



AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search

<http://ageconsearch.umn.edu>

aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*



CARIBBEAN FOOD CROPS SOCIETY

34th Annual Meeting 1998

**Rural Agricultural Development Authority
Ministry of Agriculture, Jamaica**

***“Enhancing Regional Food Security and Exports
by Integrating National Strategies”***

JAMAICA

VOL. XXXIV

IDENTIFICATION OF MAJOR PESTS AND A SAMPLING PLAN FOR LEPIDOPTERA LARVAE IN *AMARANTHUS VIRIDIS* (CALLALOO) IN JAMAICA

D O Clarke-Harris¹, S J Fleischer²

¹ Caribbean Agricultural Research and Development Institute,
P O Box 113, Kingston 7, Jamaica

² Department of Entomology, Pennsylvania State University,
University Park, Pennsylvania 16802-3508

ABSTRACT

Major species in the pest complex on callaloo are moth caterpillars (Lepidoptera) *Spodoptera frugiperda*, *S. exigua*; *Herpetogramma bipunctalis*, *Spoladea recurvalis*, beetles (Coleoptera) *Disomycha* spp. *Diabrotica baletata*, leafhoppers (Homoptera) *Empoasca* spp. and mites (Acarina) *Tetranychus* sp. Baseline surveys on 15 callaloo farms in the major callaloo producing area of Bushy Park, St Catherine indicated that of these pest species, the lepidoptera complex ranked highest in importance. Adult and larval populations of the five lepidoptera species on callaloo, were monitored over three cropping seasons between April 1997 and March 1998 at Bodles Experimental Station, St Catherine. There was significant correlation between moth flights and larval populations which suggests a potential for using adults as an early warning to intensify in-field scouting. The frequency distribution of the larval populations was determined and a sequential sampling plan developed for use by farmers in scouting. Comparison between a sequential sampling plan and a sampling plan based on a fixed sample size of 25 plants per farm showed the former to be 46% more efficient (mean 13.5 sample plants per farm) while giving the same pest management decision as the latter on 87.5% of the farms. Of the remaining 12.5% of farms in the validation exercise the sequential sampling plan recommended additional samples on 9.4% of them and only gave inaccurate decisions at 3.1% of the sites. This work will allow greater efficiency and structure for implementing scouting programmes in callaloo production systems.

INTRODUCTION

Callaloo, *Amaranthus viridis* which has been an important leaf vegetable in Jamaica has in the past decade gained recognition as a non traditional export commodity. This improved economic status has mandated closer examination of quality standards at all levels of crop production.

Pest management is a critical part of production of this crop. Callaloo is plagued by numerous species of leaf eating insects some of which threaten the profitability of callaloo production. Chemical control has essentially been the unilateral approach to pest management of this crop. Farmers have historically used calendar based schedules for timing pesticide applications. This system has resulted in excessive use of pesticides and all the attendant problems (pesticide residues and resistance, environmental contamination and user hazards) of injudicious pesticide use.

As an initial step to the development and implementation of an integrated pest management system for callaloo, research activities have been geared toward minimising pesticide inputs through identification of major pests, scouting and decision making based on pest densities. Baseline surveys were first conducted to identify the major culprits in the pest complex inflicting economic damage.

Scouting techniques should accurately measure the pest status and in order to do this the geographical limits within the field and within the plant must be identified (Morris, 1960). Information on the expected frequency

distribution is also important for the development of statistically sound sampling techniques (Southwood, 1978). It was therefore assumed that the development of effective sampling and decision making protocols for major pests would lead to a reduction in the number of spray applications made in the production of this vegetable amaranth.

MATERIALS AND METHODS

Baseline Surveys

Fifteen callaloo farms in Bushy Park, St Catherine, a major callaloo growing belt, were selected and informal farmer interviews and field surveys conducted to identify and to gather qualitative information on arthropod species associated with callaloo and their relative importance. Crop damage levels caused by pest species were assessed based on the effect on salability of the crop. Crop loss levels reported by farmers were also used to determine the relative potentials of pest species to inflict economic damage. Taxonomic classification of species found was done through networking with local, regional and US scientists.

Monitoring lepidoptera populations

Populations of lepidoptera larvae were monitored twice per week for three cropping seasons in field plots located at Bodles, St. Catherine between April and July 1997, August and November 1997 and December 1997 and March 1998 (during the vegetative to late reproductive phases of each crop). The size of experimental plots was 137 m² with 1000 plants. Two transects divided the field into four quadrats each containing 250 plants.

Four central plants were selected by systematically walking a zigzag path through central plants in each quadrat and tagging one plant after every ten paces. Similarly four plants were tagged per quadrat among the designated edge plants. Six leaves each from the inner and outer whorl of each tagged plant were randomly selected, searched for lepidoptera larvae and records made of number, position and size of larvae found. Size of larvae were recorded as one of four categories: small, < or = 10 mm ; medium, 10.1- 20 mm and large >20 mm.

Lepidoptera adults were monitored by using a sweep net to catch moths. Two sweeps were done per row per quadrat among the designated centre plants. The number of each species of moth caught was recorded. Four sweeps were also done per quadrat along the designated edge of the field. The variation of lepidoptera populations with respect to crop phenology and the association between adult and larval lepidoptera populations were analyzed using Pearsons ranked correlation.

Development and validation of a sequential sampling plan

Equations in Elliot (1997) and Waters (1955) were used to model the probability density function of larval populations and to prepare a computer spreadsheet for calculating sequential sampling plans (Clarke-Harris and Fleischer, 1998). A suitable plan was designed based on an action threshold of 1 larva per plant, the level of accuracy required balanced with the need for the process to be practical to the farmer. A chart was designed to be used as a field tool to guide in making pest management decisions based on the sequential sampling plan. In order to determine the efficiency of the sequential sampling plan compared to a sampling plan based on a fixed sample size, 32 callaloo farms within a 28 km² radius in St. Catherine were monitored. Twenty-five plants were sampled per farm. The pest management decision reached based on the sequential sampling plan was compared to a decision based on a fixed sample of 25 plants using a threshold of 1 larva per plant. This procedure for validation was described by Luna et al (1983).

RESULTS AND DISCUSSION

Survey of fauna

Forty-eight arthropod species found on callaloo were both pest and beneficial species belonging to seven orders

(20 insect families and one mite species) (Tables 1 and 2).

Table 1: Inventory of pest species found in callaloo fields in Bushy Park, Jamaica.

Order /Family	Number of species
Hemiptera/Homoptera	
Cicadellidae	3
Coreidae	1
Cixiidae	1
Pentatomidae	5
Tessarotomidae	1
Aleyrodidae	1
Coleoptera	
Chrysomelidae	7
Lepidoptera	
Pyralidae	3
Geometridae	1
Noctuidae	4
Acarina	
Tetranychidae	1

Table 2: Inventory of natural enemies found in callaloo fields in Bushy Park, Jamaica.

Order /Family	Number of species
Hemiptera/Homoptera	
Miridae	3
Reduviidae	1
Coleoptera	
Coccinellidae	3
Diptera	
Sarcophagidae	1
Syrphidae	2
Carcinophoridae	4
Hymenoptera	
Braconidae	2
Chalcididae	2
Cheloninae	1
Vespidae	1

Major pest species

The primary pest species of the observed pest complex were moth caterpillars (Lepidoptera) *Spodoptera frugiperda*

(J. E. Smith) *S. exigua* (Hb.); *Herpetogramma bipunctalis* (Fabr.) *Spoladea recurvalis* (F.) beetles (Coleoptera) *Disomycha laevigata* (Jacoby); *Disomycha gowdeyi*, *Disomycha leptolineata taxana* Blakc. *Diabrotica baletata* LeC; leafhopper (Homoptera) *Empoasca* spp.; and mites (Acarina) *Tetranychus* sp. These pests were either constant with seasonal variation in population levels or sporadic but were identified as the major culprits causing damage losses.

Of these pests lepidoptera species ranked highest as they were frequently damaging to the crop throughout the cropping season, were present on all farms and would cause up to 100 % loss in yields. Pesticide inputs by farmers were primarily to reduce 'worm' damage. The leaf eating beetles were sporadic pests and were not as widespread however high populations could devastate a crop. Mite damage levels varied from farm to farm causing high losses on some farms while on others were maintained at relatively moderate to low levels. Leafhopper damage which is characterised by yellow etches on the leaf surface is more consumer tolerable at low levels compared to other pest damage but extensive damage at higher levels affects leaf texture and aesthetics.

Temporal and spatial distribution of lepidoptera pests

Seasonal dynamics was considered to determine generally when to intensify sampling activities. The total number of lepidoptera larvae observed per sampling date ranged from 19 to 238 during crop 1, 0 to 322 during crop 2 and 2 to 193 during crop 3 (Figure 1). Population monitoring data collected for the three cropping seasons substantiated farmer perception of the hot months being the season of highest pest pressure. Although the highest number of lepidoptera larvae was recorded in October, a comparison of the means and medians of individual crop seasons (Table 3) showed consistently higher pest numbers during the April to July crop, followed by August to November, and lowest numbers between December and March.

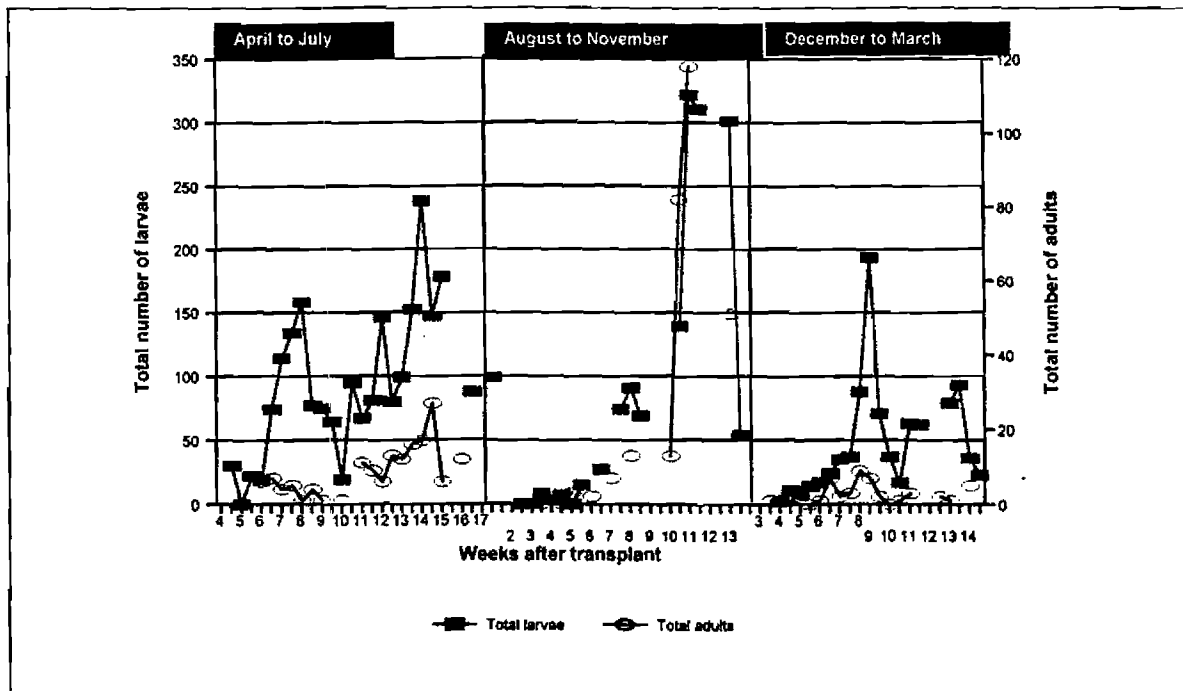


Figure 1: Larval and adult population changes of lepidoptera species during three callaloo seasons between April 1997 and March 1998- Bodles, St Catherine, Jamaica

Table 3. Population levels of lepidoptera larvae observed during three cropping seasons at Bodles, St Catherine.

Duration	Crop 1 <i>April to July</i>	Crop 2 <i>August to December</i>	Crop 3 <i>November to March</i>
Maximum	238	322	193
Minimum	19	0	2
Median	88	40.5	36
Mean	98.09	88.75	47.89
Standard Deviation	53.59	113.52	43.82

The correlation between total adult and total larval lepidoptera populations over all crop seasons (Table 4) was very significant ($P < 0.0001$). The more visible sign of increased moth activity can therefore be used as a signal to increase sampling activity for lepidoptera larvae. Proposed studies to assess pheromone and light traps as early warning devices will complement these findings.

Table 4. Correlation of adult and larval (number per 12-leaf sampling units using a visual search) populations of lepidoptera observed between April 1997 and March 1998 at Bodles, St. Catherine.

Lepidoptera species	Correlation coefficient
<i>Spoladea recurvalis</i>	0.714
<i>Herpetogramma bipunctalis</i> ($P < 0.0001$)	0.724
<i>Spodoptera</i> spp. ($P < 0.0001$)	0.611
Total All species ($P < 0.0001$)	0.722

Crop phenology was also found to significantly correlate with larval population of lepidoptera. A positive correlation ($r = 0.525$) between total lepidoptera larvae and number of weeks after planting was highly significant ($P = 0.0070$).

The within-plant distribution of the pest was investigated to define specifics of the sampling unit. Analyses carried out on a partial data set revealed significantly greater ($P = 0.001$) number of larvae on outer whorl leaves than on the inner whorl. Larval size was also found to affect within plant distribution. More larvae in the small size class were found in the outer whorl, while larger larvae were found more often in the inner whorl ($P = 0.002$). Within field distribution (edge versus center) was not significant ($P = 0.428$). These early analyses were the basis of sample allocation (3 inner and three outer whorl leaves per 6-leaf sample) using sampling plans in field validation activities. To ensure that sampling for decision-making would consider both small and large size classes, further work was conducted with a 6-leaf sampling unit, comprising 3 inner leaves and 3 outer leaves.

The sequential sampling plan

In designing the plan a minimum requirement of 10 samples was set to reduce decision errors and the maximum number of samples was fixed at 25 based on the estimated time required (forty-five minutes to an hour) to take

these samples. The sampling chart (Table 5) was further modified to be used as a field guide to sampling and decision making in pest management of lepidoptera larvae on callaloo. In the chart pre-determined decisions as to whether or not to apply pesticides were listed based on the cumulative number of larvae found after a given number of 6-leaf samples. Additional samples are recommended when counts fall within the range of uncertainty.

Validation

To date, validation has been done in 32 callaloo fields (Table 6). Of these fields, 87.5% gave the same management decisions using the sequential sampling plan as a fixed sampling plan of 25 samples (estimated farmer tolerance threshold). Inaccurate decisions were only reached in 3.1% of the fields while 9.4% of the fields resulted in no decision (after 25 samples) with the sequential sampling plan. Overall the sequential sampling plan gave 87.5% accurate decision with a mean of 13.5 samples, this represents 46% savings in sampling time when compared to 25 samples per field using the fixed size sampling plan.

Table 5. Sequential sampling plan for lepidoptera larvae on vegetable amaranth.

Sample Number	Cumulative Frequency of Larvae		
	Do not Spray	Take another sample	Spray Now
10	3	4 to 15	16
11	4	5 to 16	17
12	5	7 to 16	18
13	6	7 to 18	19
14	7	8 to 19	20
15	8	9 to 20	21
16	9	10 to 21	22
17	10	11 to 22	23
18	11	12 to 23	24
19	12	13 to 24	25
20	13	14 to 25	26
21	14	15 to 26	27
22	14	15 to 27	28
23	15	16 to 28	29
24	16	17 to 29	30
25	17	18 to 30	31

CONCLUSION

Identifying the major pests from the large complex of arthropods in callaloo fields has formed the foundation for all future work in the development of Integrated Pest Management programme for callaloo. These species can now be targeted collectively and individually for IPM component research. The lepidoptera larvae have been identified as the most important of all pests on callaloo and this finding has informed the process of prioritisation of research efforts in IPM.

Population dynamics studies have helped to identify when to concentrate sampling efforts, and has defined a sampling unit that considers the within plant distribution of the major defoliating pest species and brackets larval size classes. Expected frequency distributions using these sampling units were modeled, and a common model developed for the range of conditions and pest densities observed in local agroecosystems (Clarke-Harris and Fleischer, 1998). These probability density functions were combined with empirical, expert opinion regarding farmers, and then used to develop a sequential sampling plan that could optimize allocation of sampling

labour resources.

Table 6. Pest management decisions based on sequential sampling plan compared to decisions based on a fixed sample size of 25.

Field No.	Pest Management Decision		
	N using the Sequential Plan	Sequential Size Sampling Plan	Fixed Sample (25 samples)
1	10	No Spray	No Spray
2	10	No Spray	No Spray
3	10	No Spray	No Spray
4	12	No Spray	No Spray
5	10	Spray	Spray
6	11	No Spray	No Spray
7	15	No Spray	No Spray
8	10	No Spray	No Spray
9	10	Spray	Spray
10	10	No Spray	No Spray
11	17	No Spray	No Spray
2	10	No Spray	No Spray
13	10	Spray	No Spray
14	23	No Spray	No Spray
15	10	No Spray	No Spray
16	19	No Spray	No Spray
17	17	Spray	Spray
18	10	Spray	Spray
19	25	No Decision	No Spray
20	10	No Spray	No Spray
21	10	No Spray	No Spray
22	15	Spray	Spray
23	10	Spray	No Spray
24	10	No Spray	No Spray
25	25	No Decision	No Spray
26	21	Spray	Spray
27	25	No Decision	No Spray
28	18	Spray	Spray
29	15	No Spray	No Spray
30	10	Spray	Spray
31	10	No Spray	No Spray
32	10	No Spray	No Spray

Validation trials of the selected sampling plan generated from the developed model suggest that it is effective, resulting in savings of >40% of the sampling resources. This work will be reviewed, adding the formal hypothesis testing to the modeling effort and completing the validation work. If necessary, additional sampling plans can be generated to improve the efficiency, and validation work will now move into educational and implementation efforts.

Two educational and implementation tools for IPM in callaloo have been developed: an identification guide for major pests of callaloo (Clarke-Harris et al. 1998) based on field collection and collaborative taxonomic research,

and a sampling plan, based on field research and collaborative statistical research. Both have been formatted for use in educational programmes with extensionists and farmers. These programmes have already been initiated with a training workshop and will subsequently include on-farm training and assessment of audience knowledge of major pests and level of adoption of scouting procedures. Select groups in other geographic locations will also be targeted to implement scouting systems.

In tandem with these activities, other pest management components are being tested, namely, assessment of the use of early warning devices as a signal of pest immigration, evaluation of new chemistries to replace existing pesticides which are no longer effective, assessment of exclusion as a method of preventing pest attack, conservation of natural enemies through the use of biopesticides and formulation of a list of best management options to be used at pre and post harvest stages of callaloo production.

Farmer adoption of scouting activities will have positive implications for pesticide use management as it relates to insecticide resistance management for new chemicals, conservation of natural enemies, pesticide residue levels, consumer safety, and environmental contamination. The number of pesticide applications in a growing season would be reduced especially during periods of reduced pest pressure, and detection of early stages of lepidoptera larvae will allow for increased, effective use of safer pesticides such as *Bacillus thuringiensis* while cost of labour and pesticide to the farmer would also be reduced.

ACKNOWLEDGEMENTS

The authors take this opportunity to recognize the contribution of Dr M Munir Alam who compiled a baseline inventory of arthropods collected from callaloo fields and Dr Steven Passoa for clarifying the taxonomy of lepidoptera larvae. Special mention of the efforts of Messrs. Oral James and Donald Simpson, Technical Assistants at CARDI, in data collection and collation and Mr. Bruce Lauckner, Biometrician, CARDI in data analyses. We also acknowledge Mr Don de Mackiewicz, Research Assistant, Penn State University for his assistance during the collaborative training and data analyses at Penn State University. The Ministry of Agriculture, as part of the collaborative effort, provided the experimental site at Bodles Research Station, for population monitoring.

REFERENCES

- Clarke-Harris D. and S. J. Fleischer 1998 (in press). Development of a sequential sampling plan for a complex of lepidopteran larvae in vegetable amaranth in Jamaica. *In* Proceedings of The Third IPMCRSP Symposium, Virginia Polytechnic Institute, Blacksburg, Virginia, May 15-16, 1998.
- Clarke-Harris D., S. J. Fleischer and A. Fender 1998. Identification Guide- Major Pests of Callaloo, Pennsylvania State University Press 16pp.
- Elliot, J. M. 1977. Some methods for the statistical analysis of samples of benthic invertebrates, 2nd ed. Freshwater Biological Association, Scientific Publication 25 pp.
- Iwao, S. 1968. A new regression method for analyzing the aggregation pattern of animal populations. *Res. Popul. Ecol.* 10: 1-20.
- Luna, J. M., S. J. Fleischer and W. A. Allen. 1983. Development and validation of sequential sampling plans for potato leafhopper (Homoptera: Cicadellidae) in alfalfa. *Environ. Entomol.* 12: 1690-1694.
- Morris, R. F. 1960. Sampling insect populations *Ann. Rev. Ent.* 5: 243-264.
- Southwood, T. R. E. 1978. *Ecological Methods*. Chapman and Hall and ELBS-London, 524 pp.
- Waters, W. E. 1955. Sequential sampling in forest insect survey. *For. Sci.* 1: 68 -79.