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Forensic Entomology - Insect Development and Temperature

Kumara TK*[1], Abu Hassan A[2] and Bhupinder S[3]

[1]*Faculty of Agro Based Industry, University Malaysia Kelantan, Malaysia*

[2]*School of Biological Sciences, University Sains Malaysia, Malaysia*

[3]*Department of Forensic Medicine, Penang Hospital, Malaysia*

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***Corresponding author:** Kumara TK, Faculty of Agro Based Industry, University Malaysia Kelantan, 17600 Jeli, Kelantan, Malaysia; Email: thevan@umk.edu.my

Introduction

Forensic entomology involve the use of insects mainly fly larvae to estimate the post-mortem interval (PMI) based on the developmental rates and the succession ecology of specific insects that feed on carcasses. Since, insects are poikilothermic; their development is largely dependent on the ambient temperature [1-7]. There are two terms used by researchers to note the development of the insects which is "development rate" and "growth rate". Others defined "development rate" as the reciprocal of the time required to complete the egg, larval, or pupal stages while the "growth rate" is the larva's rate of relative weight increase [8]. The link between the insect development and the temperature was first reported by a French scientist named Reaumur in the eighteenth century [5]. However, the methods for using this understanding to predict insect development mostly dated from the 1950's through to the present [5].

Since the fly development is a temperature-driven event and varies according to species, accurate developmental data are fundamental to medico-criminal estimates [2]. When modeling temperature dependent development in insects, researchers can use either time or rate. Though, most entomologists prefer to use rate because many of the developmental rate models is derived from biochemical and biophysical principals, which rely on rates. From reviewed literatures, there are various models of predicting insect development and affect of temperature on the development of insect have been published [3,4,9-22].

However, among those published literature, the degree day/hour approach is used widely because it requires minimal data for formulation, is easy to calculate and apply; often yields approximately correct values [9] and have been successful in practical application [18]. The insect development models in relation to temperature have been categorized into few basic approaches [23].

The oldest and most widely used model is the linear degree-day model, a simple linear description of insect development in relation to temperature [3,23]. This degree-day approach is widely used to understand development time in plant sciences, pest management and ecology and is useful in understanding insect and plant phenology [16,24]. Though this approach has been widely accepted, the model do not consider the factor such as biochemical reaction in the process of insect development, photo period or genetic factor, and fluctuating temperatures [16]. In this model, the relationship between temperature and growth rate usually calculated as linear and one of the essential assumption in degree-day approach is that insect development is directly related to ambient temperature and time [16]. The model has the advantage of simplicity and allows estimation of the developmental threshold and the degree day requirement of insect species [3] also have been widely used with linearity is found in almost 300 species examined so far [8]. However, this model does not include nonlinearity at high and low temperatures and produces biased results at the lower and upper threshold limits [3]. In estimating the PMI, it is the degree-day approach frequently used by many scientists [5,25,26]. The linear model forms the basis to the well known thermal summation or degree day approach to timing prediction [23].

Degree days are defined as the number of degrees above a threshold temperature required for growth [18,23] and degree days per day are accumulated over the time it takes the particular life stage to complete development [23]. Hence, degree days or hours are the accumulated product of time and temperature between the developmental thresholds for each day [27]. Because this heat is accumulated as "thermal units", it can be calibrated and described as "degree-day" or "degree-hours", depending on the accuracy of temperature readings and time period involved [2]. Each development stage has its own total development requirement and each species requires a defined number of degree days to complete its development. This fact helps us to predict the time when a certain developmental stage will be reached [27]. The duration of development is calculated by adding up the number of thermals units (degree-hours or degree-day) contributed at each temperature [9].

Some researchers called degree days as thermal units, or heat units or growing degree days [23]. In this approach, the assumption that field temperatures lie within the more linear portion of the development rate function suggests a linear model can be used for predictive purposes [18]. This model, which assumes a linear relationship between development rate and temperature, is often accurate for intermediate temperatures, though it yields considerable error when temperature conditions tend toward the extremes temperature [11,23] because developmental rate becomes curvilinear at both high and low extremes with increases or decreases in temperature [28].

The assumption in this models is, as the environmental temperature decreases, their rates of development slow and, if the temperature falls low enough, development will cease at their lower developmental threshold; as temperature increases, their rates of development increased up to a temperature optimum and they again decreased development at upper threshold temperature [9,29].

The second approach to predicting insect phonology in relation to temperature encompasses the many non linear mathematical description used to describe non linear development of insects [23]. Variety methods of non- linear have been found in literature [10,11,13,17,30]. Though researchers admitted that for most species the degree-day approach is acceptable if the development occurs within the intermediate temperature [10,13,16,22,24,31,32]. The focus in this second approach is to predict the insect development at the low and upper threshold limit.

Conclusion

Therefore, the estimation of PMI depends on choice of models preferred by the forensic entomologist. Furthermore, regardless of type of model chosen, the error related to each model must be explained accordingly to avoid confusion among the forensic entomologists in estimating PMI.

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