Reprinted from *The Florida Entomologist*, Volume 69, Number (1), March 1986.

USE OF PHEROMONE TRAPS AS A WARNING SYSTEM AGAINST ATTACKS OF SPODOPTERA FRUGIPERDA LARVAE IN FRENCH GUIANA

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ABSTRACT

Experiments in French Guiana since 1979 have shown that it is possible to use pheromone traps in improved pastures, to enable not only a follow-up of the seasonal

evolution of adult *Spodoptera frugiperda* populations, but also to estimate, a week in advance, the subsequent abundance of larvae in these pastures. Based on these results, an experimental warning network for attacks of *S. frugiperda* larvae in pastures and on pluvial rice was installed in July 1983. The results confirmed earlier observations and showed that the *S. frugiperda* populations evolved in the same fashion all along the coastal strip of French Guiana. Today, a warning network of nine stations helps broadcast regular warning messages to cattle breeders, thus enabling them to monitor their pastures at the right times and to carry out insecticide treatments as necessary.

RESUMEN

Experimentos en la Guayana Francesa desde 1979, han demonstrado que es posible usar trampas de feromonas en pastizales mejorados, no solo para permitir una subsiguiente evolución temporal de las poblaciones del adulto de *Spodoptera frugiperda*, pero también para estimar con una semana de anticipo, la subsequente abundancia de larvas en estos pastos. Basado en estos resultados, una red experimental de aviso de ataques por larvas de *S. frugiperda* en pastos y en arroz pluvial, fue instalada en Julio de 1983. Los resultados confirman observaciones previas y demostraron que poblaciones de *S. frugiperda* evolucionaron en la misma forma a lo largo de la costa de la Guayana Francesa. Hoy, una red de aviso de 9 estaciones, ayuda a trasmitir mensajes regulares de advertencia a los ganaderos, pudiendo ellos chequear sus pastos en los momentos oportunos y aplicar insecticidas cuando es necesario.

Since 1976, imported pasture grasses have been planted over large surfaces of improved pasture-land in French Guiana. Simultaneously, population outbreaks of *Mocis latipes* (Guenée) and *Spodoptera frugiperda* (J. E. Smith) larve have been observed. During the rainy season, these larvae damage old and new pastures; and in the latter case, the introduction of pasture grasses could become endangered. These insects appeared as veritable limiting factors in the development of cattle breeding in French Guiana.

For lack of a regular monitoring program, these larval outbreaks were usually discovered too late, and despite insecticide treatments, the loss of large quantities of vegetation could not be avoided, nor could the advent, a few weeks thereafter, of new larval outbreaks on the same pastures. To rectify this situation, it was necessary to develop a system aimed at forewarning cattle-breeders about imminent larval outbreak risks. But, for very practical reasons, such a system based on monitoring of larval populations would never do; consequently, we tried to see if it was possible to use pheromone traps as a method of predicting the development of *S. frugiperda* larval populations and, subsequently, as a method of warning. This step became a challenge, considering the divergent opinions of various scientists on the subject of using pheromone traps as an effective monitoring method for *S. frugiperda* populations (Mitchell 1979, All 1980, Barfield et al. 1980, Sparks 1980, Starratt & McLeod 1982). However, their selective character, the ease and simplicity with which they can be used, as well as the reasonable cost of pheromone traps strongly urged us to make the attempt.

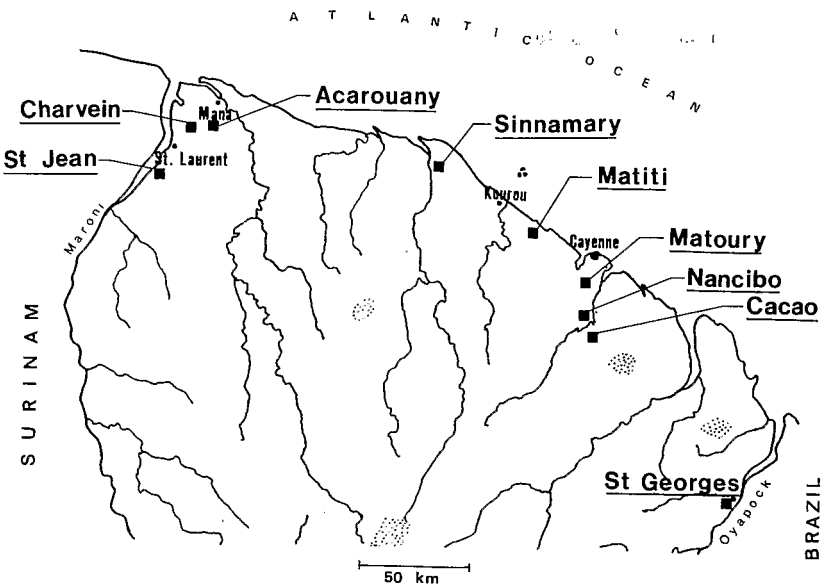
This paper reports experiments carried out between 1979 and 1985 which led to the installation in French Guiana of a network of warning stations equipped with pheromone traps to alert about possible *S. frugiperda* larvae attacks.

DEMONSTRATING THE EFFICIENCY OF PHEROMONE TRAPS AS A METHOD OF PREDICTING THE EVOLUTION OF *S. FRUGIPERDA* LARVAL POPULATIONS.

Starting in 1979, we began testing the efficiency of these traps in a cattle-farm in

Matoury, not far from Cayenne (cf. Map 1). Three Zoecon Pherocon 1 C sticky traps, baited with 25mg of (Z)-9-dodecen-1-ol acetate in Conrel hollow fiber dispensers were operated every weekend. A blacklight trap was operated on Mondays and Thursdays and, with the help of a sweep net, larval populations were sampled on Tuesdays and Fridays (Silvain & Ti A Hing 1985). Several lessons were gleaned from this experiment:

—A strong, positive and very significant correlation (Spearmann's Rank Correlation coefficient higher than 0.65 between November 1979 and April 1983) exists between the results obtained through the pheromone and blacklight trap systems (Silvain 1984, Silvain & Ti A Hing 1985). Considering the fact that blacklight traps attract mostly females (80%) (Silvain & Ti A Hing 1985), this result leads to the conclusion that, in the case of improved pastures in French Guiana, the development of male and female populations occurs in a similar fashion in the course of time, yet another advantage of pheromone traps.
—There is a strong positive and very significant (higher than 0.70) correlation between the results obtained through pheromone traps and those of larval densities in the pastures a week later. A slightly lower correlation is found between the results of moth captures and those of larval catches during the same week (Silvain & Ti A Hing 1985). Those results show that pheromone traps can be used not only to follow the seasonal development of *S. frugiperda* larval populations, but also to predict the future development of these populations on the study site.
—Adult and larval *S. frugiperda* populations are generated monthly during most of the year, and normally these generations are well separated. These findings are of great importance in the setting-up of a warning system, because they show that predictions about the periods when new generations will appear can be made well in advance.
—There are positive, low or moderate, but still significant correlations between the development of adult and larval populations and the pluviometry 3, 4 and 5 weeks earlier.



Map 1: Location of the warning stations

In 1982, a second monitoring station for noctuid populations was installed in Sinnamary, and this helped confirm the results obtained in Matoury. For both moth and larval catches, the results obtained in Sinnamary between 1982 and 1984 were positively correlated to those in Matoury, 100 km to the south-east (Silvain 1983, Silvain 1984). This observation led to the belief that the seasonal development of *S. frugiperda* populations in pastures along the costal strip followed the same general pattern.

It is possible that the highly positive character of results obtained in French Guiana may be due to the nature of the crop observed (low perennial pasture grasses) and to the adoption of a method of use of pheromone traps which tended to minimize the principal defect of the type of trap chosen, i.e. its rapid saturation (Tingle & Mitchell 1975). Also, it may be noted that we haven't tried to directly compare the number of moths and larvae caught, since this would give coefficients with a relative low correlation; but rather to compare the development within a given period of these two variables with the help of a Spearmann rank correlation test. The main idea was to first show that a peak in moth catches in pheromone traps was followed by a peak in larvae captured in the pastures.

What remained was to expand these types of experiments to other sites along French Guiana's coast, to verify whether results obtained from Matoury and Sinnamary could be applied to the whole of the coastal strip, and to install an operational warning system in collaboration with the Plant Protection Service.

Installation of an Experimental Warning Network

Equipment and methods used

Beginning in July 1983, 7 new monitoring stations of noctuid populations gradually were set up in pastures and on pluvial rice (cf. Map 1). Table 1 shows the nature of experiments conducted at each station. Two types of pheromone traps and dispensers were used: sticky Albany Sentry Wing traps baited with a commercial pheromone in Albany hollow fiber dispensers, and International Pheromone Moth Traps baited with a mixture originating from Dr. Mitchell's Laboratory in rubber septum dispensers. The two pheromones contained a mixture of the 4 compounds recommended by Mitchell, i.e. the Z7DDA, Z9DDA, Z9TDA and Z11HDA. The Albany traps were operated as described above, whereas the IPM traps were permanently positioned and their contents emptied every Tuesday and Friday and the pheromone changed every two weeks. Sampling of larval populations continued as before.

Results obtained

Comparison of the moth captures recorded in the different sites—There were 3 periods of abundant *S. frugiperda* moths between July 1983 and March 1985 at practically all the stations (cf. Fig. 1a).

—The July to August period in 1983.

—The November-December 1983 to April 1984 period, during which the largest populations occured in January and especially in February 1984.

—The May-September period in 1984, during which the most abundant populations were observed in July-August.

This relatively simultaneous appearance of moths at the different sites explains the homogeneity in the correlation coefficients obtained at the different stations. Positive and significant correlations existed in all the cases, except for results obtained from Charvein. This confirms the hypothesis that the evolution of *S. frugiperda* populations follows the same general pattern all along French Guiana's coastal strip, thus supporting

TABLE 1. EXPERIMENTATIONS CARRIED OUT IN EACH STATION OF THE EXPERIMENTAL WARNING SYSTEM

Locality	Type of Crops	Experimentations Carried Out
St. Georges de l'Oyapock	Pasturegrasses	P.T. 1* (2)**
Cacao	Pluvial rice	P.T. 1 (3) L.T. ***
Nancibo	Pasturegrasses	P.T. 2 (3)
Matoury	Pasturegrasses	P.T. 1 (4) et P.T. 2 (1) L.T. Larval sampling with sweep net
Matiti-Macouria	Pasturegrasses	P.T. 2 (3)
Sinnamary	Pasturegrasses	P.T. 1 (4) Larval sampling with sweep net
Acarouany	Pasturegrasses	P.T. 1 (3) L.T. Larval sampling with sweep net
Charvein	Pluvial rice or sorghum	P.T. 1 (2) Larval sampling
St. Jean	Pasturegrasses	P.T. 1 (3)

*P.T. 1: Monitoring of male *Spodoptera frugiperda* populations with Albany Scentry™ Wing Trap, baited with commercial pheromone.
P.T. 2: Monitoring of male *Spodoptera frugiperda* populations with International Pheromone Moth Traps baited with pheromone furnished by the Insect Attractants Lab. (U.S.D.A. Gainesville).
**No. of traps used.
***L.T.: Monitoring of adult *Spodoptera frugiperda* populations with blacklight trap.

the validity of warnings based on these results. At Charvein, in a sorghum crop, *S. frugiperda* populations were able to persist at an abundant level during the dry period, which was not the case in habitats having only pasture grasses. Pluvial rice crops grown in the same site and at Cacao did not influence the development of adult *S. frugiperda* populations.

During the October 1984-March 1985 period, adult populations persisted at a relatively low level at the various stations with the exception of Matiti; and *S. frugiperda* were only caught sporadically at Cacao and Nancibo. This situation seems to be linked to the absence of a dry season in October-November 1984, and again to the absence of a marked rainy season from December 1984 to February 1985. In Matiti, where the populations increased dramatically from January to March 1985, the wet/dry season and dry/wet season transitions were slightly more pronounced than at the other stations.

During practically the entire period of study, and at all the different sites, a succession of well separated moth generations occurred ca. every 4 or 5 weeks.

Influence of the type of trap used—The results obtained from the two types of traps were very similar with significant ($p>0.01$) rank correlation coefficients among the results from Matiti (IPM traps) and those from Matoury (0.51) and Sinnamary (0.57)

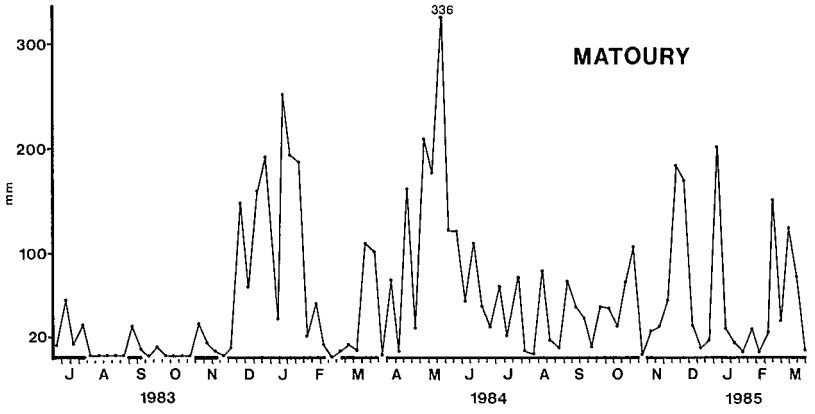


Fig. 1c. Rainfall in Matoury, F. G.

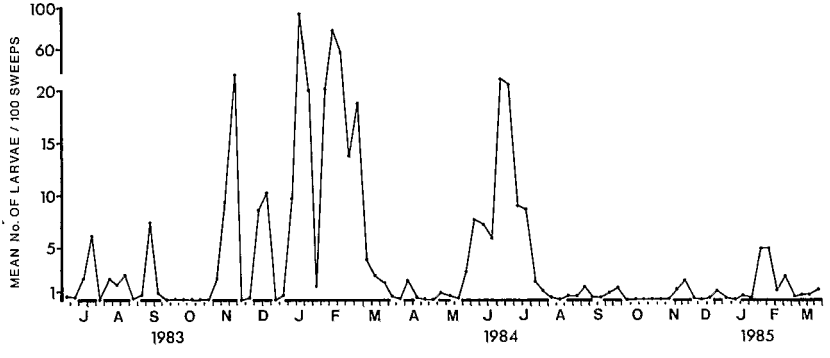


Fig. 1b. *Spodoptera frugiperda* arvae per 100 sweeps on improved pastures.

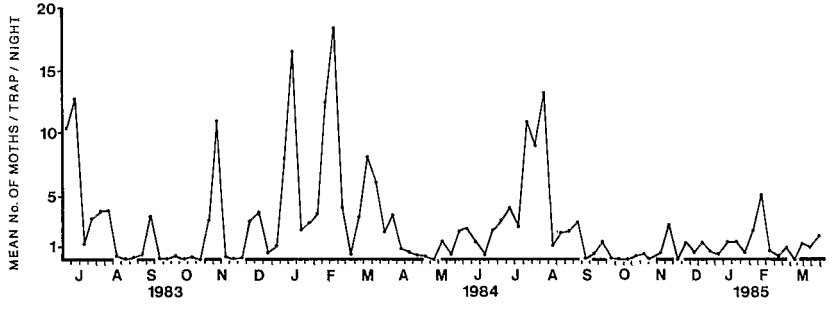


Fig. 1a. *Spodoptera frugiperda* moths captured per night in pheromone traps. Matoury, F. G. 1983-1985.

where Albany traps were used. (It is interesting to note that if the month of March 85 is excluded from these comparisons, we arrive at coefficients of 0.68 and 0.60 with Sinnamary and Matoury, respectively). The same was true of the results obtained from Nancibo (IPM traps) and Cacao (Albany traps) ($rs=0.69$, $p>0.01$

Correlations between pheromone trap moth captures and larvae caught—At the three stations located in pastures where a seasonal development of larval populations had been tracked, we again found positive and very significant correlations between moth catches in a given week and larval densities during the same week and particularly with larval densities in the following week (correlation with larvae caught during the following week: Acarouany: $rs=0.44$, $t=4.54$, $p>0.01$; Sinnamary: $rs=0.48$, $t=5.13$, $p>0.01$; Matoury: $rs=0.55$, $t=6.28$, $p>0.01$). In the Matoury and Sinnamary sites, rank correlation coefficients obtained are lower than those observed earlier; however, we consider this decrease to be linked with the low level of *S. frugiperda* larval populations during a major portion of the study period. We compared highly fluctuating moth captures in Acarouany and Sinnamary with populations of larvae which were close to zero level during half of the experimentation time. An analysis of results obtained between September 83 and March 84 in Matoury confirms this hypothesis. During this period of dense adult and larval populations (cf. Fig. 1a & 1b), the rank correlation coefficient existing between moth and larvae catches, made a week later, reached 0.81 ($t=7.02$, $p>0.01$). Similarly, a calculation of existing rank correlation coefficients, during period of dense populations, between pheromone trap results and larval abundance the following week in Sinnamary and Acarouany, revealed far higher correlations between the two population estimates than those observed during the entire study period (Sinnamary: November 83-May 84: $rs=0.69$, $t=5.01$, $p>0.01$; Acarouany: July-November 1983: $rs=0.67$, $t=3.82$, $p>0.01$). These results support the soundness of chosing of pheromone traps as a method of forewarning the development of *S. frugiperda* larval populations in pastures. This method appears as the most efficient one at times when adult and larval populations are most abundant, which also corresponds exactly with the periods when a warning is most urgently needed.

The results obtained from sorghum crops and pluvial rice to date are not sufficient to permit any definite conclusions.

Correlations between moth trapping, larval abundance and rainfall—In Matoury, between July 83 and March 85, positive, weak, but still significant correlations ($p=0.01$) were again observed between pheromone trap catches during a given week and the rainfall of 3 ($rs=0.26$) or 4 ($rs=0.22$) weeks before (cf. Fig. 1a & 1c). The same was true for larval abundance and rainfall in the preceeding 4 ($rs=0.26$, $p=0.01$) and 5 ($rs=0.25$, $p=0.01$) weeks (cf. Fig. 1b & 1c). These results confirm the belief that rainfall has a definite place among the factors contributing to the seasonal evolution of *S. frugiperda* populations.

Warning About *S. Frugiperda* Larvae Attacks

Basis of the Warning

Results obtained between July 83 and March 84 emphasize the 3 essential points upon which the warning procedure depends:

—A new generation of moths and then larvae appears every 4 to 5 weeks at each of the stations. Hence, it is possible to predict, a month in advance, the approximate date when the next generations will appear for any given station.

—Pheromone traps help to predict one week in advance how the larval populations present in a given week will develop. This respite is enough to warn farmers who then will be able to carry out insecticide treatments before its too late, if densitites necessitate action.

—The adult *S. frugiperda* populations develop over time in a similar manner all along the French Guiana coastal strip; so all the sites in this zone covered by the warning network will be protected.

Therefore, a 2-fold prediction of larval outbreaks in pastures will be undertaken. The first predicts the period when monthly generations of moths and larvae appear, using moth captures. The second predicts the weekly magnitude of these larval populations, from the most recent results. Rainfall during the preceeding weeks also are taken into consideration.

Composition and Broadcasting of Warning Messages

Every Monday, we analyze and synthesize results coming from the different stations. Every 15 days, this synthesis appears in a press-release published on Fridays in the agricultural supplement of the major local newspaper. Should there be a risk of larval outbreak, the farmers are forewarned by means of this printed message as well as radio broadcasts. A direct warning by telephone to one or many cattle breeders may occur.

Future Prospects

The warning network consists of nine stations. We are replacing sticky traps at all the stations, with International Pheromone Moth Traps because of their high level of efficiency (Mitchell, personnal comm., as well as our own observations) and the greater facility with which they can be used. Pheromones from INRA's Chemical Mediator Laboratory (France) have replaced pheromones from Albany. We are progressively entrusting the Plant Protection Service with the management of the warning network. Nevertheless, we shall continue testing new pheromones and traps for efficiency, and these could be proposed eventually to improve the validity of warnings issued. In the future, we hope to include in the system for monitoring *S. frugiperda* populations, another pheromone trap system for *Mocis latipes* populations to provide warning about the risks of subsequent larval outbreaks of this species.

Conclusion

The results of 5 years of work in French Guiana confirm that pheromone traps for the *Spodoptera frugiperda* males can be effectively used as a warning method about damages caused by larvae of this pest in improved pastures. The installation of a warning network permits farmers to protect their pastures precisely when necessary and to take adequate measures at the right moment for *S. frugiperda* larval outbreaks. During the months to come, a modernization of equipment and methods in use should contribute further in ameliorating the performance of pheromone traps and consequently, in improving the validity of warnings issued.

Acknowledgements

I thank Dr. E. R. Mitchell for inviting me to participate in this symposium and for supplying pheromones, D. Dauthuille for his assistance and suggestions, S. Boucher, J. Ti-A-Hing (ORSTOM) for technical assistance, and technicians from Plant Protection Service (SPV) and others for their field assistance. I want to thank Dr. J. McNeil (Université Laval, Québec, Canada) for reviewing this manuscript.

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