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Project Summary

Objective

The goal of this project was to determine the validity of the western bean cutworm, *Richia albicosta* (Noctuidae), growing degree day (GDD) model developed at the University of Nebraska with western bean cutworm flight and weather data collected in Iowa. The completed project will show if the current GDD model holds up when compared with data collected in Iowa from 2003 to 2005. The project will also show if more data needs to be collected and analyzed to further test the current GDD model.

Outcomes

The outcomes of the project show that the previously developed GDD model for western bean cutworm is valid for populations in Iowa. However the data shows that the current model might not be as accurate as researchers would like. Considering the error is so large in the current model, more research is recommended to try to improve the accuracy of the model. Since the current model is relatively accurate in Iowa, it can reasonably be expected to be as accurate in other states where the range of the western bean cutworm is spreading to. With the growing economic importance of western bean cutworm in Iowa, and possibly other states, it is important to be able to predict accurately when western bean cutworm moth emergence can be expected so control options can be considered. In the end having an accurate GDD model for western bean cutworm will help growers control the pest and researchers to be able to focus their resources when studying the insect.

Western Bean Cutworm History

Life History

Western bean cutworm adults lay eggs in corn, sweet corn, popcorn, or dry beans in masses of five to 200 (Seymour, 2004). The eggs develop over five to seven days (Seymour, 2004). The larvae feed for approximately 31 days passing through five larval instars (Seymour, 2004). As a fifth instar the larvae drops to the ground, burrows five to ten inches below the surface, and constructs an over wintering cell where it spends the winter in the pre-pupal stage (Seymour, 2004). The larvae will pupate in late May and adults begin to emerge in early July (Seymour, 2004).

Hosts and Distribution

Western bean cutworm adults were first described by J.B. Smith in 1887 in Arizona (Blickenstaff, 1982). The literature describes it as a pest of beans, *Phaseolus vulgaris,* before 1950 and on corn, *Zea mays*, in several states in the 1950s and 1960s (Blickenstaff, 1982). The historical distribution has placed the western bean cutworm in Idaho, Kansas, Nebraska, Utah, Colorado, Arizona, New Mexico, Texas, Wyoming, Oklahoma, and western Iowa (Blickenstaff, 1982).

In recent years the distribution of the western bean cutworm has been moving eastward across the Corn Belt. In 1999 western bean cutworm larvae were collected from corn ears from west central to southern Minnesota (O'Rourke, 2000). In 2000 economically damaging populations were found in northwestern Iowa (Rice, 2000). In 2004 a pheromone trapping network was set up that collected adult western bean cutworm in Illinois and Missouri (Dorhout, 2004).

The Survey

Historical Study

The current GDD model shows the GDD needed to reach 25%, 50%, and 75% moth emergence are 1319, 1422, and 1536 (Ahmad, 1979). The model was reached using the simple method, which was shown to have no significant difference to the more complicated sine wave method (Ahmad, 1979). The simple method GDD was calculated from May 1, which was slightly superior to April 1, using a base temperature of 50°F (Ahmad, 1979). The simple method takes the average of the daily high and low temperatures and subtracts 50 to reach the GDD for the day (Ahmad, 1979). These are then added for each day until moth numbers are counted in light traps (Ahmad, 1979). The data for the model was collected from seven different Nebraska cities: North Platte, Aurora, Parks, Scottsbluff, Lexington, Kearney, and Sidney (Ahmad, 1979). The years the data was collected included 1958 to 1965, 1968 to 1971, 1974, and 1976, not all locations were collected for each year (Ahmad, 1979). All together over the years and locations there were 23 total sites from which the data was calculated.

Data Collection

Data for western bean cutworm in Iowa was collected by Iowa State University in cooperation with many collaborators across the state in 2003, 2004, and 2005. The Iowa State University Department of Entomology has posted all of the data on the internet on the Western Bean Cutworm Monitoring Network page, www.ent.iastate.edu/trap/westernbeancutworm. The data included the county of the trap location, description of the trap location, collector, date the trap was collected, and number of moths collected on that date. The data from this website was copied into Microsoft Excel on a county by county basis for each year. Some counties had multiple sites that were separated out into their own observations.

The temperature data for each location was then collected from www.weatherunderground.com. The temperature data recorded was for the location closest to the trap location that the website could offer, which routinely was greater than 20 miles. The data recorded for each location for the dates from May 1 to August 31 was the high temperature for the day, average temperature for the day, and the low temperature for the day.

The data was then formatted in the same way for each year. The moth flight data format varied from year to year, so it had to be arranged to be analyzed more easily. The weather data was then added for each observed location.

Data Analysis

The degree days to reach 25%, 50%, and 75% moth flight were calculated. The percent moth flight was calculated for each day of observed data. The date that the percent moth flight exceeded the 25%, 50%, and 75% thresholds was noted then matched to the corresponding date on the degree day calculations. The degree days for each day were calculated by taking the average of the high and low temperatures for the day and subtracting 50. For days when the average was below 50 a zero was recorded. Then the total number of degree days accumulated from May 1 onward was tallied for each day. The degree days calculated to reach the 25%, 50%, and 75% thresholds was then recorded for each location.

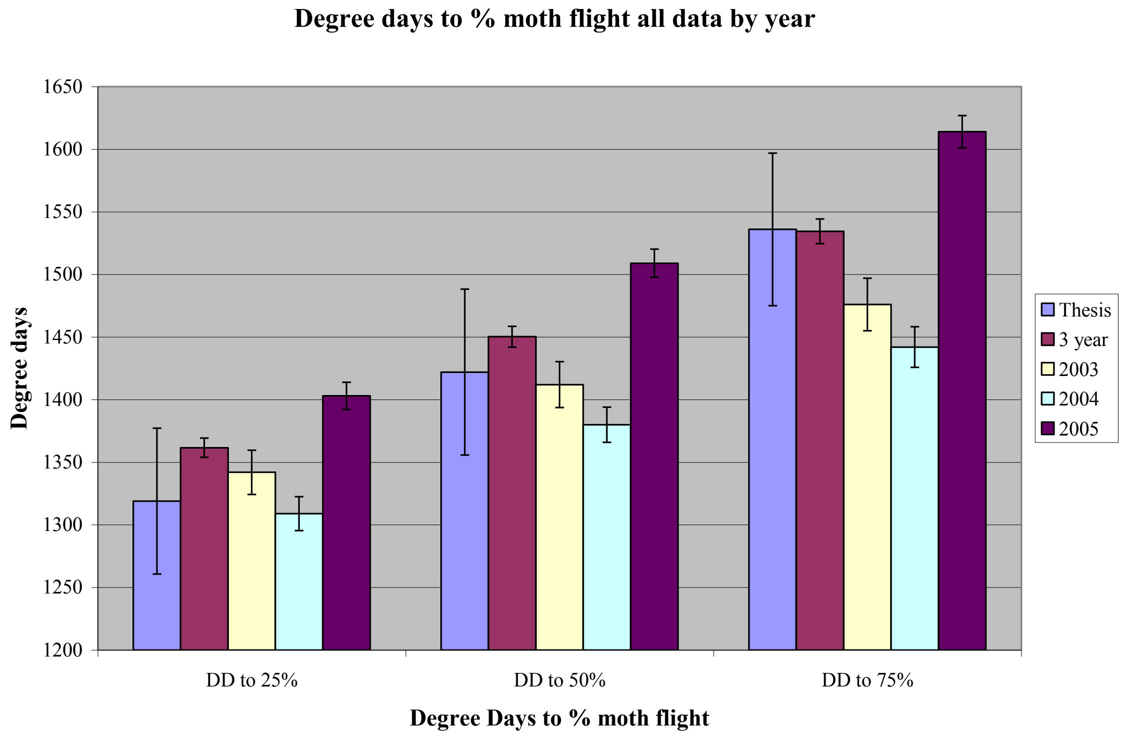
The first exclusion of data was then made. Some locations had data that was not usable for various reasons. Some locations only had five or fewer days where data was collected and some locations collected fewer than 10 moths, both of which made calculating 25%, 50%, and 75% moth flight very difficult. Some locations also had large gaps between collection dates, those greater than a week were also excluded.

To compare the data collected to the original thesis the mean error from the thesis had to be converted. The mean error in the thesis was presented in calendar days rather than

growing degree days. The calendar days given as the mean error were then converted to growing degree days by taking an average of July temperatures across Nebraska. The average July temperate for Omaha was averaged with the average July temperature for Scottsbluff, and with a base of 50 degrees gave an average growing degree day of 26.5 for one July day in Nebraska. The average growing degree day was then multiplied by the mean error of 2.2, 2.5, and 2.3 calendar days for 25%, 50%, and 75% moth flight to give a mean error of 58.3, 66.25, and 60.95 growing degree days.

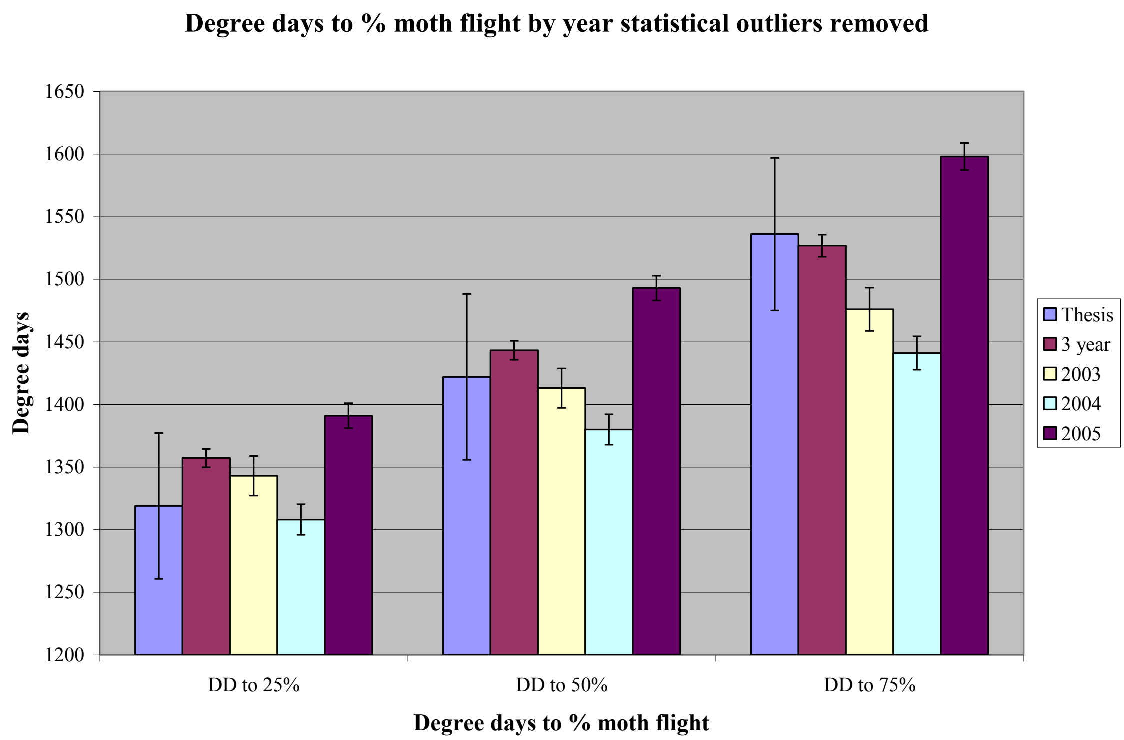
The growing degree day data for the 25%, 50%, and 75% thresholds were then averaged over all three years and for each individual year. The results are shown in Figure 1. The average for all three years was 1362, 1450, and 1534 growing degree days, showing no significant difference from the thesis. However, when looking at the individual years there were some significant differences. For all percent moth flight measures 2005 was significantly higher than both 2003 and 2004, as well as being significantly higher than the thesis data. Also the 2004 75% moth flight was significantly lower than the thesis data.

Figure 1



From the statistical analysis, outliers were observed in the data which were then removed. The results are shown in Figure 2. The average for all three years with the outliers removed was 1357, 1443, and 1527 growing degree days, showing no significant difference from the thesis. With the statistical outliers removed only 25% moth flight for 2005 was significantly higher than the thesis data and 2004 75% moth flight was significantly less. For all three percent moth flight observations 2005 was still significantly higher than both 2003 and 2004.

Figure 2



The data was then analyzed to determine if there were any observable differences in moth flight data from the western part of Iowa to the eastern part of Iowa. The reason for this analysis is because the range of the western bean cutworm is moving eastward and any discernable differences in percent moth flight growing degree days might be of interest. The state was divided into three regions: West, Central, and East. Figure 3 shows how the counties were divided into each region. When analyzed no region was significantly different from the thesis data and none of the regions was significantly different from each other. Figure 4 shows the comparison between the geographic regions and with the thesis and three year average.

Figure 3

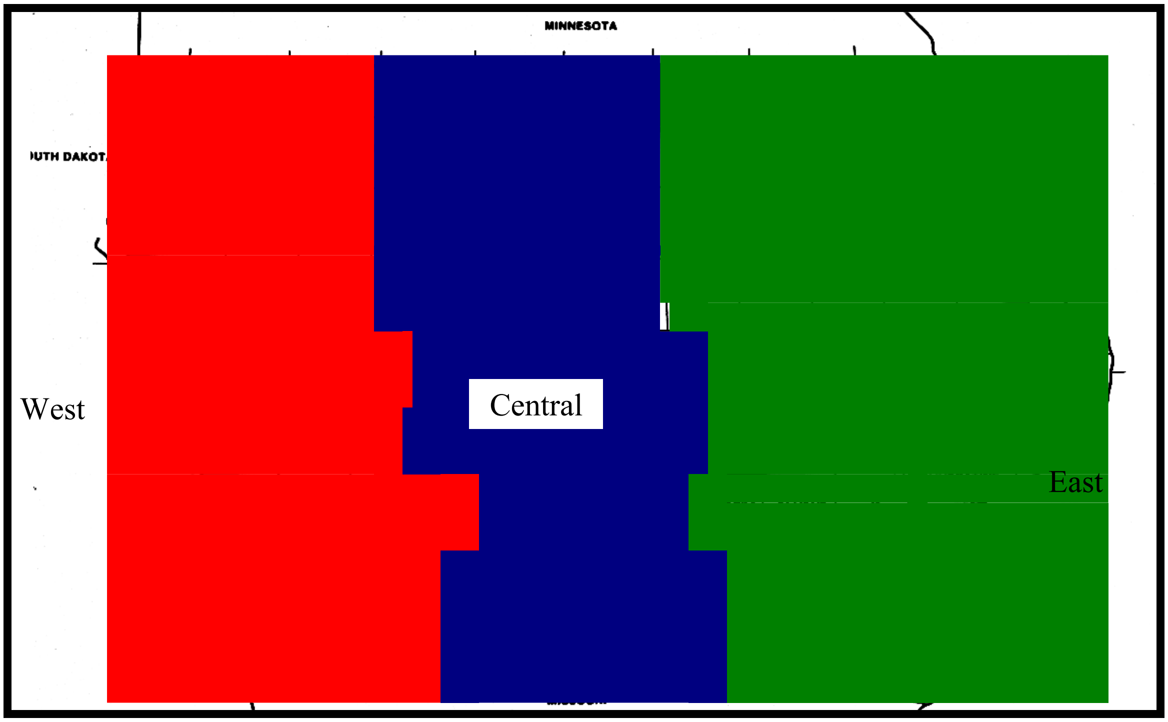
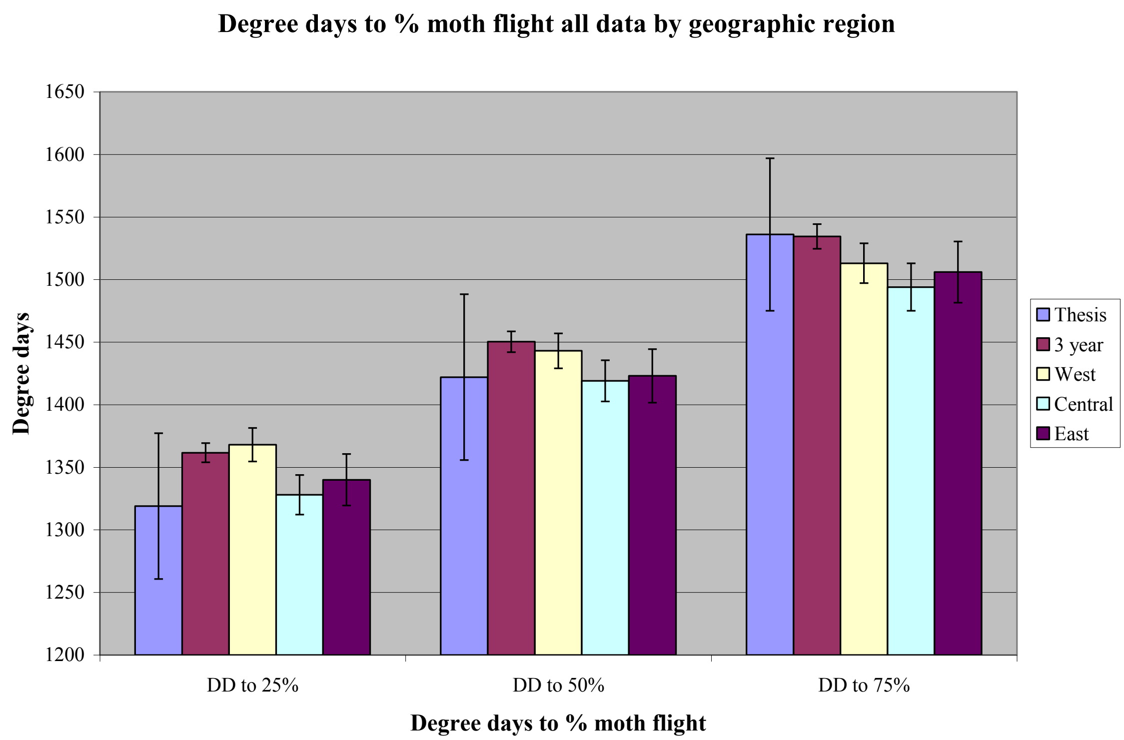


Figure 4



Taking a closer look at the data it was determined that the data collected from each site might not be a complete representation of the total moth flight. It was observed that many sites did not have zero moths as the first and last observations. Without zero as the first and last observation it was quite possible that there could have been a significant number of moths missed for these locations. Looking at the moth flight numbers excluding all sites that did not begin and end with zero observations would eliminate the vast majority of sites. So to ensure the data was well bracketed all sites that had a first and last observation where the number observed on the first and last dates of observation were less than 1% of the total number of moths collected were included in the data set. With these criteria in place the total number of sites analyzed over all 3 years dropped from 282 sites to 85 sites.

With the sites outside the bracketing criteria removed the averages for all three years of data for 25%, 50%, and 75% moth flight were 1376, 1460, and 1545 growing degree days, which is not significantly different than the thesis data. When looking at the individual year data in 2005 the 25% and 50% moth flight growing degree days were significantly higher than the thesis data and all 2005 percent moth flights were significantly higher than both 2003 and 2004. Figure 5 shows the year to year comparisons with sites removed. With the sites removed the region to region comparisons still showed no significant differences. Figure 6 shows the region to region comparisons with the sites removed.

The same statistical analysis was applied to all three percent moth flight responses. The across three years analysis fit the 25%, 50%, and 75% moth flight with a linear mixed model where the total number of moths emerged and the distance between locations were taken into account as covariates, and the variance and the effects of year, region and year by region interaction were estimated by the REML-BLUP method. The data outliers were determined to be those with standardized residual larger than 3.5 after fitting the linear mixed model, causing nine data points to be removed for the outliers removed data. For individual year analysis each year of 25%, 50%, and 75% moth flight was fitted with a linear mixed model where total emerged number and distance between locations were

also taken into account as covariates and the effects of region were estimated. For the data with the selected sites removed the same statistical models are used for across three years analysis and by year analysis. SAS codes for model fitting were the same. All of the analysis was completed using SAS System Version 9. The total number of moths emerged and distance between locations did not show to be statistically relevant.

Figure 5

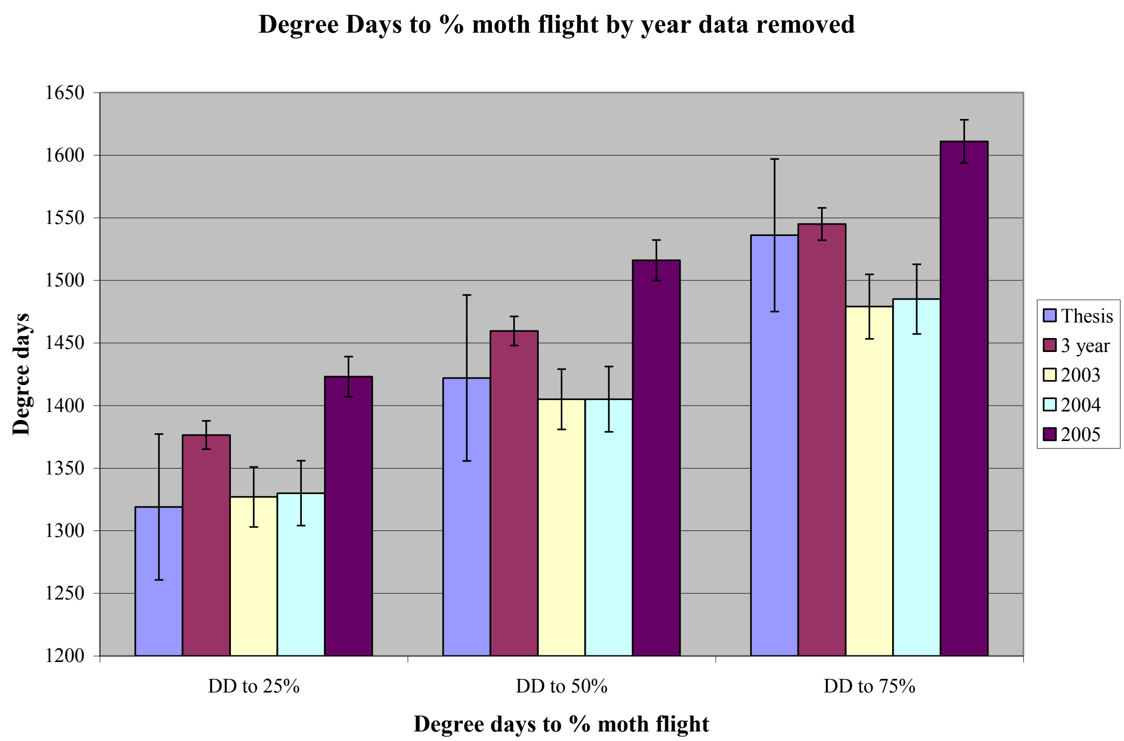
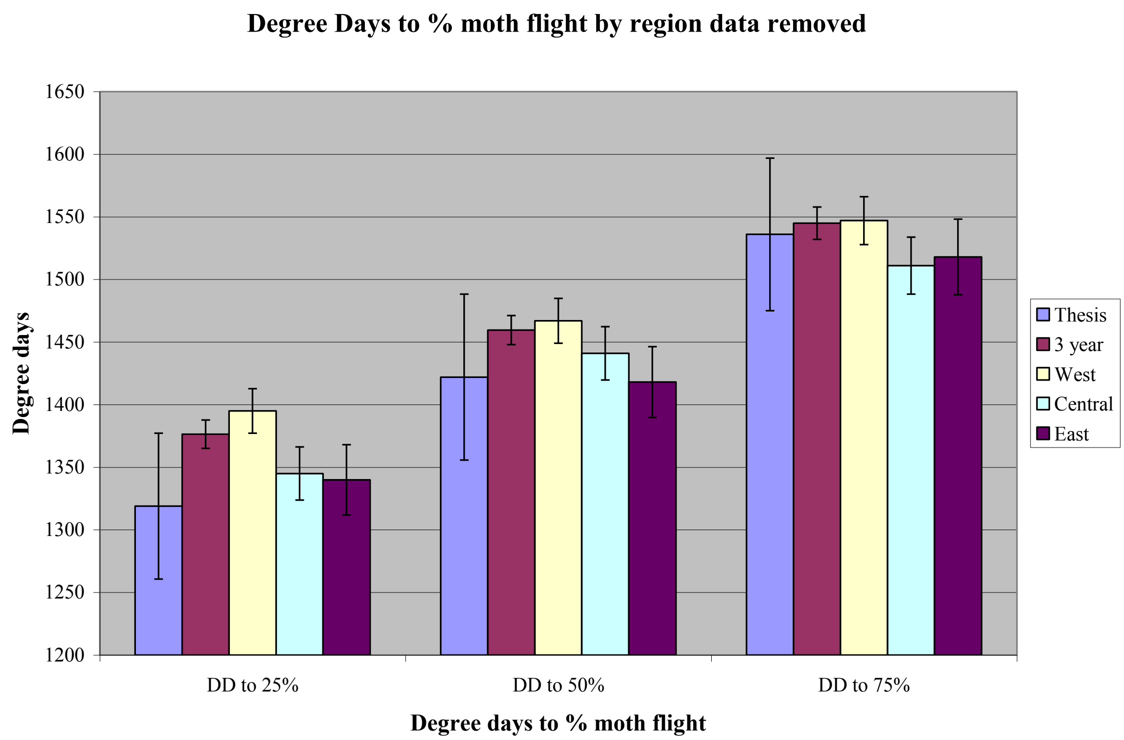


Figure 6


Degree Days to % moth flight by region data removed
1650
1600
1550
1500
1450
1400
1350
1300
1250
1200
Degree days
Thesis
3 year
West
Central
East
DD to 25%
DD to 50%
DD to 75%
Degree days to % moth flight

Conclusions

Survey Conclusions

From the results of the survey the average of all three years of data fall well within the error of the thesis data no matter how the data was broken down. When comparing regions of the state there was no discernable difference between the regions. In all comparisons 2005 was significantly higher than 2003 and 2004. 2005 was also significantly higher than the thesis when all data was included, at 25% moth flight with outliers removed, and at 25% and 50% moth flight with sites removed. 2004 75% moth flight was significantly lower than the thesis data when all data was compared and with the statistical outliers removed from all data. It should also be noted that there were more sites added to the survey each year for all data. In 2003 there were 50 sites for all data, 93 in 2004, and 139 in 2005. When sites were removed based on beginning and ending numbers the number of sites dropped to 28 for 2003, 17 for 2004, and 40 for 2005.

The best data to consider for comparing the model would be the data where sites were removed based on beginning and ending moth captures being nearest to zero. The data with the incomplete sites removed gives the best indication of when the moth flight truly occurred at each location. When looking at this data it can be seen that 2003 and 2004 are very close to each other for all three percent moth flights as well as being close to the thesis data. The 2005 data is significantly higher than both 2003 and 2004 as well as having 25% and 50% moth flight being significantly higher than the thesis.

When comparing the survey data to the thesis there are some numbers that jump out as interesting. The thesis data was collected from only seven different sites, but over the course of 14 different years between 1958 and 1976. In total there were only 23 sites of data collected for the thesis. In the most reliable data set from the survey there were 85 different sites over the course of only 3 different years, for a total of 62 more sites than the thesis but with 11 less years of data collection.

Based on the observations from the survey it can be concluded that the growing degree day model from the UNL thesis holds up reasonably well when comparing it to data collected in Iowa from 2003 to 2005. However there are some issues that should be noted. The 2005 data set appears to be an outlier from the thesis and the 2003 and 2004 data. There is a much smaller set of data used to calculate the thesis growing degree day data than was used in the current survey. Also the temperature data collected in the current survey was not as close to the moth collection location as would be ideal, many times extending to more than 20 miles difference. So while the thesis data holds up reasonably well when compared to the years 2003, 2004, and 2005 in Iowa, an investment needs to be made into further research to determine a more accurate western bean cutworm moth flight growing degree day model.

Recommendations

First data needs to be collected in a more consistent manner. Cooperators in the monitoring network should be asked to place traps well before moth flight is expected, probably beginning the middle of June and to leave traps out until after no new moths have been captured for two or three days in August. Keeping the traps up longer will enable researchers to better look at when moth flight truly occurred by having the numbers from every day of moth flight. Also it should be stressed to the cooperators to try to collect the traps over a regular period. Daily would be ideal, but might not be realistic for all cooperators, so a regular interval should be stressed for those who are unable to collect daily.

Along with better moth collection, it would be useful to have temperature data collected from closer to the moth collection site. Cooperators could be asked to record temperature data themselves starting May 1, a recording device could be sent to cooperators in mid-April and placed close to where the moth trap will be located to begin collecting weather data from May 1 to trap removal, or weather station data could be located closer to the trap locations. Having temperature data collected closer to the moth collection sites would help improve the accuracy of the degree days for each site.

In order to improve upon the model the methods used in this survey should be continued each year and expanded to include other states that collect moth flight data. The data is already being collected and with a small amount of effort and organization continuing this study would not be overly difficult. Continuing to collect this data would help determine if 2005 happened to be an outlying year, or if the moth flight growing degree days can vary this widely naturally meaning it could depend partially on factors other than air temperature.

Another way the model could be improved would be not to use air temperature data at all. Since the larvae over winter and then pupate in the soil creating a model using soil temperature might prove to be more accurate. The same base 50 degrees Fahrenheit could be used from May 1 which would make the model easy to set up once soil temperature data could be obtained for trap locations. Such a model would probably take several years to develop, but might prove to be much less variable than using the current air temperature model.

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