

Chapter 6

Summary

Insect seasonal ecology is governed by the interactions between intrinsic life-history traits and extrinsic factors (Danks, 1994). Experiments in this dissertation specifically investigated the effects of three dominant environmental factors (temperature, endosymbiont *Wolbachia*, and neonicotinoid insecticides) on *O. sulcatus* reproduction and development.

In chapter 2, the effects of temperature on development of immature stages of *O. sulcatus* were quantified using mathematical models. Temperature-dependent survival rate showed a skewed bell shape, due to the insect's vulnerability to high temperatures. Maximum survival at the optimum temperatures for each stage was estimated to be 63.7% at 19.0 °C for eggs, 32.1% at 19.0 °C for larvae and 97.0% at 17.3 °C for pupae. The nonlinear temperature-dependent model (Logan et al., 1976) estimated the optimum temperatures for highest development were 27.5, 25.1, and 24.1 °C for eggs, larvae, and pupae, respectively. A linear regression analysis provided the estimation of the lower developmental threshold temperatures (T_b), which were 5.9, 4.1, and 6.4 °C for eggs, larvae, and pupae, respectively. The inherent variation of development time in each stage that quantified using Weibull function (Régnière, 1984) revealed that the high variation in the duration of larval development might play a substantial role in the seasonal occurrence of different stages simultaneously in the field. The differential range of optimal temperature for development among stages suggest that temperature may work as a driving force to adapt each stage to the different prevailing temperature condition of the season. Information herein can be useful in designing rearing protocols, developing monitoring and management schemes.

In Chapter 3, it was first found that the temperature significantly influenced each reproductive life history trait of *O. sulcatus* adult. Adults oviposited at temperatures from 11-27 °C. The lower and upper threshold temperatures and optimum temperature for reproductive maturation were estimated to be 6.8, 30.0, and 22.7 °C by using Briere model (Briere et al., 1999). The developmental threshold and thermal constant for reproductive maturation were 6.7 °C and 505.0 degree-days, respectively, using a linear model at temperatures 11-21 °C. The median longevity of *O. sulcatus* adults at 18-36 °C decreased linearly as temperatures increased. At 27 °C or above, reproductive success of *O. sulcatus* was substantially impaired due to reduced adult longevity, delayed reproductive maturation, and lowered egg viability. It was speculated that establishment and population growth of *O. sulcatus* would be substantially limited in geographic areas that experience very hot summers.

In chapter 4, it is shown that *Wolbachia* in supergroup B is highly prevalent in *O. sulcatus* population in the United States. Given that two antibiotics differing only in their efficacy against *Wolbachia*, it is hypothesized that lack of egg hatch rate may result from the suppression *Wolbachia*. The impact of *Wolbachia* on thelytokous reproduction of *O. sulcatus* should be clarified by investigating *Wolbachia* infection on the F-1 generation.

In chapter 5, bioassay with imidacloprid and thiamethoxam revealed consistently that weevils that survived short-term exposure to sublethal dosages of imidacloprid and thiamethoxam produced viable offspring, when they have access to insecticide-free leaves after the exposure. Thus, despite intensive insecticide spray programs the persistence of *O. sulcatus* populations in field can be attributed to the reproductive success of the females that survive insecticide applications. Treatment with imidacloprid and thiamethoxam on larval diet significantly reduced the survival of early instar larvae, which is the most suitable target for

application of systemic neonicotinoid insecticides. However, there was no ovicidal activity of the insecticides, which implies that incidental contact during foliar application of imidacloprid or thiamethoxam would not influence egg survival.

Based on research findings, *O. sulcatus* has several ecological features that contribute to the presence of overlapping stages in field and thus difficulty in monitoring and management.

- (a) Inherent high variation in larval development,
- (b) Each immature stage has well adapted to the prevailing temperature conditions,
- (c) Parthenogenetic females have relative long reproductive period, with high reproductive potential,
- (d) Polyphagous females can survive the short-term exposure of insecticides and continue to produce viable offspring.

In conclusion, all the environmental factors that herein examined were significant factors to influence the development and reproductive success of *O. sulcatus*. Incorporating all of the data provides a standard framework from which future research is directed. More investigation is required on various aspects of *O. sulcatus* ecology and interactions with environmental factors. Recommendations for further research include:

- (1) Determine the effects of short-term exposure of extreme temperatures on immature survival and reproduction of *O. sulcatus*. Short-term exposure to high or low temperatures may change mortality or reproductive success beyond predictions based on constant temperature studies (Beck, 1983).
- (2) Determine the effects of *Wolbachia* density on egg hatch rate of *O. sulcatus* using heat and tetracycline treatments using quantitative PCR. Reduced fecundity of *O. sulcatus* at high

temperature in Chapter 3 may result from the suppression of *Wolbachia* density, since heat treatment is known to reduce *Wolbachia* density (Hurst et al., 2000).

(3) Determine the effects of temperature on *O. sulcatus* survival and reproduction under field conditions. The short-term exposure to imidacloprid and thiamethoxam may more drastically reduce the viable production offspring if they are applied under conditions *O. sulcatus* weevils are exposed to high temperatures.

References

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