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# Temperature-dependent development of diapausing larvae of *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae)

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ABSTRACT

Temperature-dependent development rate, percent diapause induction (hibernation at low temperature and aestivation at high temperature), and survival of diapausing larvae of *Chilo partellus* (Swinhoe, 1885) were examined on 13 constant temperatures ranging from 8 to 40 °C. Development of hibernating and aestivating larvae occurred from 10 to 25 °C and 27–38 °C, respectively. However, no development occurred at 8 °C and 40 °C. To determine actual thermal conditions that affect development and trigger both kind of diapause (hibernation and aestivation), various thermal parameters were estimated by fitting the development rate data to two linear (Ordinary equation and Ikemoto & Takai) models and thirteen non-linear models. The lower thermal thresholds ($T_{min}$) for development of diapausing larvae of *C. partellus* were calculated as 9.60 °C and 10.29 °C using the ordinary linear model and Ikemoto & Takai model, respectively. Similarly, the thermal constants ($K$) estimated using the ordinary linear model was 333.33 degree-days and that estimated with Ikemoto & Takai model was 338.92 degree-days. Among the non-linear models, Lactin-2 followed by Lactin-1 were found to be the best as these models estimated the critical temperatures ($T_{min}$, $T_{max}$ and $T_{opt}$) similar to those of observed values. Conclusively, the Ikemoto & Takai linear model and Lactin-2 followed by Lactin-1 non-linear models are useful and efficient for describing temperature-dependent development and estimating the temperature thresholds of diapausing larvae of *C. partellus*. Our findings provided fundamental information for estimation of thermal requirement and temperature based development models for diapausing larvae of *C. partellus*. This information will be highly useful for predicting the occurrence, seasonal emergence, number of generations and population dynamics of *C. partellus*.

## 1. Introduction

Spotted stem borer, *Chilo partellus* (Swinhoe, 1885) (Lepidoptera: Crambidae) is one of the most destructive pest causing 18–25% loss in maize and sorghum in Asia (Dhaliwal et al., 2015). One aspect of *C. partellus* biology that is relevant to understanding its population dynamics and geographic distribution, is the diapause strategy (Ofomata et al., 1999; Kfir et al., 2002). It enters facultative diapause as mature larvae inside the old stems or stubbles which usually occur under drought conditions and maturity of host plants (Scheltes, 1978; Dhillon et al., 2017). When dry conditions of host plants synchronize with cold season, *C. partellus* enters winter diapause (hibernation) in North India (Dhillon et al., 2017). Similarly when dry conditions synchronize with warm season it enters summer diapause (aestivation) in southern India (Trehan and Butani, 1949). Genetic determination of locally adapted life-history traits like diapause and polyphenism are important to understand bio-ecology and population dynamics of insects in response to abiotic and biotic factors (Söderlind and Nylin, 2011). Diapause is a genetically determined stage of suppressed development which is expressed by unfavorable environmental factors (Tauber et al., 1986). Among the environmental factors, temperature plays an important and critical role in development biology of insects. The relationship between temperature and rate of development is crucial, as it influences insect phenology, distribution and abundance (Sharpe and DeMichele, 1977; Zahiri et al., 2010; Padmavathi et al., 2013; Arbab et al., 2016).

Temperature-dependent development rate models using physiological time data have been developed for many insect species to predict emergence of adults from the diapausing generations (Howell and Neven, 2000; Aghdam et al., 2009). Several phenological models have been developed to determine the development rate of an insect. These models have practical implications to predict the important events in the life cycle of insects as well as to devise an appropriate control strategy (Brière et al., 1999; Kontodimas et al., 2004). These phenological models are based on temperature-dependent development rate and governed by either linear or non-linear relationships (Howell and Neven, 2000; Arbab et al., 2016). Linear approximation allows the

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