Biology and Control of the Egyptian Alfalfa Weevil, *Hypera brunneipennis* (Boh.), in California

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The Egyptian alfalfa weevil, *Hypera brunneipennis*, is a native of the Middle Eastern region of the Old World and was first detected in this country in Arizona's Yuma Valley in the 1930's. Its method of introduction is unknown but it is speculated that perhaps date palm stock imported from the insect's native area contained adult weevils which had sought shelter under the bark of the plants for their period of summer dormancy (aestivation). From its initial introduction it spread rapidly into the Coachella and Imperial Valleys and has been a serious pest in the latter area since that time. During the 1950's and early 1960's, it spread into the southern and central California coastal counties where it now causes extensive losses in many localities each year.

It appeared in several counties in the upper Sacramento Valley in 1965 and in Tulare County in the San Joaquin Valley in 1966. Over 70% of the state's 1,141,000 acres of alfalfa is located in the Central Valley and the continuing spread of the insect in the prime alfalfa-growing areas there now represents a major threat to the crop.

Economic loss figures, summarized from van den Bosch and Marble (Calif. Agr., May 1971), accurately describe the critical nature of the problem and rank the weevil as the number-one insect pest of alfalfa in the state. Alfalfa hay is among the top three agricultural crops in California with a total value of over $197,000,000 in 1970. During that year, a statewide survey by the Agricultural Extension Service determined that the combined costs of yield-losses attributable to this insect and of chemical control measures aimed at it totaled more than $6,000,000. Glenn, Merced, Stanislaus, and Tulare Counties each suffered losses of over $250,000 to the weevil in 1970 and similar figures for each of Imperial, San Joaquin, and Yolo Counties exceeded $1,000,000. In Yolo County, detailed loss figures for 12,100 acres, about 25% of the county's alfalfa acreage, totaled $422,000 or about $35.00 per acre.

The rapid increase in the severity of the problem is emphasized by comparison of the above figures with those of the early 1960's when losses to the Egyptian alfalfa weevil in California amounted to less than $500,000 annually.

The increasing magnitude of losses attributable to *H. brunneipennis* involves a complex of reasons, the most important of which relate directly to the present limited state of knowledge regarding certain key aspects of its biology. A description of the biology of this insect together with a summary of recent research best describes the complex nature of the problem and the current progress being made in areas of critical concern.

After completing the larval period in late spring, the insect spins a cocoon, located on the aerial parts of the plants or on the ground, and inside this transforms to the pupal and then the adult stage. The new-generation adults emerge and feed, sometimes causing damage to the second cutting in areas of heavy infestation. They then migrate out of the fields, primarily by flight, and seek sheltered places where they congregate and become dormant for an extended period. A favorite aestivation site is under the bark of Eucalyptus trees but cracks in or under the bark of several other species of trees are also used as well as a diversity of other sites which provide some sort of shelter. Such sites include protected areas bordering some fields, woodpiles, cracks in fenceposts and buildings, and even secluded areas in homes where the insects are sometimes found in such numbers that they are reported as household pests.

In the fall, the adults again become active and begin their movement back into the fields. Research on the patterns of this movement accomplished during the fall of 1970 indicated that all but a small percentage of the population was back in the fields by late November. In this study, screen traps placed over sections of Eucalyptus trunks were closely monitored and the observed patterns correlated with the buildup of field populations These data provided important information upon which the modifications in the timing of chemical control measures described later in this paper were based. Research in this area is continuing in order to provide cumulative data relating to variations in this fall movement that may occur subject to annual differences in field weather patterns.

Upon returning to the fields, the adults feed and begin reproductive activities. Current data indicate that mating begins in late fall and that egg-laying (oviposition) can occur any time from mid-December on with the subsequent pattern varying in association with fluctuations in temperatures between areas and years. Most eggs are laid inside of stems of the last cutting left standing in the fields or in those forming the surface litter with the remainder normally being deposited in the new stems later in the winter or in early spring. Throughout most of the weevil's inland range in California, the bulk of the oviposition occurs in January and February but during cool springs large numbers of eggs can be laid well into March causing an excessive prolongation of the damaging larval period and associated problems of control. Hatching can begin in late January and is generally well underway by mid-February. Damaging larval populations can occur as early as late February and, in the absence of control measures, population levels of over 300 individuals per square foot can occur throughout the month of March in the most severely infested areas.

The biological patterns exhibited by this insect during the larval developmental period form the basis for some of the most pressing research needs associated with this problem. Illustrative of this is the relationship of the changes in larval behavior that occur during this time to the efficiency of current sampling techniques and the associated implications for the application of control measures.

Upon hatching, the young larvae crawl up the plant and burrow deep into the terminal buds where their initial feeding activities occur. During this period, which may last several weeks, few if any individuals can be dislodged by the sweep net although the larval population may approach its maximum number. As the larvae mature, however, they crawl out of the tips and feed on more exposed portions of the plant and thus become more readily recoverable by sweeping. This shift in behavior and associated increase in the numbers recoverable per sweep can occur in a relatively short time and in the most heavily infested localities counts can go from only a few individuals to over 200 per sweep within two weeks and to even higher numbers in a few days more. At some brief point in this sequence the level at which chemical control is recommended, 20 larvae per sweep, will occur at all but the very lowest population levels. The 20 per sweep point therefore commonly does not represent a maximum population level or in all cases even an economically damaging level per se but more often rather an "early warning" of a large population that is rapidly changing from the less damaging younger larvae to the later stages which cause greater losses due to their increased feeding capacity.

From the foregoing, then, it is obvious that the maximum level which the population will reach, when evaluated in terms of numbers of larvae per sweep, can only be known in retrospect. Of key importance relative to this is the fact that the population level at which losses equal the price of control measures, a point termed the economic-injury level, is at present not accurately defined for the Egyptian alfalfa weevil. It should be further stressed that this level can vary with the growth stage of the plant, the alfalfa variety involved, differential pest population age-class structures, the abundance of key beneficial species, etc., adding further complexity to the problem.

Of highest priority, then, is the need for development of sampling techniques that will allow more accurate prediction of population levels of this insect than is possible with the current approach. Further research correlating various population patterns with quantitative and qualitative yield-loss figures will give us a basis upon which accurate pest-management decisions involving the use of various control techniques can be based. Such data will also hopefully provide guidelines for further modification of presently-existing approaches to control and for the development of new approaches focused on reduction of losses from present levels at minimum costs to the grower and with minimal disruption of the complex of beneficial insects associated with alfalfa.

Research on the areas previously discussed is currently underway by the authors. The present and future outlook for control is as follows.

As noted earlier, in areas where the Egyptian alfalfa weevil has been established for a number of years, it is not uncommon to obtain counts which exceed 200 larvae per sweep during the population peak. At the present time, chemical control offers the only practical means of maintaining such potentially high populations below the economic-injury level. In the absence of such treatments, the losses attributable to this insect would be significantly greater than at present. Chemical control of the Egyptian alfalfa weevil, however, itself involves some complex considerations.

Larval populations may occasionally reach treatable levels in first year stands, particularly those planted early the previous fall, although serious damage is more likely to occur in stands two years of age or older. Although weevil activity is essentially limited to the first and second alfalfa cuttings, variations in the development of the larval population coupled with the relatively short residual activity of the presently-recommended insecticides, compared to the cyclodiene materials formerly used, make the timing of such applications of critical importance in obtaining optimum control of this insect. Insecticides applied too early may lose their effectiveness before the majority of the larvae are present. Conversely, if treatments are applied too late, considerable damage and subsequent loss of hay may occur before the population is brought under control

The importance of proper timing of insecticide treatments is shown by the results of an experiment conducted near Porterville, Tulare County, in 1971. Guthion® and Imidan®, two of the more frequently used insecticides in Egyptian alfalfa weevil control, were applied to a series of replicated plots on March 1 (1 larva per sweep) and to a second series of plots on March 24 (21 larvae per sweep). Both materials were applied in the equivalent of 20 gallons of water per acre at a pressure of 40 psi with a CO_2 powered back-pack sprayer. Materials were applied at the rate of 1 pound of active ingredient per acre with the exception of the March 24 Guthion application which was at the rate of 0.5 pound of active ingredient per acre. The plots were sampled on March 30, at the population peak, by taking 10 sweeps per plot. Populations in the Guthion and Imidan plots treated March 1 averaged 19 and 87 larvae per sweep respectively while the untreated check averaged 93 larvae per sweep. No control was afforded by the early Imidan application and under commercial production conditions, a second treatment would have been necessary to protect the crop. While better control was obtained with the early Guthion application, the population had still reached the recommended treatment level by March 30. Satisfactory control was obtained by both Guthion and Imidan applied March 24. Counts in these plots averaged 8 and 5 larvae per sweep respectively.

In order to time these applications to obtain maximum control, population growth must be watched closely. Fields should be sampled frequently as soon as the larvae appear. Early in the year, weekly samples are sufficient but, as the season progresses, fields may require sampling every two or three days. Several sweeps should be taken from different parts of the field in order to insure that the average population level in the entire field has reached the currently recommended treatment index. Usually, if treatments are timed properly, a single application will give adequate control until the first cutting is made. However, in years when the population reaches damaging levels in February or early March, a second treatment, two to three weeks after the first, may be necessary. Fields should be watched closely for evidence of any additional build-up of larvae following the first treatment. Insecticides applied by both ground sprayers and aircraft have given satisfactory control and the method of application chosen may be determined by local conditions.

Following the first cutting, fields should be examined for evidence of larval or new-generation adult feeding on the regrowth. If regrowth is slow or stunted, and weevils are found feeding on the new shoots, a stubble treatment may be necessary. Particular attention should be given to fields in which the first cutting was not treated or cutting was used in lieu of an insecticide treatment. Since stubble or short regrowth cannot be effectively swept, the decision to treat must be based on the pattern of regrowth, the presence of weevils on the shoots, and the amount of damage sustained. Relatively few individuals may cause considerable damage to the crop at this stage since the new buds may be eaten before having a chance to grow.

In a continuing series of experiments, underway near Woodland, Yolo County, and Porterville, the possibility of maintaining larval populations below the economic-injury level by early season control of the adults is being investigated. The 1970-71 migration studies discussed earlier, indicated that the adults had left their summer aestivation sites and returned to the fields by early winter. No larvae were present at this time and oviposition had been minimal. Furadan®, Supracide®, and Guthion were applied to replicated plots on January 16. Imidan was applied 1 week later on January 24. These four materials were applied to a second series of plots on March 1 and to a third series on March 24. Furadan, Supracide, and Guthion were applied on March 24 at the rate of 0.5 pound of active ingredient per acre. All other applications (both materials and dates) were at 1 pound of active ingredient per acre. The insecticides were applied with a back-pack type sprayer as previously described.

The experiment was sampled on March 30 by taking 10 sweeps per plot. Furadan was the only material applied January 16 that gave adequate control throughout the weevil season. Counts in the Furadan plots averaged 15 larvae per sweep, 5 below the recommended treatment level. Populations in the Imidan, Guthion, and Supracide plots averaged 105, 70, and 56 larvae per sweep respectively, all well above the recommended treatment level. Both Furadan and Supracide gave good control when applied on March 1. Counts in the Furadan plots averaged 6 larvae per sweep and larval populations in the Supracide plots reached 14 per sweep. Again, Imidan gave inadequate control with an average of 87 larvae per sweep. Control with Guthion applied on March 1 was questionable. Net counts averaged 19 larvae per sweep which indicated the possible need for a second treatment. All four materials gave satisfactory control when applied on March 24. Counts averaged 4, 8, 9, and 9 larvae per sweep in the Imidan, Supracide, Furadan, and Guthion plots respectively. Populations in the untreated check averaged 93 larvae per sweep.

Additional experiments are being conducted to evaluate other important aspects of early-season insecticide applications. If consistent satisfactory control can be obtained with such an approach, timing of applications may become less critical than at present where a delay of a few days may result in economic losses. Also of importance is the probability that treatments applied during winter or very early spring may have significantly less adverse effects on the beneficial insect species found in alfalfa than would applications made later in the season.

The relationship between weed control and weevil control discussed by Norris (this symposium) has prompted a series of experiments designed to investigate the degree of interaction of the two. Studies are currently underway to determine if improved control can be obtained by well-timed insecticide-herbicide applications.

Alfalfa varieties highly resistant to the Egyptian alfalfa weevil would provide an inexpensive and simple means of controlling this pest. It is unlikely, however, that varieties with sufficient resistance to the weevil to serve as the principal control method will be found but it is hoped that varieties with sufficient resistance or tolerance to serve as an adjunct to other control measures can be developed. The results of work conducted by the University of California and elsewhere indicate that this is possible. The United States Department of Agriculture in cooperation with a number of State Experiment Stations has developed the variety Team which contains some tolerance to the alfalfa weevil Hypera postica but is too dormant for maximum production in California and is not resistant to the spotted alfalfa aphid. The same pattern holds true for the commercially-developed variety Weevlchek. A series of test plots is currently being established at the University of California Kearney Field Station in Parlier, Fresno County, to evaluate the resistance of alfalfa varieties more adapted to our area.

Investigations by other researchers on control of the weevil by the use of biotic agents (Gonzalez and van den Bosch) and flaming (Norris) are discussed elsewhere in this symposium.