photoperiod room for observation of behavioral activities. No mating or egg-laying was observed during the entire adult life in all experiments. An examination of the dissected females also showed no sign of ovarian development. It appears that some specific environmental conditions are required to induce mating and reproduction of this species. Henry (1961) suggested that mating may be important to induce reproduction of the female defoliator moths. This aspect of the biology of the defoliator will need further investigation.

Mortality factors. Field samples collected at weekly intervals were brought back to the laboratory and the incidence of parasitism, predation and diseases were recorded. Table 2 summarizes the findings of 1971. A total of 10 species of parasites, one species of predator and one microbial pathogen have been recorded for the defoliator. Specimens of these insects have been sent to the U.S. National Museum to obtain accurate identification. The most important parasites include a Braconidae and an Ichneumonidae (2). Mortality due to parasites occurred mainly in the 5th larval instar (34.3-35.6%) and the pupal stage (16.8-30.9%). Total mortality due to extrinsic factors averaged 63% in the sagebrush defoliator. An examination of 150 birds fecal droppings collected at the study site showed no defoliator head capsules, indicating bird predation is not an important mortality factor. Intrinsic mortality was apparently quite low in this species. The larval stage from 3rd to 5th instars had less than 3% natural mortality when reared in the laboratory. The pupal stage showed 2-9% mortality. Adults at the time of emergence showed 2-3% mortality.

Population sampling. During the season, two sampling methods have been used to determine the reliability of estimating the population density of *A. websteri*. The most frequently used method was taking an individual sagebrush plant as a sampling unit. Twenty or more plants were selected randomly on a 200 meter transect at the study site on each sampling date. Field data, such as plant height and size and plant fresh weight were then taken. The foliage of the plants was clipped and placed in plastic bags. In the laboratory, the number and stages of the defoliator were determined. Parasitism and other mortality factors were determined through rearing of the immature stages. A second method of sampling was based on a sampling unit of one square meter area and the population density of the defoliators was determined in the same manner as mentioned above. The number of sagebrush plants varied from 1 to 6 per square meter in the study site with an average of 3 plants per square meter. A total of 20 randomly selected samples were collected on each sampling date. At the beginning of the season, samples were taken of sagebrush tips according to a method described by Hall (1965). However, this technique has the inherent difficulty of assessing population density per unit area. It was not used in subsequent samplings.

The results of population sampling carried out during 1971 are summarized in Table 3. The peak of population density was observed on June 30, 1971, at about 13 insects per plant or 3.9×10^5 defoliators per hectare. This population level decreased as the season advanced.

Biomass of defoliators at the study site was measured in a study conducted on July 7, 1971. Ten square-meter samples were selected randomly at the site and the above-ground portions of sagebrush were clipped and placed in plastic bags. The number and dry weight of defoliators and the sagebrush plants were determined. The result showed a biomass of 0.1183 gm of defoliators per square meter area or 1.183 kg. per hectare. The biomass of sagebrush plants was estimated to be 1.17 x 104 kg. per hectare.

Table 2. Extrinsic mortality factors of *Aroga websteri* at Curlew Valley Site.

Species	Stage attacked	% Mortality
Solitary parasites:		
Chalcidae (1) sp.	Larva 4th instar	0.47-2.65
Chalcidae (2)	Larva 4th instar	0.20-0.56
Chalcidae (3)	Pupa	3.93-6.58
Chalcidae (4)	Pupa	0.74-1.32
Chalcidae (5)	Pupa	2.19-6.58
Braconidae	Larva 5th instar	17.67-34.29
Horogene platellae	Larva 5th instar	0.16-0.43
Ichneumonidae (1) sp.	Larva 5th instar	2.63-12.41
Ichneumonidae (2)	Pupa	10.90-13.82
Gregarious parasites:		
Copidosoma sp.	Larva 5th instar	0.32-1.72
Multiparasitism:		
Chalcidae (3) and (5)	Pupa	less than 1.0
Chalcidae (3) and Ichneumonidae (2)	Pupa	less than 1.0
Hyperparasitism:		
Braconidae Chalcidae (3)		less than 1.0
Braconidae Chalcidae (1)		less than 1.0
Predators:		
Phyllobaenus sp.	Larva 2-5th instar	4.68-5.78
	Pupa	0.24-0.54
Pathogens:		
Nasema sp.	Larva and Pupa	1.64-3.32

Table 3. Population density of *Aroga websteri* at Curlew Valley Site.

Date of Sampling	No. plant Samples	No. Defoliators	Aver. No. Defoliator/Plant	Aver.No. Defoliator/Hectare
June 30	22	290	13.2 ± 1.9*	3.9×10^5
July 7	53	370	7.0	2.1×10^5
July 14	59	410	7.0 ± 0.7	2.1×10^5
July 21	20	110	5.5 ± 1.3	1.6×10^5
July 28	20	124	6.2 ± 1.5	1.8×10^5
Aug. 4	17	114	6.7 ± 1.0	2.0×10^5

*Standard error

The variations in population density as shown in Table 3 suggest that the number of samples obtained in each sampling may not be adequate. A statistical analysis according to a method described by Harcourt (1962) has been made to determine the number of samples required which will result in a 10% standard error among samples. Four types of sampling units derived from data shown in Table 3 were compared as to their efficiency for sampling. These are: number of defoliators per plant, number of defoliators per square meter of vegetation, number of defoliators per kilogram of fresh sagebrush plants, and number of defoliators per kilogram of fresh sagebrush per square meter of vegetation. The results are summarized in Table 4. The data show that the sampling unit of insects per plant would require from 40 to 120 samples in order to achieve a 10% standard error. The sampling unit of number of defoliators per square meter also needs about 40 samples at each sampling date. When the fresh weight of sagebrush plants is considered, there is a good correlation between number of defoliators and plant weight. Therefore, the number of samples required can be reduced to around 30. This finding should be considered in sampling procedure for 1972.

Table 4. Estimation of required sample size based on a 10% error. Data obtained by various sampling techniques are compared.

Date of Sampling	Sampling Unit	C.V.*	Required** Samples
June 30	Insects/Plant	68.74	47
July 14	"	79.42	63
July 21	"	108.00	117
July 28	"	110.00	121
Aug. 4	"	58.27	34
July 7	Insects/M^2	62.50	39
July 14	"	57.31	33
July 28	Insects/Kg. plant	60.26	36
July 14	Insects/Kg./M^2	53.10	28

* C.V. = S x $100/\bar{\bar{X}}$.

** Required samples = $(C.V./10)^2$

Defoliation study. Several methods have been used to determine the extent of defoliation and plant injury (Southwood, 1966). Hall (1965) used a relative estimate of number of defoliators per 10 samples of 7-inch sagebrush tips to determine the level of defoliation. His data showed that the severity of defoliation was closely correlated with larval population density. Eight larvae were recorded with about 25% defoliation, 25 larvae with 50% defoliation, 46 larvae with 75% defoliation, and 66 or more larvae with 100% defoliation.

In order to develop a more reliable method of assessing the percentage defoliation of the entire plant, the ratio of the dry weights between defoliated leaves and non-defoliated leaves were used to calculate the degree of defoliation. It was assumed that the leaves enclosed in the defoliator webs were usually damaged and eventually consumed. Twenty square-meter samples of sagebrush plants were taken randomly at the study site in mid-July, when defoliation appears to be at its maximum. The amount of defoliated and non-defoliated leaves were separated and the numbers of defoliators recorded. Data based on percentage are presented in Figure 1. Regression analysis of the samples showed a 75-90% correlation between percentage defoliation and defoliator numbers. This method of evaluation of defoliation appears to be reliable. Further improvement and modification of this method will be made in 1972.

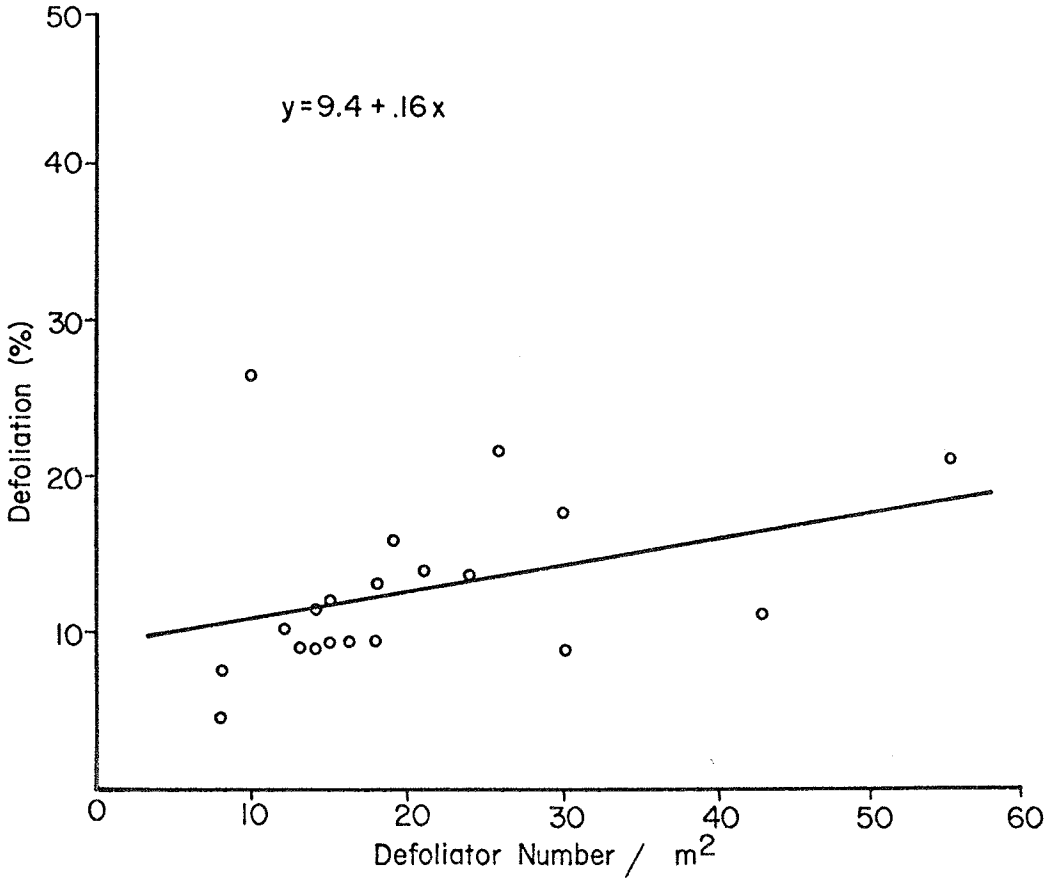

Figure 1. Relationships between % defoliation and population density of defoliators per square meter of vegetation.

The Garden Casebearer, *Apterona Crenulella*.

Investigation on this species was conducted at the mouth of Green Canyon, Cache County, Utah. The infestation of the casebearer at the Curlew Valley Site was negligible during the season. Hence, no study was made there in 1971.

Population sampling of this species on sagebrush plants at the beginning of the season indicated that the overwintering populations were found only on the top 20 inches of the plant. Of the 134 cases examined in the laboratory, 77 contained larvae. These larvae were found folded into V-shapes within the transparent egg shells. Upon removal from the cases, the young larvae became active. The larvae per case ranged from 2-31 with a mean value of 16.3.

Young larvae were observed on sagebrush plants at the beginning of April. However, the peak of larval hatching did not occur until the end of the month. In early June, most of the casebearers were found to feed on low-growing plants, including some Compositae and the rabbit-brush (*Chrysothamnus*). The larvae gradually moved to the young sagebrush as the low-growing plants began to dry up during the latter part of the month. Measurements of the head capsule size and body length of the larvae were made to determine the number of larval instars of this species. Parasitism recorded so far included a hymenopteran parasite and a predatory clerid larva.

EXPECTATIONS

Investigations on the seasonal history, population density and natural mortality of the sagebrush defoliator will be continued during 1972. Efforts will be made to obtain larger population samples for the construction of life tables and population density measurements. Objectives 2 and 3 of the proposal will be emphasized in the study. Field cages will be set up on the study site at the beginning of the season. One set of experiments will be conducted to determine the relationship between number of defoliators and percentage defoliation of sagebrush plants. Different levels of defoliator population will be established in the cages by artificial infestation with overwintering larvae. The amount of plant injury and defoliation will be determined. During the course of the study the feeding behavior and the number of webs constructed by individual larvae will be observed and recorded. Field cages will also be used to study the mating behavior and reproduction by the females. Laboratory studies will be conducted to determine the effects of temperature, humidity and photoperiod on development and survival of different developmental stages. Intrinsic mortality of different stages will be determined in the laboratory and the field. These data are essential for the construction of life tables.

The seasonal history and mortality factors of the garden casebearer will be investigated at the Green Canyon site in 1972. Population samplings will be made at weekly intervals to determine the age structure of this species and for construction of life tables. The host range and feeding behavior of this species will be investigated in the field as well as in the laboratory. The effects of temperature, humidity and photoperiod on overwintering larvae and different developmental stages will also be investigated.

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