7. ANNEX

7.1 The Collection of Temperature-dependent Life Tables: Essential Input Data for Developing Insect Phenology Models

Temperature-dependent life tables were constructed of an insect cohort (i.e., of a group of individual insects of the same species and age). Observations started from “eggs,” all laid within the last 12–24 hr. Owing to natural mortality within each of the immature life stages (egg, larva, and pupa), a minimum of 100 eggs were used ($n \geq 100$). Depending on the insect species, complete life-table or single-stage cohort studies were employed. Life-table data were collected over a range of constant temperatures (at 10°, 15°, 20°, 25°, 30°, and 35°C) in which a species could develop. This was done to understand each species’ minimum and maximum thresholds for development.

In **complete life-table** experiments, a group of individuals of the same age were observed from the beginning of their egg stage until the death of all adults. During insect development, all phenological events (i.e., development time of immature life stages, mortality, longevity, and fecundity) were recorded at constant intervals of generally 1 day. In **single-stage cohort studies**, individuals of the same age of each developmental stage (egg, larva, pupa, and adult) were used. The phenological events were monitored until the development to the next stage or death of all individuals in the cohort.

Data on the daily oviposition at each constant temperature were collected, which included the variation in the female rate and the proportion of females in the progeny. In complete life tables, at least 30 females were included in the assessment of fecundity. The number of insects used for constructing a life table at extreme high and low temperatures, where mortality is generally high, was increased because of the expected increase in mortality during immature life stages. The number of individuals used was not necessary balanced. Analysis of the data included weights that account for differences in numbers of individuals entering a certain life stage at a given temperature. In some cases, life tables were repeated at the same temperatures with another batch of individuals from the population. During the analysis, data from the same temperature (replications) was pooled when fitting models for describing temperature effects on insect development or fecundity.

7.2 Detailed Definition of Risk Indices Used in GIS Mapping

Establishment risk index

The establishment risk index (ERI) is defined as the number of time intervals with a net reproduction rate, R_o, above 1 ($I_{i=1}$) divided by the total number of time intervals within a year (I_I). By default, the maps, as presented in the Atlas, are generated by using a 1-month time scale; however, the calculation can also be based on other time scales (e.g., 1-day intervals). The formula for using monthly intervals is as follows:

$$ERI = \frac{\sum_{1}^{i=12,} I_i}{I_I}$$

in which I_i is the interval of the month i (with i = 1, 2, 3, …, 12). Its value is 1 if the population is expected to increase within this interval ($I_i = 1$ if $R_o \geq 1$), and the value is 0 if the population is expected to decrease ($I_i = 0$ if $R_o < 1$) according to the established temperature-driven phenology model, and the total number of intervals, I_I, is 12.

Generation index

The generation index (GI) is computed by averaging the sum of estimated generation lengths, T_i, calculated for each Julian day, x , as shown in the following expression:

$$GI = \frac{\sum_{1}^{i=12,} 365/T_i}{12}$$

where 365 is the number of days per year and T_i is the predicted average generation lengths in days during the month, i (i = 1, 2, 3, …, 12).

Activity index

The activity index (AI) is computed by employing the following equation:

$$AI = log_{10} \prod_{i=1}^{365} \lambda$$

$$AI = log_{10} \prod_{1}^{12} \lambda_i^{\frac{365}{12}}$$

where λ_x is the finite rate of increase at Julian day, x (x = 1, 2, 3, …, 365).

where λ_i is the finite rate of increase per day during month i (i = 1, 2, 3, …, 12).