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Short communication

Global warming affects the occurrence of stem borers in ecological engineering-based diversified farming ecosystems

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ABSTRACT

Ecological engineering-based diversified farming systems contribute to the delivery of ecosystem services, which is critical for biological control of pests in agro-ecosystems. In paddy ecosystems, rice stem borers are the most destructive lepidopteran pests that have been studied in detail, but the effects of meteorological factors related to global change on these pests have been scarcely explored. Our 9-year data from Chongming Island of China indicated that there was an exponential decay each year in the numbers of adult pink stem borers and striped stem borers trapped in the lamp in ecological engineering-based diversified farming ecosystems. By stepwise regression analysis, we found that both average daily temperature and average daily wind velocity had significantly negative effects while sunshine duration had a significantly positive effect on the number of adult pink stem borers, and that average daily temperature significantly and positively affected while average daily wind significantly and negatively affected the number of adult striped stem borers. Our study reveals that global warming might promote the occurrence of striped stem borers but inhibit the occurrence of pink stem borers in the future.

1. Introduction

Agricultural intensification has led to the loss of biodiversity in agro-ecosystems (Tilman et al., 2001; Tscharntke et al., 2005) and induced the reduction in the provisioning of globally significant ecosystem services such as biocontrol services (Symondson et al., 2002), plant pollination (Ricketts et al., 2004), soil and water quality maintenance, efficient nutrient cycling and carbon sequestration (Stehle and Schulz, 2015). However, biologically diversified farming, as one of the most important eco-engineering ways to outperform conventional monocultures, can integrate some farming practices and landscape management strategies at multiple spatiotemporal scales to enhance ecosystem services (Kremen and Miles, 2012). For instance, this farming mode could promote biocontrol services (Wan et al., 2014b), enhance the abundance of natural enemies (Landis et al., 2000) and increase arthropod diversity (Symstad et al., 2000).

Chongming Island is the 3rd-largest in China after Taiwan and Hainan, located on the estuary of Yangtze River. The Island has a population of more than 700,000, covers an area of 1411 square kilometers, and its economy is dominated by agriculture with an area of 2.6×10^4 ha for rice cultivation. In order to develop low-carbon agriculture, biologically diversified farming has been gradually ushered since the 2000s (Wan et al., 2013, 2015), but up to now the effect of biologically diversified farming on the occurrence of rice stem borers has not been explored.

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On Chongming Island of China, the pink stem borer, *Sesamia inferens* (Walker) (Lepidoptera: Noctuidae), and the striped stem borer, *Chilo suppressalis* (Walker) (Lepidoptera: Pyralidae) are the major stem borer pests. In order to better manage the stem borers in paddy ecosystems and guarantee food security, we conducted the long-term monitoring of the two stem borers by using insecticidal lamp traps and by virtue of correlated meteorological analysis to predict the population trends on Chongming Island of China. Our work can provoke further research regarding the effects of ecological engineering-based diversified farming on pest population dynamics and the response of pests to global change at larger temporal scales.

2. Materials and methods

2.1. Study sites

Our study was conducted at the Shanghai SIIC Modern Agriculture Development Co., Ltd., Chongming Island, China (30.5°N, 121.9°E). At the site, the main rice cultivated were "Xiushui" varieties provided by the Crop Research Institute, Shanghai Academy of Agriculture Sciences. A total of 1.67 thousand hectares of rice were sown, which produced an average yield of 13.8 thousand tons (Wan et al., 2015). A single insecticidal lamp (solar frequency vibration lamp 1.5 m in height, PS-15II type), manufactured by Jiaduo Company Limited of Henan province, China, was installed in the center of a rice fields to monitor the occurrence of the rice stem borers (Wan et al., 2016a, 2016b). Biologically diversified farming strategies used in the study region included: (1) using a rice–milk vetch or rice–wheat rotation to improve soil fertility and increase land use efficiency; (2) leaving naturally-occurring weeds uncontrolled on paddy field ridges to promote the abundance and diversity of natural enemies of rice pests; and (3) using crops such as corns, soybeans, watermelons and other vegetables cultivated near rice fields to maintain biodiversity and promote biocontrol services (Wan et al., 2016b). Agricultural practices of pest control, fertilization and irrigation were the same in experimental paddy fields. A variety of insecticides, such as Abamectin EW, *Bacillus thuringiensis*, Chlopyrifos EC, Emamectin benzoate EC, Chlorantraniliprole SC and Flutolanil SC, were used to control rice stem borers in accordance with the pest forecast information offered by the Plant Protection Station on Chongming Island, China.

2.2. Data collection

The number of adult stem borers trapped in the insecticidal lamp was counted at the emergence time of rice stem borers. Meteorological factors-average daily temperature (°C), daily rainfall (mm), sunshine duration (h) and average daily wind velocity (m/s) were offered by the Chongming Meteorological Bureau.

2.3. Data analysis

Stepwise regression analysis was used with SPSS 16.0 to analyze the relationship between the meteorological factor (average daily temperature X_1, daily rainfall X_2, sunshine duration X_3 or average daily wind velocity X_4) and the number (square root-transformed) of adult pink stem borers or adult striped stem borers trapped in the lamp. Exponential models were adopted to analyze the relationships between the years (2006–2014) and the average number of adult pink stem borers or striped stem borers trapped in the lamp each year.

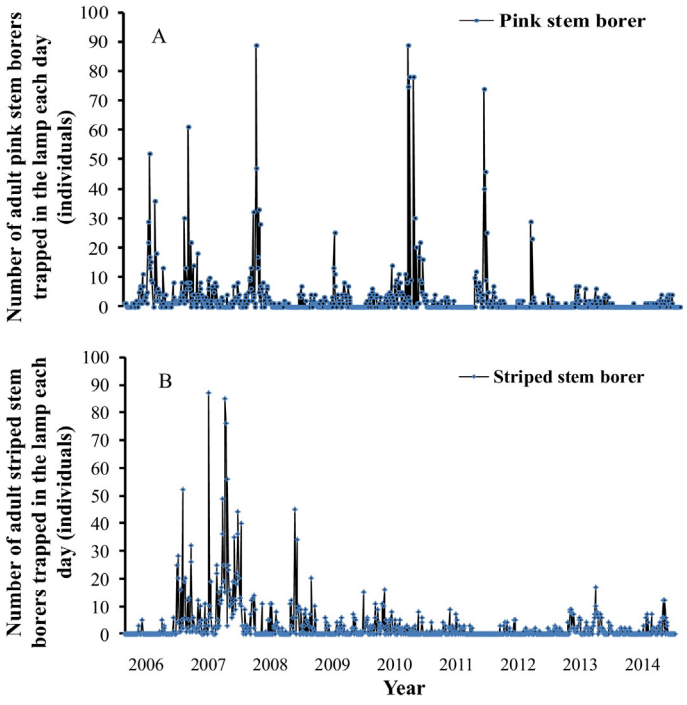

Fig. 1. Population dynamics of adult stem borers trapped in the lamp in ecological engineering-based diversified farming ecosystems from 2001 to 2014 (A and B denote the adult pink stem borers and striped stem borers respectively).

3. Results

The interannual difference in the number of rice stem borers trapped in the lamp was distinct on Chongming Island of China from 2006 to 2014. The peaks of adult pink stem borers were obvious in 2006, 2007, 2010 and 2011, with 61, 89, 89 and 74 being the maximum number trapped in the insecticidal lamp, respectively, while the peaks of adult striped stem borers were obvious in 2006, 2007 and 2008, with 52, 87 and 44 being the maximum number trapped in the insecticidal lamp, respectively. The lamp could induce more than 60 adult pink stem borers and more than 40 striped stem borers per sampling day at the peak (Fig. 1). The simulated result showed that there was an exponential decay each year in the average numbers of adult pink stem borers and striped stem borers trapped in the lamp in ecological engineering-based diversified farming ecosystems (Fig. 2).

The stepwise regression analysis indicated that both average daily temperature and average daily wind velocity had significantly negative effects while sunshine duration had a significantly positive effect on the number of adult pink stem borers; average daily temperature significantly and positively affected while average daily wind significantly and negatively affected the number of adult striped stem borers (Table 1).

4. Discussion

Compared to conventional monocultures mainly relying on chemicals, biologically diversified farming, as one of the most important eco-engineering projects in agro-ecosystems, contributes to the promotion of biocontrol services (Wan et al., 2014b), conservation of biodiversity, improvement of environmental quality (Yang et al., 2014), efficient use of energy, and increase in the resistance and resilience to global climate change. According to preliminary estimates, once the paddy ecosystems were adopted with biologically diversified farming, serious outbreaks of stem borers were eliminated and the abundance of stem borers could