

Letter to the Editor

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Subject Editor: John Trumble

Received 16 July 2018; Editorial decision 30 July 2018

Dear Prof. Trumble,

There were obvious errors in the article ‘Fecundity and Egg Laying in *Helicoverpa armigera* (Lepidoptera: Noctuidae): Model Development and Field Validation’ published by Noor-ul-Ane et al. (2018b) (<https://doi:10.1093/jeet/toy183>) in Journal of Economic Entomology.

- In Table 1, the authors reported the fecundity as 125, 553, 973, 636, 121, and 72 eggs at 15, 20, 25, 30, 35, and 37.5°C, respectively. In Table 2, the authors reported the net reproductive rate (R_0) as 124.65, 553.07, 977.6, 636.34, 121.19, and 71.15 at the respective temperatures. Because the net reproductive rate is calculated as $R_0 = \sum l_x m_x$ (i.e., the survival rate, l_x , is included), the net reproductive rate should never be greater than the fecundity. Chi and Su (2006) proved mathematically that in the female age-specific life table the net reproductive rate (R_0) equals the mean female fecundity (F), if and only if there is no preadult mortality in the female population and all offspring are female. If the sex ratio is 0.5 as they claimed ‘The sex ratio of *H. armigera* was 0.5 (Noor-ul-Ane et al., in press)’, the net reproductive rate should be approximate $0.5 \times F$. Therefore, the net reproductive rates reported by Noor-ul-Ane et al. (2018b) are incorrect, because they did not include the immature survival rate and the sex ratio in the calculation of the net reproductive rate.
- When calculating the intrinsic rate of increase using $\sum l_x m_x e^{-rx} = 1$, the duration and survival rate of the immature stages must be included (Euler 1760, Lotka 1913, Lewis 1942, Birch 1948). Lewontin (1965) pointed out that the earlier the first reproductive age and the earlier the reproductive peak is, the higher the intrinsic rate values will be. This work has been cited in a number of textbooks (e.g., Price 1997). In Noor-ul-Ane et al. (2018b), the authors wrote ‘The development time and survival were obtained from published data sets (Noor-ul-Ane et al. 2017)’ (It should be Noor-ul-Ane et al. 2018a). According to that paper, there were immature durations and immature mortalities in *Helicoverpa armigera* at these temperatures. However, in Noor-ul-Ane et al. (2018b) the authors

did not include the immature duration and mortality in calculating the intrinsic rate of increase. Therefore, the extraordinarily high values of 0.31, 0.93, 1.53, 2.09, 1.66, and 1.28 that were calculated for the intrinsic rates are incorrect. Akca et al. (2015) proposed a simplified version of the Lotka–Euler equation $e^{-r(a+1)} F \cdot l_a = 1$ (F , the mean fecundity; a , the age of the first offspring, l_a , the preadult survival rate) to enable critical examination of errors involving calculating the intrinsic rate of increase in reported papers. In Noor-ul-Ane et al. (2018b), the authors cited the paper of Mironidis and Savopoulou-Soultani (2008). Mironidis and Savopoulou-Soultani (2008) studied the life table of *H. armigera* for temperatures between 12.5 and 40°C and reported the intrinsic rate of increases of *H. armigera* ranging from 0.06 to 0.15 and the net reproductive rates from 9.37 to 203.14. Jha et al. (2012) reported the intrinsic rate of increases of *H. armigera* as 0.0853 d⁻¹ (on hybrid sweet corn) and 0.1015 d⁻¹ (on artificial diet). The data of Mironidis and Savopoulou-Soultani (2008) and Jha et al. (2012) are consistent with life table theory. When ‘day’ is used as the age unit, the intrinsic rate of increases of insects and mites will, for the most part, not exceed 1, unless the immature stage is extremely short. Bussaman et al. (2017) reported a rapid population growth in physogastric reproduction in the mite, *Luciaphorus perniciosus* (Acari: Pygmephoridae), with an intrinsic rate of increase of 1.0892 d⁻¹ at 35°C, because the first reproductive age was 3 d and the highest peak of m_x was 122.8 at age 4 d. Based on the lengths of immature stages and mortalities in *H. armigera* reported in Noor-ul-Ane et al. (2018a,b), the extraordinarily high values reported for the intrinsic rates of 0.31, 0.93, 1.53, 2.09, 1.66, and 1.28 are incorrect.

- The errors of intrinsic rate of increases consequently resulted in the irrationally short population doubling times of 2.23, 0.74, 0.45, 0.33, 0.42, and 0.54 d. The population of *H. armigera* cannot double its size within 2.23, 0.74, 0.45, 0.33, 0.42, and 0.54 d, at 15, 20, 25, 30, 35, and 37.5°C, respectively.
- The authors of Noor-ul-Ane et al. (2018b) reported ‘approximate’ and ‘accurate’ results for their intrinsic rate of increase.

But since they did not define them in the Materials and Methods, we suspect that they meant the two methods reported by Birch in 1948. The approximation method suggested by Birch at that time reflected the difficulties involving calculations during the 1940s (Jha et al. 2012). Because personal computers are now widely available, we suggest that the approximation method should not be used unless the authors failed to collect the necessary data. However, it is peculiar that the ‘approximate’ values in Table 2 in Noor-ul-Ane et al. (2018b) seem more rational.

5. In the Materials and Methods section in Noor-ul-Ane et al. (2018b), the authors wrote ‘Additionally, a precise estimate of the intrinsic rate of increase, r_m , was calculated for ages x from 0 to the maximum longevity using the Euler equation, as $1 = \sum l_x m_x e^{-rx}$ (Roughgarden 1996). The development time and survival were obtained from published data sets (Noor-ul-Ane et al. 2017)’. In Fig. 1, however, there were no data points at age 0.
6. According to the statements ‘A sigmoid function was used to describe the age-specific survival distribution of *H. armigera* females’ and the frequent occurrences of ‘female adult’ in Noor-ul-Ane et al. (2018b), the authors inexplicably used ‘adult age’ in their life table analysis. Huang and Chi (2012) clearly pointed out that ‘if one used the “adult age” to construct the life table, he/she would be unaware of the improper manipulation of the survival and fecundity curves. Consequently, the interpretation of demographic traits based on an “adult life table” will result in a variety of problems’.
7. Because these data are the bases of their model, the authors of Noor-ul-Ane et al. (2018b) need to revise their calculation and correct all errors.

Life tables are an important tool in insect ecology, pest management, and biological control. The problems of applying female age-specific life tables to insect populations were thoroughly discussed in Huang and Chi (2012) and Huang et al. (2018).

Because scientific papers present not only new data and finding, they serve also as important information sources for scientific education and learning; therefore, it is important to provide accurate scientific information to readers of the Journal of Economic Entomology.

Sincerely yours,
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