[3957] *TRICHOGRAMMA TURKESTANICA*, A CANDIDATE FOR BIOLOGICAL CONTROL OF *EPHESTIA KUEHNIELLA* IN FLOUR MILLS

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The Mediterranean flour moth *Ephestia kuehniella* (Lep.: Pyralidae) is an important pest in flour mills. The egg parasitoid *Trichogramma turkestanica* (Hym.: Trichogrammatidae) is being investigated as a possible candidate for biological control of this pest. Investigations have previously been conducted in Germany on this strain, published under the name *T. evanescens* "Lager" strain. The identity of the strain has been revealed by the means of molecular methods, but the taxonomy of this strain is a matter of discussion at present. Relatively low temperatures may prevail for long periods in Scandinavian flour mills so the ability of the natural enemy to be efficient at 15-20°C is essential for the success of the system. In laboratory investigations life table parameters of *T. turkestanica* reared on *E. kuehniella* have been determined at four constant temperatures (15, 20, 25 and 30°C). At these temperatures the development time ranged between 33 and 7 days. No emergence occurred at 10°C although some development took place: the parasitised host eggs turned black thus indicating development until the third larval stage. Fecundity amounted to 67 eggs per female at 15°C, increasing to a maximum of 82 eggs per female at 25°C; the minimum value was found at 30°C. Female longevity ranged from a mean of 32 days at 15°C to 2 days at 30°C. Based on the investigations the intrinsic rate of natural increase was calculated; the maximal value of 0.40 was found at 30°C. The investigations were designed so that the rate of host-feeding as well as the daily parasitism exerted by the parasitoid could be calculated. Daily parasitism ranged between 4 and 15 hosts per female per day, depending on temperature. Host-feeding accounted for up to 49% of the total mortality of the host eggs, after correction for control mortality. These investigations show that host-feeding is an important factor in the total effect of the parasitoid on its host. The lower temperature threshold for female walking activity was investigated; activity was seen at temperatures as low as 7°C. The effect of the parasitoid on a flour moth population in a mills is being calculated. The results give reason to believe that this parasitoid will be efficient even at the low temperatures found in industrial flour mills in early season. Field trials are being planned to elucidate this.

Index terms: life tables, host-feeding, development time, temperature

[3958] USE OF TROPICAL AND TRANSGENIC *BACILLUS THURINGIENSIS* CORN HYBRIDS IN SOUTHEASTERN UNITED STATES GRAIN AND SILAGE PRODUCTION SYSTEMS

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Corn is an important crop in the southeastern United States and the Caribbean Basin, grown for both grain and silage production. This region of the U.S. and adjacent islands are grain deficit areas, which means that the product (either grain or silage) must be produced locally or shipped from some other production area. Both grain and silage production are impeded by factors such as inadequate rainfall or severe injury by both insects and diseases. Normal planting dates used by producers in the southeastern U.S. are limited to the months of March and April because of both rainfall patterns and the potential for severe insect injury to the crop. The fall armyworm, *Spodoptera frugiperda*, causes severe injury and significant losses to both grain and silage biomass by feeding in whorl-stage corn. The corn earworm, *Helicoverpa zea*, is primarily a pest of ear-stage corn, where it often produces significant loss of grain yield and may predispose grain to infection by mycotoxin-producing organisms such as *Aspergillus flavus* and *A. parasiticus*, which may render the crop unmarketable. The fall armyworm also secondarily infests ear-stage corn and may reduce grain yields and influence mycotoxin levels in the grain. Two or more species of pathogens producing corn leaf rust diseases are of economic importance and often result in significant losses in grain yield. Results of three years of field experiments with a Pioneer tropical hybrid and several transgenic *B.t.* hybrids from the Pioneer and Novartis breeding programs will be presented. Monthly plantings were made from March to August, 1997-99, to evaluate the effects of differing environmental patterns. Insect populations were monitored in whorl-state and ear-stage corn, and yields of both silage and grain were obtained. Results indicated that even with delayed planting of transgenic corn hybrids, injury by the fall armyworm in whorl-stage corn was significantly reduced. Similar results were observed with the corn earworm in ear-stage corn. Delayed planting of the transgenic hybrids was observed to result in severe injury from leaf rust diseases. Tropical corn hybrids remain susceptible to fall armyworm injury with delayed planting; however, these hybrids are quite resistant to injury by corn leaf rust pathogens. Adaptation of a relative larval consumption index will be described. Plant breeding needs that would enhance corn grain and silage production in the southeastern U.S. and in the Caribbean Basin will be discussed.

Index terms: *Spodoptera frugiperda*, *Helicoverpa zea*, *B.t.* corn, tropical corn, larval consumption index

[3959] REVIEWING A MULTI-AGENCY BIOLOGICAL CONTROL PROGRAM FOR BEMISIA ARGENTIFOLII IN THE SOUTHWEST UNITED STATES: FOREIGN EXPLORATION, MASS CULTURE & EVALUATIONS

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Outbreaks of *Bemisia argentifolii* (*B. tabaci* strain "B") in the USA during the late 1980s led to a national research and action plan, which included efforts to discover, evaluate and establish more effective biological control agents. Although many parasitoids, predators and pathogens were reported to attack *Bemisia* species around the world, no widespread search had previously been conducted. Foreign exploration for natural enemies of *Bemisia* spp. was therefore conducted during 1991-98 in Africa, the Arabian peninsula, Central and South America, the Mediterranean basin, the Indian subcontinent, and Southeast Asia. Concurrently, indigenous natural enemies attacking *B. argentifolii* in the USA were investigated. Overseas collections of predators, parasitoids and pathogens were shipped to the USA for quarantine, identification and/or evaluation. More than 80 shipments of natural enemies were received. Pathogens were sent to the USDA-ARS entomopathogen repository (Ithaca, NY). The majority of exotic arthropods were received and maintained in culture at the USDA-APHIS quarantine laboratory in Mission, TX. Since many of these species belonged to genera in need of taxonomic revision, initial identifications or characterizations were often made by a combination of morphology and molecular markers while systematic revisions of the genera were undertaken by taxonomists. Colonies and selected mass-rearing cultures of parasitoids and predators were maintained at Mission, TX, in support of field evaluations conducted at various locations in the USA. Following the preparation of environmental assessments, release permits were issued for species of *Eretmocerus, Encarsia* and *Serangium,* which were originally associated with *Bemisia* spp. at the foreign collection site. Imported and selected indigenous parasitoids were first compared in the laboratory at Mission, TX, with cotton, cantaloupe, broccoli and sowthistle as host plants. The best-performing species were then re-tested in walk-in field cages on alfalfa, broccoli, cantaloupe and cotton in desert climates. In these evaluations, *Eretmocerus emiratus* (UAE), *E. nr. emiratus* (Ethiopia), *E. mundus* (various sources), and *E. hayati* (Pakistan) were superior to other *Eretmocerus* and uniparental *Encarsia.* Among biparental *Encarsia* tested, one population of *E. sophia* [=*E. transvena*] (Pakistan) was significantly superior to others from Spain, Thailand and Malaysia, and to *Encarsia bimaculata* (India) when evaluated on broccoli, cantaloupe, and cotton in field cages.

Index terms: *Bemisia tabaci* strain "B", parasitoids, *Eretmocerus, Encarsia*

[3960] REVIEWING A MULTI-AGENCY BIOLOGICAL CONTROL PROGRAM FOR BEMISIA ARGENTIFOLII IN THE SOUTHWEST UNITED STATES: ESTABLISHING, CONSERVING & AUGMENTING NEW PARASITOIDS & EVALUATING THEIR IMPACT

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Colonization has established *Eretmocerus mundus, E. hayati, E. emiratus* and *E. nr. emiratus* in several desert valleys of Arizona and California and in the temperate southern San Joaquin Valley, CA. More than 50 million pupae and adults were reared in insectaries in TX, AZ and CA, and released during 1993-99 in agricultural field crops and citrus orchards, urban areas, wildlife preserves, managed refuges and commercial plant nurseries. Introduced *Eretmocerus* populations have increased in size and expanded outwards from release sites each year since recoveries were first detected. In 1999, exotic *Eretmocerus* were found at a majority of numerous survey sites in Imperial Valley, CA. *Eretmocerus emiratus* (ex UAE) / *E. nr. emiratus* (ex Ethiopia), which are morphologically indistiguishable but separated by RAPD-PCR, predominate in recoveries and now account for increasing proportions of *Bemisia* parasitism each year. *Encarsia sophia* (ex Pakistan) also appears to have established in the Imperial Valley. Four years of augmentation field trials in Imperial Valley with exotic *Eretmocerus* species demonstrated that parasitism could be increased, and *Bemisia* suppressed, by making open-field inoculative releases. These releases were compatible with the use of selective pesticides in some crops, such as imidacloprid in early-season melons. Exotic *Eretmocerus* were more easily reared and were more effective in these trials, compared to the indigenous *E. eremicus.* Different methods for field distribution of mass-reared parasitoids were evaluated, including mechanical applicators and pre-planting inoculation of melon transplants with parasitoids. Surveys of indigenous, non-target whiteflies have been in progress since 1993, and their parasitoids identified or described to document the native parasitoid complexes. There is no evidence yet of reproduction by exotic species on any of the nontarget whitefly species being monitored. Determining the impact of exotic parasitoids on *Bemisia* populations is complex, because whitefly density varies widely according to weather, natural enemies, host plants, cropping patterns and cultural practices, etc. A multivariate analysis of agricultural crops is in progress in Imperial Valley to correlate whitefly density with these factors and determine the proportion of mortality which is due to introduced parasitoids.

Index terms: *Bemisia tabaci* strain "B", *Eretmocerus, Encarsia*, Aphelinidae