IPM in Forage Grasses: Spittlebug Bioecology for Advancing Management in Neotropical Pastures

Despite a high pest status and long history in the Neotropics, an effective and coordinated program for the integrated management of spittlebugs in forage grasses does not yet exist. Among the challenges are a poor basic understanding of biology and ecology at the species and family level, a high diversity of insect/host/habitat associations, and IPM tools that are rudimentary or absent (For more information, see Challenges).

To overcome these limitations we have completed a 5-year diagnostic phase where we sought to (1) acquire new bioecological information on this pest complex and the family Cercopidae, (2) advance diverse components of integrated pest management and (3) develop and evaluate research methodologies and technologies to promote higher quality research from NARS. Achieving these objectives was structured around the development of develop five contrasting ecoregions in Colombia as model sites for advancing the diagnosis and management of spittlebugs (For more information, see Ecoregions].

The pest complex in each ecoregion (Cauca River Valley, Caribbean Coast, Orinoquian Piedmont, Amazonian Piedmont, South Pacific Coast) was characterized through comparative biological and population ecology studies to establish the patterns of variation in biology, behavior and ecology, fundamental for advancing management by tailoring control tactics to the diverse habitats, regions and production systems where spittlebugs are economically important.

Among the diverse IPM components advanced in parallel to these basic studies was the evaluation of fungal entomopathogens as biological control agents. A diverse collection of 77 strains isolated from spittlebugs was established and screened to identify promising isolates. These select strains are being characterized for virulence across different life stages and species of spittlebugs and for deployment in recently initiated field trials to establish application and evaluation techniques in two ecoregions.

These studies led to the development of new and improved methodologies and technologies for studying spittlebugs and evaluating management tactics, including improved mass-rearing techniques and an artificial adult diet. These tools and the new information are being disseminated through a variety of avenues including workshops, field days, publications and the involvement of national collaborators.

1. Comparative biology and ecology: acquire new bioecological information on graminoid spittlebugs and the family Cercopidae in general
   a. Biology and habits of major spittlebug species
   b. Population dynamics and phenology of spittlebugs in contrasting ecoregions
   c. Determinants and seasonal changes in the incidence and duration of egg diapause
   d. Characterization of substrate communication in adult spittlebugs

2. Management: advance in the development of diverse IPM components
   a. Establishment and maintenance of a ceparium for fungal entomopathogens of major forage grass and cassava pests
   b. Fungal entomopathogens
   c. Identity and distribution of grass-feeding spittlebugs
   d. Economic impact of spittlebugs for animal production in *Brachiaria* pastures

3. Information sharing: develop, evaluate and disseminate methodologies and technologies to promote research of higher quality and impact
   a. Improved mass-rearing design and small-scale unit
   b. Artificial diet for maintenance of spittlebug adults
   c. Workshop on the Bioecology and Management of Spittlebugs in Graminoid Crops
   d. Reference collection and on-line bibliography of the Cercopoidea

Major Challenges for the Management of Spittlebugs in Forage Grasses and Sugar Cane

- Habits of the family Cercopidae are poorly understood
- Insect/host/habitat associations are diverse
- Biological information on the majority of economically important species is lacking
- Detailed site-specific studies on ecology are scarce
- IPM tools are rudimentary
- Pest status is continuously changing
- Access to the literature is difficult

Model Ecoregions of Colombia

Development of contrasting ecoregions is crucial for linking bioecological information to improvements in pest management. Our research on the spittlebug complex in each of these sites is establishing the patterns of variation in biology, behavior and ecology, fundamental for advancing management by tailoring control tactics to the diverse habitats, regions and production systems where spittlebugs are economically important.

Through the development of contrasting ecoregions as model sites for advancing the diagnosis and management of this pest complex, these studies will serve as a template for other regions or countries confronting their own problems with this pest. Linking these results to advances in spittlebug IPM will depend on the transfer and diffusion of new information, diagnostic tools, and research methodologies and technologies.

An informal network of collaborators was organized to contribute to this research. During the past five years this included the participation of 17 undergraduate thesis students from five universities, six professors, and seven professionals.

Model Ecoregions

- Cauca River Valley (Departments Cauca, Valle del Cauca) - pronounced seasonality, bimodal precipitation, 1200 mm/yr
- Caribbean Coast (Departments Córdoba, Sucre) - pronounced seasonality, unimodal precipitation, 1000-1400 mm/yr
- Orinoquian Piedmont (Department Meta) - intermediate seasonality, unimodal precipitation, 2800 mm/yr
- South Pacific Coast (Department Tumaco) - continuously humid, 3000 mm/yr
- Amazonian Piedmont (Department Caquetá) - continuously humid, 3600 mm/yr

Undergraduate Student Thesis on Spittlebug Bioecology and Management

Ballesteros G., Yara Ximena & Claudia Patricia Gallego R. 1999. Biología y comportamiento de *Mahanarva* sp. (Homoptera: Cercopidae) bajo condiciones de invernadero. Tesis pregrado, Zootecnista. Universidad de la Amazonia, Florencia, Colombia. 98 pp.

Barrios G.. M. & J. Rojas S. 2000. Dinámica poblacional de *Aeneolamia reducta* Lallemand (Homoptera: Cercopidae) sobre la pastura colosoana (*Bothriochloa pertusa* Camus), en Corozal-Sucre, Colombia 1998. Tesis pregrado, Biólogo. Universidad del Sucre, Sincelejo, Colombia. 77 pp.

Blanco T., Magda Milena & Beatriz Eugenia Giraldo P. 1999. Alternativas para el manejo del mión de los pastos en el piedemonte caqueteño. Tesis pregrado, Zootecnista. Universidad de la Amazonia, Florencia, Colombia. 85 pp.

Corradine Z., Daniel & German Chacón M. In preparation. Establecimiento de hongos entomopatógenos como alternativa para el manejo de ninfas del complejo salivazo de los pastos. Universidad de la Amazonia, Florencia, Colombia.

Gamboa, F. & A. Hincapie. 2000. Dinámica poblacional del complejo del mión de los pastos (Homoptera: Cercopidae) en el Piedemonte Llanero. Tesis pregrado, Ingeniero Agrónomo. Universidad de los Llanos, Villavicencio, Colombia. __ pp.

López M., Francisco. 2000. Importancia de la comunicación vibracional en el comportamiento reproductivo del salivazo de los pastos *Zulia carbonaria* (Lallemand) (Homoptera: Cercopidae). Tesis pregrado, Biólogo. Universidad del Valle, Cali, Colombia. __ pp.

Obregón P., Fabio A. & Orlando Narváez S. In preparation. Establecimiento de hongos entomopatógenos como alternativa para el manejo de adultos del complejo salivazo de los pastos. Universidad de la Amazonia, Florencia, Colombia.

Puentes P., William & Clara Ines Ramirez O. 1999. Respuesta del mión de los pastos (Homoptera: Cercopidae) a praderas asociadas y no asociadas en dos zonas del Departamento del Caquetá. Tesis pregrado, Zootecnista. Universidad de la Amazonia, Florencia, Colombia. 113 pp.

Rodríguez, J. 2001. Biología comparada de tres especies de salivazo del género *Zulia* (Homoptera: Cercopidae). Tesis pregrado, Ingeniero Agrónomo. Universidad del Tolima, Ibague, Colombia. 99 pp.

Rojas B., L.M. & J.C. Rubio V. 2000. Valoración poblacional del complejo mión de los pastos a nivel de finca durante un año en el Departamento del Meta. Tesis pregrado, Ingeniero Agrónomo. Universidad de los Llanos, Villavicencio, Colombia. 87 pp.

Biology and Habits of Major Spittlebug Species

Advances in spittlebug management are limited by the lack of information on the biology, habits and behavior of the majority of economically important species. For example, of the 15 grass-feeding spittlebug species reported for Colombia, the biology of only four has been studied before and only two within Colombia. This basic information is fundamental for improving management.

The biology and habits of nine previously unstudied species was described, representing the genera *Aeneolamia*, *Mahanarva*, *Prosapia* y *Zulia* and the most damaging species in Colombia. Comparative methodologies were used to describe certain aspects of the basic biology including description and recognition of the life stages, duration of the life stages and oviposition sites to define the basic biology of these species and thereby guide advances in pest management. Another goal was to strengthen our understanding of the patterns and variation exhibited by this pest complex.

To facilitate differentiation of the life stages, certain features of the external morphology were described including the size of egg, nymph and adult developmental stages. The duration of these same life stages was quantified under laboratory and greenhouse condition, and oviposition site preferences were studied as part of the description of reproductive behavior.

For each species, eggs pass through four developmental stages, morphologically distinguished by external characteristics and accompanied by an increase in size from one stage to the next. For each species, nymphs passed through five instars, each one showing an increase in size head capsule width, body length, stylet length and anterior wingpad length. Head capsule width was the most diagnostic because there was very little overlap among instars. There was a reduction in stylet length between instar V and adults. In addition, each species exhibited sexual dimorphism in late instar V and adults expressed as a greater size of females.

Variation in the overall life cycle among species was 30 days (45.3-74.9). For eggs, nymphs and adults, the range of variation in duration was 14.1-18.0, 26.1-46.5 and 6.2-22.0 days, respectively. Among these nine species, seven laid the majority of eggs in the soil. *Prosapia simulans* laid a majority on the plant stem surface while *Zulia pubescens* showed a similar preference for the soil and the stem. Litter was the least used oviposition site, receiving 0.0-8.2% of the eggs with the exception of 22.7% in the case of *Mahanarva* sp. nov.

The results from these studies have established the patterns and variation in certain components of spittlebug biology. The variation exhibited by this pest complex in Colombia is relevant to effective application of control tactics and underlines the importance of correct taxonomic determination of the species complex in the area where management is desired.

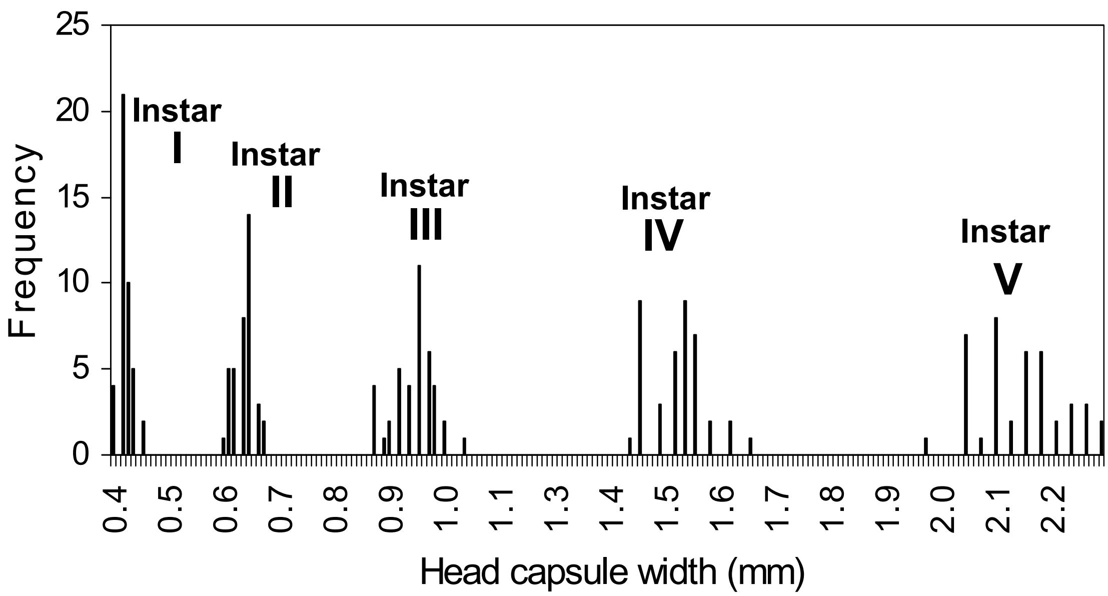
Life cycle and oviposition sites of Colombian spittlebug species

Species	**Duration (days)**				**Oviposition site preferences (% eggs recovered)**		
	Egg	**Nymph**	**Adult**	**Total**[1]	**Soil**	**Litter**	**Plant surface**
Aeneolamia lepidior	14.1	35.4	6.2	52.6	79.7	5.7	14.6
Aeneolamia reducta	15.8	26.1	6.8	45.3	90.4	8.2	1.4
Aeneolamia varia	17.2	30.8	7.2	51.6	97.6	1.7	0.7
Mahanarva andigena	16.4	46.5	24.0	74.9	67.6	0.0	32.4
***Mahanarva* sp. nov.**	17.0	44.2	6.8	64.6	74.0	22.7	3.3
Prosapia simulans	18.0	45.6	17.8	72.5	17.4	0.0	82.6
Zulia carbonaria	17.4	42.4	19.6	69.6	99.4	0.6	0.0
Zulia pubescens	14.3	38.0	18.4	61.5	40.4	0.4	59.2
***Zulia* sp. nov.**	14.6	42.7	14.2	64.4	100.0	0.0	0.0

[1] Calculated as half the adult longevity.

Spittlebug nymphs and adults maintained in pots for life cycle studies.

Histogram of head capsule widths for five instars of *Zulia carbonaria*.



Population Dynamics and Phenology of Spittlebugs in Contrasting Ecoregions

Intensive population surveys in representative farms in each ecoregion served as the basis for acquisition of new information on the bioecology of the spittlebug complex across regions. A representative farm was chosen in the Cauca River Valley (Santander de Quilichao, Dept. Cauca, *Brachiaria dictyoneura* pastures), Orinoquian Piedmont (CORPOICA C.I. La Libertad, Dept. Meta, *Brachiaria decumbens*), the Amazonian Piedmont (CORPOICA C.I. Macagual, Dept. Caquetá, *B. decumbens*), and two in the Caribbean Coast (Ciénaga de Oro, Dept. Córdoba and Corozal, Dept. Sucre, both *B. pertusa*).

In each farm three observation plots were established in separate paddocks and surveys of nymphs, adults and their natural enemies were conducted 1-2 times per week over two years. Nymphs were determined to instar and adults to sex and species to establish population fluctuation curves according to life stage. These studies were designed to measure on-farm, regional and between year variation in certain components of population ecology including species composition, abundance, phenology, number of generations and incidence of natural enemies.

Spittlebug species composition varied among ecoregions, with a total of nine species from four genera encountered. Two undescribed new species were discovered, *Mahanarva* sp. nov. from the Amazonian Piedmont and *Zulia* sp. nov. from the South Pacific Coast.

Five classes of natural enemies were found: parasitic mites (Acari: Erythraeidae), parasitic nematodes (Nematoda: Mermithidae), predaceous fly larvae (Diptera: Syrphidae) and fly adults (Diptera: Asilidae), parasitic flies (Diptera: Pipunculidae) and fungal entomopathogens. Pipunculid flies were only found on one occasion and are the first report of this fly family attacking neotropical spittlebugs. A total of 77 strains of fungal entomopathogens were isolated and are currently maintained in a ceparium for virulence trials and studies on their potential as biological control agents.

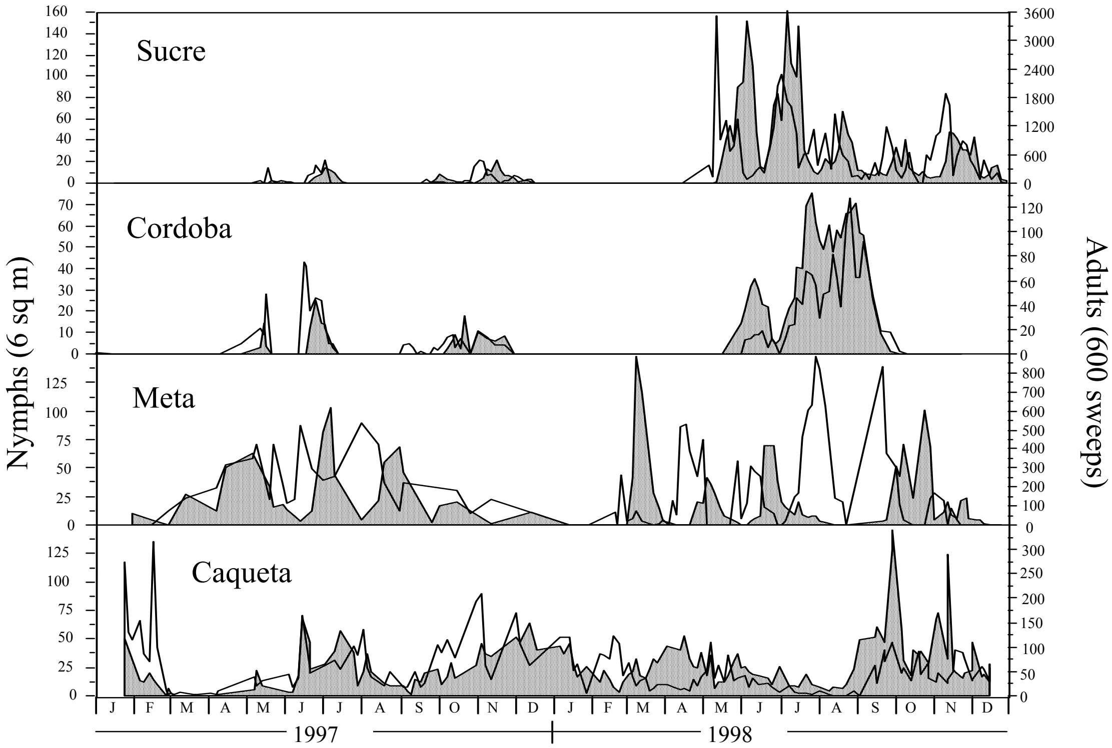
Spittlebug nymphs and adults occurred during the wet season and disappeared during the driest periods. Study of the population curves at the level of the three plots revealed the degree of on-farm variation in terms of abundance and phenology. In one case, evidence for movement and invasion of previously unaffected areas of the farm was documented when two plots whose populations had disappeared due to dry season fire were recolonized from areas of the farm unaffected by the fire.

Differentiation of the life stages permitted an even greater resolution of insect phenology. Development of the different generations was revealed by the progress in abundance of the instars and the appearance of teneral adults (still in the spittle mass of instar V). This permitted a precise interpretation of the population fluctuation in terms of discrete generations instead of simply population peaks. Finally, through an analysis of cumulative insect-days, it was possible to calculate generational time, which corresponded well with the life cycle estimated obtained from biological studies and confirming that the survey protocol is appropriate for describing the population dynamics. For example, in the case of Dept. Sucre, the generation time determined from field studies was 41.6 days compared with 45.2 from the greenhouse.

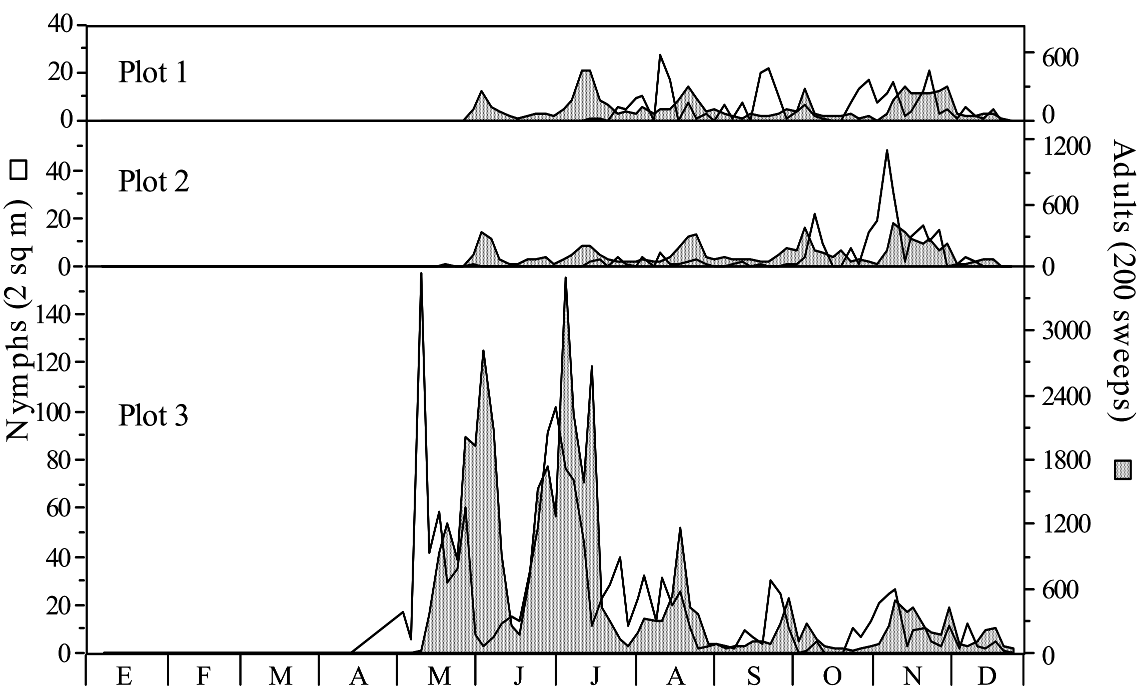
In general, compared to regions with high and continuous humidity, regions with low and seasonal rainfall can be characterized by lower diversity of spittlebugs, lower incidence of natural enemies, and more pronounced population fluctuation and synchrony. In seasonal systems management strategies should therefore focus on spatial and temporal detection of initial outbreaks to target control tactics designed to suppress focal populations. In less seasonal systems, management strategies should focus on cultural tactics to reduce habitat quality, and there are more perspectives for the use of biological control.

	Aeneolamia			*Mahanarva*	*Prosapia*	*Zulia*	
Species	*lepidior*	*reducta*	*varia*	sp. nov.	*simulans*	*carbonaria*	*pubescens*
Caribbean Coast	<1	100	0	0	0	0	0
Cauca River Valley	0	0	0	0	<1	100	<1
Orinoquian Piedmont	0	5	94	0	0	0	1
Amazonian Piedmont	0	0	74	1	0	<1	25

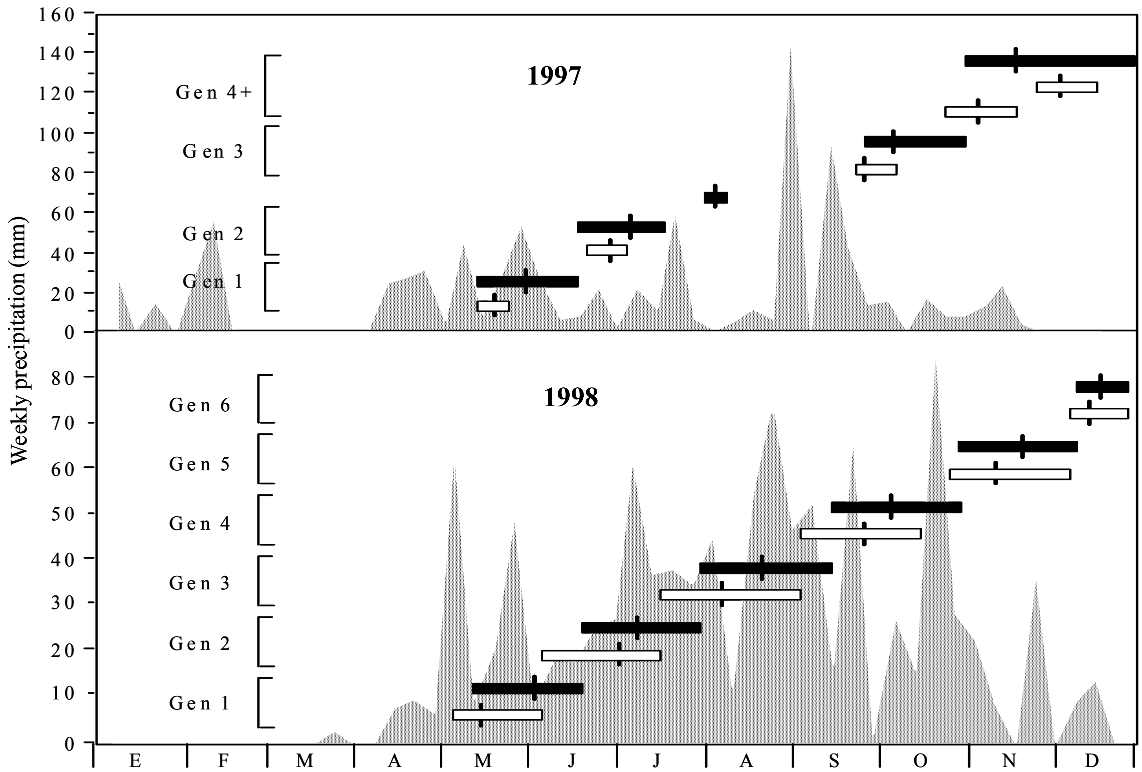
Species composition of spittlebugs (% adult abundance) in four contrasting zones of Colombia.



Population fluctuation curves of spittlebug nymphs and adults in contrasting sites in Colombia.



Population fluctuation of *Aeneolamia reducta* in *Bothriochloa pertusa* pastures of the Caribbean Coast of Colombia (Corozal, Sucre).



Phenogram of *Aeneolamia reducta* nymph and adult populations in *Bothriochloa pertusa* pastures of the Caribbean Coast of Colombia (Corozal, Sucre); bars represent period of occurrence while vertical lines indicate date of 50% cumulative insect-days.

Fungal Entomopathogens of Spittlebugs

Among the diverse IPM components advanced in parallel to these basic studies was the evaluation of fungal entomopathogens as biological control agents. A diverse collection of 77 strains isolated from spittlebugs was established. Initial screenings identified highly promising isolates that are being characterized for virulence across different life stages and species of spittlebugs and for deployment in recently initiated field trials to establish application and evaluation techniques in two ecoregions. Given our new and detailed understanding of spittlebug bioecology, we expect to overcome the challenges and limitations of previous studies and serious assess the biological control potential of fungal entomopathogens for spittlebug management in pastures.