Environment, Resource and Ecology Journal (2021) 5: 19-22 DOI: 10.23977/erej.2021.050205
Clausius Scientific Press, Canada ISSN 2616-3756

Expose the true and false faces of the Asian Giant Hornets

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Keywords: Visualization, Vector Radial Circle, Leslie population growth model

Abstract: The goal of this article is to build a dynamics prediction model, in order to estimate the propagation characteristics of Asian giant hornets in Washington State. We expect to implement some strategies for the Washington State Department of Agriculture to reduce the losses caused by the biological invasion. This paper build up to Hornet's dynamics prediction model. About this Model, firstly produce the positive ID data **visualization** points, then use the **vector radial circle** to examine the estimated propagation direction. Then, according to the **Leslie population growth model** [1], a propagation dynamics model (time series model) was established. Then, the model was used to construct a propagation diffusion map for the next few years.

1. Introduction

The Asian giant hornet, as one of the largest wasps in the world, which was originally lived in most areas of Asia. In their domestic environment, they essentially live on a series of pollinating insects, nevertheless recently it appeared in Washington State. The competitive relationship of the original biological system, which has brought a great influence, particularly other hornet groups, which harms the local hornet keeping industry. The goal of this article is to build a dynamics prediction model, in order to estimate the propagation characteristics of Asian giant hornets in Washington State. We expect to implement some strategies for the Washington State Department of Agriculture to reduce the losses caused by the biological invasion.

2. Model establishment and solve

2.1 Model analysis

Leslie model is a discrete matrix population model based on age and gender. Its main idea is to use age-specific female fertility rate $\boldsymbol{b_i}$, death rate $\boldsymbol{c_i}$, and birth rate $\boldsymbol{k}$. Construct a Leslie matrix vector with three parameters [2]. Then multiply the actual population of females by age $\boldsymbol{X_i(0)}$ in the initial year to obtain the predicted population vector Xi(t) of females by age. By optimizing the model, a prediction model of hornet propagation can be established.

2.2 Model Establishment

The number of one-year-old male hornets at the position of longitude j and latitude u at (k+1)th year is

$$x_{j,u}^{M}(1,k+1)=s_{j,u}^{M}(0,k)a_{j,u}^{M}(k)\sum_{i=i_1}^{i_2}b_{j,u}^{Q}(i,k)\cdot x_{j,u}^{Q}(i,k)+v_{j,u}^{M}(0,k).$$

The number of one-year-old female hornets at the position of longitude j and latitude u at (k+1)th year is

$$x_{j,u}^{F}(1,k+1)=s_{j,u}^{F}(0,k)a_{j,u}^{F}(k)\sum_{i=i_1}^{i_2}b_{j,u}^{Q}(i,k)\cdot x_{j,u}^{Q}(i,k)+v_{j,u}^{F}(0,k).$$

The number of one-year-old queens at the position of longitude j and latitude u at (k+1)th year is

$$x_{j,u}^{Q}(1,k+1)=s_{j,u}^{Q}(0,k)a_{j,u}^{Q}(k)x_{j,u}^{F}(i_0,k)+v_{j,u}^{Q}(0,k).$$

Changes in the number of various hornets can be represented by the following recurrence

$$x_{j,u}^{l}(i+1,k+1)=s_{j,u}^{l}(i,k)x_{j,u}^{l}(i,k)+v_{j,u}^{l}(i,k),i>1,l=W,M,F,Q.$$

The sum of the number of births of each queen at each childbearing age in kth years can be expressed by the following formula

$$\beta_{j,u}^{Q}(k)=\sum_{i=i_1}^{i_2}b_{j,u}^{Q}(i,k).$$

If it is assumed that all queens maintain this number of births during reproductive age, the above formula can be expressed as the average number of births in the lifetime of each queen hornet [3].

So, the proportion of queen hornet's i-year-old fertility in the lifetime can be obtained

$$h_{j,u}^{Q}(i,k)=\frac{b_{j,u}^{Q}(i,k)}{\beta_{j,u}^{Q}(k)}.$$

The distribution vector of various types of hornets was easily obtained

$$x_{j,u}^{l}(k)=[x_{j,u}^{l}(1,k),x_{j,u}^{l}(2,k),\cdots,x_{j,u}^{l}(n,k)]^{T}.$$

The survival matrix of various hornet species at year k with longitude j and latitude u is

$$S_{j,u}^{l}(k)=\begin{bmatrix}0 & 0 & \cdots & 0 & 0\\ s_{j,u}^{l}(1,k) & 0 & \cdots & 0 & 0\\ 0 & s_{j,u}^{l}(2,k) & \cdots & 0 & 0\\ \vdots & \vdots & & \vdots & \vdots\\ 0 & 0 & \cdots & s_{j,u}^{l}(n-1,k) & 0\end{bmatrix}.$$

In year k, the matrix of fertility proportions of queen hornet in longitude j and latitude u is

$$H_{j,u}^{Q}(k)=\begin{bmatrix}0 & \cdots & 0 & h_{j,u}^{Q}(i_1,k) & \cdots & h_{j,u}^{Q}(i_2,k) & 0 & \cdots & 0\\ 0 & \cdots & 0 & 0 & \cdots & 0 & 0 & \cdots & 0\\ \vdots & & \vdots & \vdots & & \vdots & \vdots & & \vdots\\ 0 & \cdots & 0 & 0 & \cdots & 0 & 0 & \cdots & 0\end{bmatrix}.$$

The population migration vector of each type of hornet in year k with a longitude of J and a latitude of u is

$$v^l_{j,u}(k) = [v^l_{j,u}(0,k), v^l_{j,u}(1,k), \cdots, v^l_{j,u}(n-1,k)].$$

Since the number of various types of hornets in (k + 1)th year can be obtained by 1) Growth from the same type of hornet in the previous year. 2) Reproductive growth from the queen hornet. 3) Migration of the population [4]. Then, the following system of difference equation can be obtained

$$\begin{cases} x^W_{j,u}(k+1) = S^W_{j,u}(k)x^W_{j,u}(k) + s^W_{j,u}(0,k)a^W_{j,u}(k)\beta^Q_{j,u}(k)H^Q_{j,u}(k)x^Q_{j,u}(k) + v^W_{j,u}(k); \\ x^M_{j,u}(k+1) = S^M_{j,u}(k)x^M_{j,u}(k) + s^M_{j,u}(0,k)a^M_{j,u}(k)\beta^Q_{j,u}(k)H^Q_{j,u}(k)x^Q_{j,u}(k) + v^M_{j,u}(k); \\ x^F_{j,u}(k+1) = S^F_{j,u}(k)x^F_{j,u}(k) + s^F_{j,u}(0,k)a^F_{j,u}(k)\beta^Q_{j,u}(k)H^Q_{j,u}(k)x^Q_{j,u}(k) + v^F_{j,u}(k); \\ x^Q_{j,u}(k+1) = S^Q_{j,u}(k)x^Q_{j,u}(k) + s^Q_{j,u}(0,k)a^Q_{j,u}(k)x^F_{j,u}(k) + v^Q_{j,u}(k). \end{cases}$$

2.3 Model Results

The result is shown in the figure below:

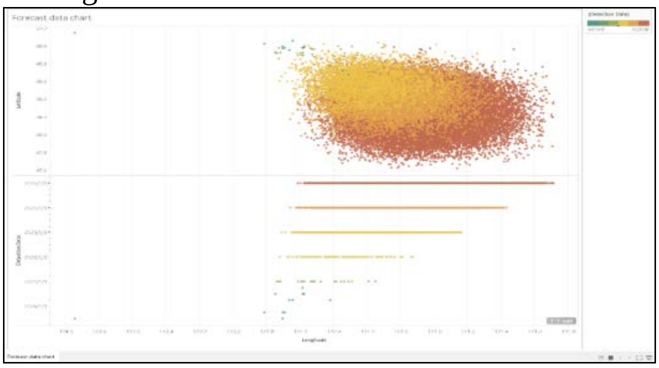

Figure 1: Forecast data chart

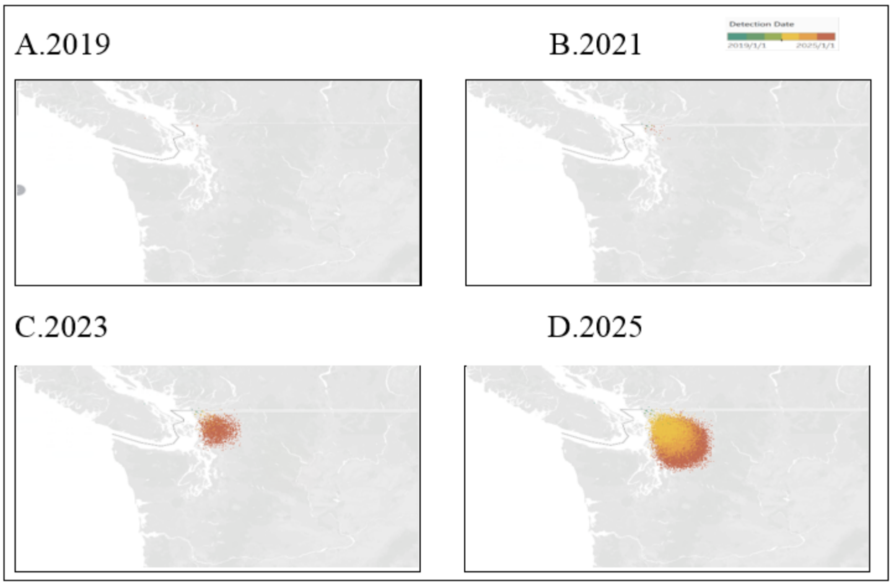

Figure 2: Dynamics of Asian giant hornet net

As shown in Figure 1, without the need for government investment, based on the prediction model established by Leslie model, the trend chart of the number and direction of Asian giant hornets in the future is predicted. This is a dynamic model of spatial distribution and quantity change without other factors.

Combining with local area map, visual processing of the established dynamic prediction model and generate dynamic network mapare shown in Figure 2.

3. Evaluation of Model

3.1 Strength

1) According to the last difference system in the model, only the initial value needs to be determined, and the number of hornet population and their diffusion in any year can be obtained.
2) The model contains many variables, so the model can change more parameters.
3) With the increase of data, the estimation of model parameters can be further optimized to make the model results more accurate.

3.2 Weakness

1) The effect of intensified interspecies fighting caused by the reproduction process on the number of hornet population was not considered.
2) The data information is relatively small, and it is unable to determine the impact of external environment such as topography and temperature on the Asian giant hornet population.
3) More data is needed for parameter estimation to make the estimation more accurate.

References

[1]. Xia Denan. Research on agricultural insect image recognition based on deep learning [D]. Anhui University, 2019

[2]. Jiang Lemei. Insect recognition method based on deep learning and its application [D]. Hunan Agricultural University, 2019

[3]. Mu Wenxiu, Hong Lei, Wang Han. Application of intelligent insect classification recognition algorithm based on machine learning [J]. Digital technology and application, 2018, 36 (11): 118-119

[4]. Pang Hongwei. Research on insect image recognition technology based on deep learning [D]. University of Chinese Academy of Sciences (School of artificial intelligence, Chinese Academy of Sciences), 202