CHAPTER 3 EUROPEAN CORN BORER: THE RELATIONSHIP BETWEEN STORED RESOURCES AND DIAPAUSE TIMING

3.1 Background

Writing due tues: 5pm

Meeting Wednesday: 2pm

Submission will include M & M’s along with Results section

According to the National Oceanic and Atmospheric Administration, 2016 was the warmest year on record and temperature increases are expected to continue through the year 2100 [25, 26, 27]. As seasonal temperatures increase, warm summers will expand, cool winters will contract, and temperatures during the spring and fall will become less predictable [28, 29]. Animals monitor variation in seasonal factors like temperature and photoperiod (daylight hours) because these factors can affect the availability of nutrition, mates, and habitat. Seasonality predictably cycles between conditions that are favorable for insect activity and conditions that are stressful and unfavorable. Many temperate-dwelling insects protect themselves from the unfavorable seasonal variation by entering diapause before their environment becomes unfavorable [1].

Insects in diapause can survive for months exposed to harsh conditions and typically do so without access to nutrition by lowering their metabolic activity and suspending their development [30, 3]. Before the environment becomes unfavorable, insects prepare for diapause by accumulating and storing nutrients in the form of lipids, proteins, and carbohydrates [1]. For example, increased energy storage in the form of proteins has been reported in Colorado potato beetles (*L. decemlineata*) (Kort and Koopmanschap 1994) and southwestern corn borers (*D. grandiosella*) (Brown and Chippendale 1978), and increased lipid storage has been reported for the pink bollworm (*P. gossypiella*) (Adkisson et al. 1963) and *Culex pipens* mosquitoes (Mitchell and Briegel 1989), among others. Energy stores fuel insect metabolism during diapause, and after diapause these stored resources are redirected to accomplish post diapause functions. However, metabolic activity for many insects is temperature dependent and insects preparing for diapause in warmer environments may struggle to meet the increased energy demands of their increased metabolism possibly reducing the amount of energy remaining for storage and use during diapause.

Insects entering diapause with inadequate nutrition stores could run out of stored energy and exit diapause before winter ends leaving them exposed to low winter temperatures which could lead to mortality. A study using *Calliphora vicina* (Robineau-Desvoidy) as a model explored the effect of nutrition on the duration of diapause [44]. Larvae were placed on either a nutrition restricted diet or an unrestricted diet and larvae with restricted access to diet entered diapause with less mass and remained is diapause for a shorter period than larvae with an unrestricted diet [44]. After diapause ends insects must have enough nutritional resources and other metabolic substrates remaining to meet the anabolic requirements for development, metamorphosis, repair, and post-diapause activities like reproduction [3, 4].

Climate change could also decrease the amount of nutrition insects by draining nutrient stores prematurely as warmer more variable temperatures in the fall increase metabolic activity [31, 32, 33, 4]. Insects experiencing temperature variations with greater warm periods at the beginning of diapause have been shown to accumulate less resources before the onset of winter [42, 43]. For example, Thompson and Davis (1981) treated two groups of diapausing *Diatrea grandiosella* Dyar moths to warmer and cooler temperatures and compared lipid mass at the end of diapause between the two groups. Moths that were exposed to the warmer temperatures demonstrated a significant decrease in lipid stores at the end of diapause compared to moths in cooler conditions [Thompson and Davis].

Warmer temperatures during diapause preparation could increase metabolic rates redirecting resources away from nutrient storage and limit an insect’s ability to build up enough stored energy before the onset of diapause. Similarly, warmer winter temperatures during diapause could raise the metabolic rates of diapausing insects and cause them to deplete stored energy before environmental conditions become favorable. Insects that manage to survive diapause with reduced resources could exit diapause in the spring without sufficient reserves to become functional adults limiting their ability to disperse, mate, and reproduce.

*Ostrinia nubilalis* (European corn borer) is an excellent model to understand how climate change and warmer winter temperatures might affect nutrition storage ahead of diapause and energy depletion during diapause. European corn borer exists as at least two naturally segregating, genetically distinct strains with unique diapause genotypes where each genotype expresses a different length of diapause. The "long-diapause" strain experiences a longer warmer diapause because it enters diapause earlier in the fall and exits diapause later in the spring. The opposite is true for the "short-diapause" strain, which enters diapause later in the fall and exits diapause earlier in the spring. Comparing nutrition storage strategies between these two strains could build our understanding of how insects might cope with anthropogenic climate change and adjust to warming winter temperatures.

In the field, climate change could select for larvae with a diapause genotype adapted to warmer diapause. temperatures a long-diapause genotype and larger nutrition stores that can off-set the energy draining effect of increased metabolic activity when diapausing at warmer temperatures. Conversely, short-diapause larvae could be negatively impacted by climate change, their long-diapause counterparts could be positively impacted by warmer temperatures and European corn borers thrive. As temperatures continue to rise, the way insects manage nutrition storage ahead of diapause and during diapause could determine which insect genotypes will lose and which will win.

The warm temperatures some European corn borers experience could increase their metabolic activity and in turn increase the share of energy required to fuel their metabolism. To meet the energetic demands of warmer temperatures, I predict the genotype that has a longer warmer diapause should accumulate more nutrient stores prior to diapause compared to larvae with a shorter diapause genotype. Larvae with long-diapause and the short-diapause genotypes occur sympatrically and must survive the same length of winter or risk being exposed to winter stress. I predict larvae, regardless of diapause genotype will deplete nutrient stores at a similar rate. Lipid stores at the start of diapause and during diapause were measured and larvae with the long-diapause genotype accumulated more lipid mass at the onset of diapause compared to larvae with the short-diapause genotype, however the rate of lipid depletion during diapause was less conclusive.