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The Rising Risk of Stem Borers in Gilan's Rice Fields Due to Climate Change: A Case Study of *Chilo suppressalis*

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Introduction and Aim

The northern provinces of Iran along the Caspian Sea coast, with their favorable climate and ample water resources, host extensive rice fields that are vital to both local livelihoods and the national economy. *Chilo suppressalis*, a major pest species, is estimated by the Agricultural Organization of Gilan Province to cause a 30–50% reduction in crop yield and a decline in product quality. Despite its significance, the potential impact of climate change on this pest has not been thoroughly studied in Iran, leaving a critical knowledge gap. In this study, we address this gap by projecting the future distribution of *C. suppressalis* under two climate change scenarios (SSP2-4.5 and SSP5-8.5) for the year 2070, using species distribution modeling tool.

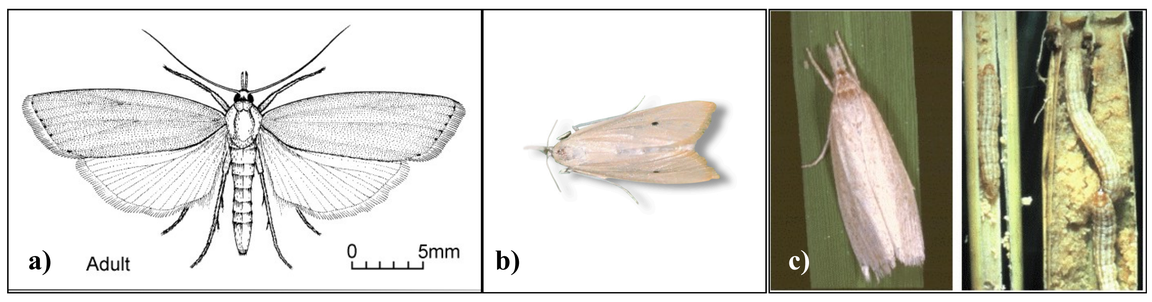

Fig. 1: *(a)* Illustration of an adult *C. suppressalis* (by Dennis S. Hill); *(b)* Photograph of an adult *C. suppressalis*; *(c)* Left: Striped stem borer adult (by Merle Shepard); Right: Larvae inside rice stems (by Roy Bateman).

Method

The study was conducted in the three northern provinces of Iran, spanning latitudes 35.5° to 38.5° and longitudes 48.5° to 56.5°. These provinces host the largest rice fields in the country (Fig. 2) and the majority of *Chilo suppressalis* populations. A total of 197 presence points for the species (Fig. 3) were obtained from the study by Jalaeian et al. (2017).

Bioclimatic variables for analyzing the current and future distribution of the species (under SSP2-4.5 and SSP5-8.5 scenarios for the 2060–2080 period) were sourced from the WorldClim database (Fick & Hijmans, 2017). To address collinearity, the variance inflation factor method was applied (Naimi et al., 2013), and the final variables were selected for modeling using Random Forest (RF), Support Vector Machine (SVM), and Multilayer Perceptron (MLP) algorithms.

Species distribution models were evaluated using AUC (Area Under the Curve) and TSS (True Skill Statistic) parameters. The models were optimized using a weighted method, applying the "max(se + sp)" threshold, with the criteria of AUC > 0.7 and TSS > 0.6 (Ghasemian Sorboni et al., 2024). The final distribution range was prepared by integrating the best-performing models. Changes in the species' range, including reductions and expansions, were analyzed using the ArcGIS Pro environment.

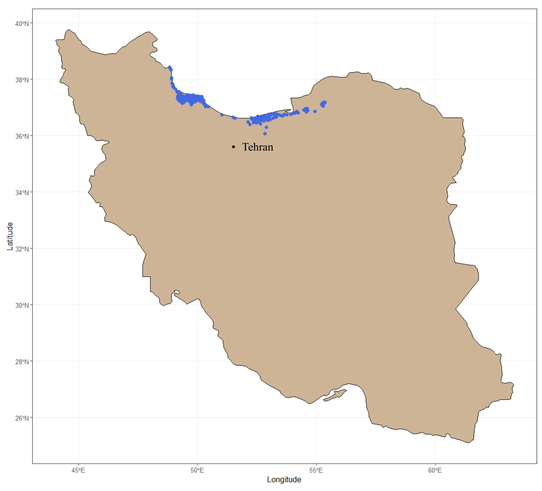

Fig. 3: Geographical distribution of *C. suppressalis* records in the Caspian region of Iran.

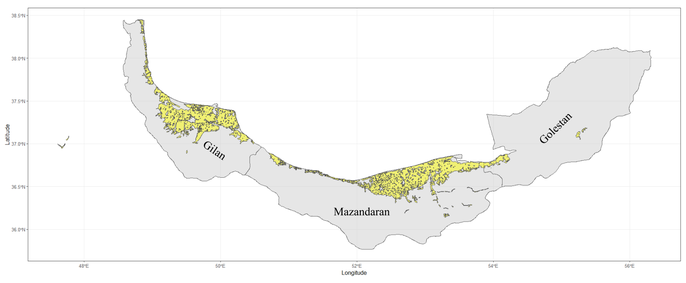

Fig. 2: Spatial distribution of rice fields in northern Iran, highlighting key agricultural areas relevant to the study of *C. suppressalis* habitat.

Results

The results confirm the pest's current widespread presence in the rice fields of Golestan, Mazandaran, and Gilan provinces, aligning with recorded data from the Agricultural Organization (Fig. 4). However, projections indicate a sharp decline in the species' spread in eastern Mazandaran and Golestan, with a shift toward western regions. Conversely, Gilan province is predicted to experience both stability and an expansion of suitable habitat for the pest (Fig. 5). Among the bioclimatic variables, bio19 had the greatest influence on the species distribution prediction (Fig. 6).

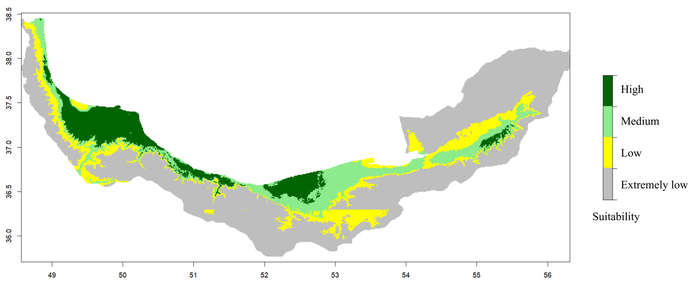

Fig. 4: Current projected distribution of *Chilo suppressalis* in northern Iran.

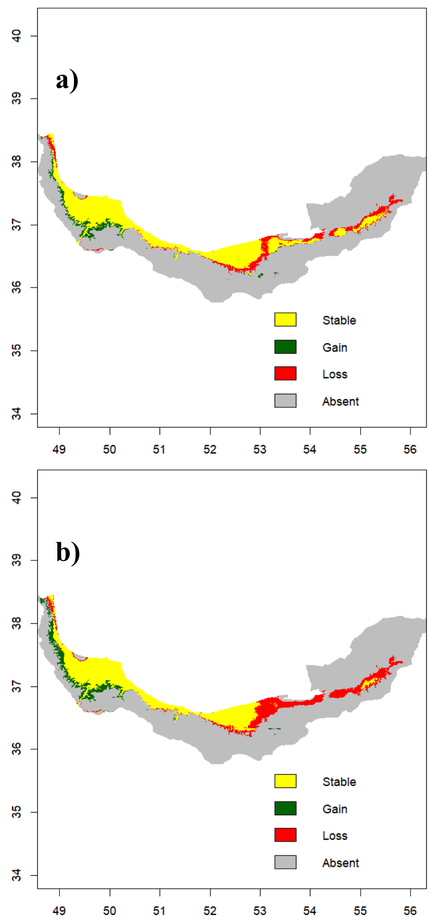

Fig. 5: Future predicted distribution of *C. suppressalis* in northern Iran under two climate scenarios for the year 2070: *(a)* SSP2-4.5 and *(b)* SSP5-8.5.

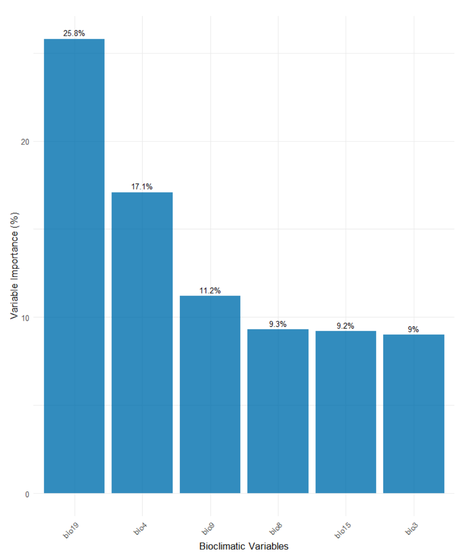

Fig. 6: Relative importance of six bioclimatic variables in predicting the geographical distribution of *C. suppressalis*.

Discussion

The rice stem borer (*Chilo suppressalis*) is the most widespread of all rice stem borers globally, causing significant annual damage to farmers. The favorable climatic conditions of northern Iran, combined with extensive rice cultivation, have facilitated the persistence of this pest in the region. Although numerous studies have examined the effects of climate change on species distributions, the specific impact on *C. suppressalis* had not been thoroughly investigated, highlighting the importance of this study. Our results indicate that the species' range will largely be maintained due to the high climatic suitability of the Caspian areas, with a notable shift toward Gilan province.

These findings align with the species' preference for an optimal temperature range of 25–32°C, which supports egg laying and growth. To mitigate potential economic losses, it is crucial to implement improved management strategies to monitor and control the distribution and spread of *C. suppressalis*, particularly in Gilan province, in response to the anticipated effects of climate change.

References

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