The induction of diapause protects insects from unfavorable environmental changes and for many insects, once diapause begins metabolic activity is fueled by stored nutrition. In European corn borer, there exists at least two different diapause genotypes, each with differences in regulating the response to the environmental cues used to trigger diapause, the physiological changes associated with induction of diapause, and most notably the duration of diapause. Our research leverages between-strain genetic variation in diapause duration in O. nubilalis to test the hypothesis that diapause length is indirectly associated with nutrition stores. Eventually, climate change is expected to cause summer temperatures to expand and fall and winter temperatures to rise. Warmer fall temperatures could increase metabolic activity and possibly reduce lipid stores during diapause preparations and/or drain lipid stores during diapause before the onset of winter. Prior to our current study, diapause programming among European corn borers collected from maize fields in October has been correlated with increased lipid accumulation (Vukašinović et al., 2013). Measurements of lipid stores from the fat body and hemolymph showed larvae preparing for diapause accumulated more lipids compared to non-diapause larvae (Vukašinović et al., 2013). These results show a clear association between nutrition accumulation ahead of diapause however, they do not account data do not the relationship between diapause length and lipid accumulation. We found that when long-diapause genotype larvae are programmed for diapause lipid storage increases store more lipids than short-diapause genotype larvae and non-diapause larvae.

Similar results were recorded in the Burnet moth (Zygaena trifolii (Esper)) by Wipking et al. (1995). These researchers reared larvae in diapause programming conditions and non-diapause conditions at 4 different temperatures then compared lipid stores between non-diapause and diapause-programmed larvae. Larvae programmed for diapause were observed to have a 2.5-fold increase in lipid stores in compared to larvae not programmed for diapause (Wipking et al., 1995). Nutrition storage prior to the onset of diapause has repeatedly been shown to be a pivotal step in diapause preparation and this result has been demonstrated across a number of taxa (Adkisson et al., 1963; Mitchell and Briegel, 1989). As fall temperatures increase, the degree to which these stores are accumulated in preparation for diapause may be compromised by the higher metabolic rates. Similarly, warmer temperatures during diapause in winter could prematurely drain stored energy causing insects to die during diapause or come out of diapause the next spring without sufficient reserves to restart their lifecycle, including dispersing, mating, and reproducing.

Warmer and more variable temperatures at the beginning of diapause have been found to reduce nutrition stores by increasing metabolic activity and draining stored energy before the onset of winter. For example, a study by Williams et al. (2012) on the effect of temperatures on stored nutrition suggests that diapausing insects experiencing temperature variations with greater warm times at the beginning of diapause store less resources and deplete those resources faster than insects in thermally stable environments before the onset of winter. To investigate the relationship between fluctuating warm temperatures and nutrition storage, these researchers reared Erynnis propertius (Scudder and Burgess) caterpillars that originated from environments that differed in thermal stability in a reciprocal common garden experiment with stable and fluctuating thermal regimens (Williams et al., 2012). Larvae reared in stable conditions also stored significantly more lipids and entered dormancy 3-4 weeks later compared to their counterparts reared in thermally variable environments (Williams et al., 2012). In addition to lipid depletion at the start of diapause, higher winter temperatures have been associated with increased depletion of stored lipids during diapause. Thompson and Davis (1981) previously demonstrated that increased temperatures at the end of diapause can significantly deplete lipid stores in Diatrea grandiosella Dyar. Caterpillars were first reared at 21◦C to program diapause. Once diapause was programmed, caterpillars were transferred into 1 of 4 temperatures regimens; 4◦C and 21◦C. After being held at these 4 different temperatures for 60-days, all of the diapausing larvae were transferred to 27◦C and lipid stores were measured for 60-days (Thompson and Davis, 1981). Researchers noted the lipid stored of larvae from the 4◦C diapause condition remained unchanged while larvae from the 21◦C diapause condition lost 1.73cal/insect per day of fatty acid during the same period (Thompson and Davis, 1981). European corn borers faced with the combination of warmer fall temperatures at the start of diapause and warmer winter temperatures during diapause could experience a similar decline in nutrition stores. European corn borers that do not accumulate enough energy ahead of diapause could fail to enter diapause, terminate diapause prematurely, or sub-optimal nutrition could lead to reductions in post-diapause adult functions.

Sub-optimal nutrition storage has been previously implicated in restricting entry into diapause and reducing the amount of time spent in diapause. For example, a study using Calliphora vicina (Robineau-Desvoidy) as a model investigated the effect of reduced nutrition on entry into diapause. Diapause in the C. vicina fly offspring begins maternally where adult female flies exposed to short photoperiod days alter how they provision the eggs of the offspring they lay, programming her offspring for diapause. After diapause-programmed larvae hatch they begin feeding and storing nutrition in preparation for a larval diapause, like the one seen in European corn borers. Based on the research of Saunders 1997, diapause in these fly maggots appears to be regulated by photoperiod, temperature, and nutrition. Reducing the amount of nutrition diapause-programmed fly larvae could accumulate significantly reduced entry into diapause and the duration of diapause. When access to nutrition was restricted 5 days after hatching, 40.5% of larvae avoided diapause while restricting nutrition 8-days after hatching, allowing them to get bigger and fatter, 95% of larvae entered diapause (Saunders, 1997). Saunders (1997) also compared the time spent in diapause between small larvae weighing less than 40mg and large larvae weighing over 60mg. Small larval mass was associated with a shorter diapause and pupated approximately 20-days after hatching, however large larval mass was associated with a longer diapause and pupated approximately 50-days after hatching (Saunders, 1997).

REFERENCES:

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