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

3.1 Background

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]. 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). These energy stores fuel their metabolism during diapause and after diapause these stored resources are redirected to accomplish adult functions and these stores are influenced by temperature.

The thermal conditions insects experience prior to diapause and during diapause affect nutrition storage and their ability to survive diapause. Climate change is producing warmer and more variable temperatures and these changes could decrease the amount of nutrition insects accumulate or drain nutrient stores prematurely [31, 32, 33, 4]. Insects experiencing temperature variations with greater warm periods at the beginning of diapause have been shown to store less resources and deplete those resources faster than insects in thermally stable environments before the onset of winter [42, 43]. Insects that experience warmer temperatures during diapause could also deplete their resources prematurely as demonstrated by Thompson and Davis (1981) in the moth *Diatrea grandiosella* Dyar. When these insects were exposed to warmer temperatures during diapause the result was a significant depletion in lipid stores at the end of diapause.

In addition to surviving diapause, 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]. A study using *Calliphora vicina* (Robineau-Desvoidy) as a model explored the role of nutrition storage in determining the duration of diapause the duration of diapause. Larvae were provided with either restricted access to nutrition or unrestricted access to nutrition during diapause preparation and the time spent in pupal diapause was compared. The result was 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].

Warmer temperatures during diapause preparation could increase metabolic rates redirecting resources away from nutrient storage and limit an ability to build up enough stored energy before the onset of diapause in the winter. Similarly, warmer winter temperatures during diapause could deplete stored energy before environmental conditions become favorable. For 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. European corn borer exists as at least two naturally segregating, genetically distinct strains with unique diapause genotypes where each genotype expresses different diapause lengths. The "long-diapause" strain experiences a longer warmer diapause as it enters diapause earlier in the fall and exits diapause later in the spring. The opposite is true for the "short-diapause" strain that enters diapause later in the fall and exits diapause earlier in the spring. Comparing nutrition storage strategies between the two strains could help explain how insects might prepare for winter temperatures.

If long-diapause European corn borers are to survive a warmer longer diapause would I predict these to store more nutrition during diapause preparation compared to short-diapause larvae. Comparing nutrition depletion between the two strains I predict the rate of depletion be similar between larvae regardless of diapause genotypes. Lipid stores at the start of diapause and during diapause were measured and larvae with the long-diapause genotype were found to be larger and to contain greater fat reserves compared to larvae with the short-diapause genotype.

In the field, climate change could favor long-diapause genotype larvae with larger nutrition stores that can off-set the energy depletion effect of warmer temperatures and higher metabolic rates. While short-diapause larvae may 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 insects will win or lose. e