



# Cropland expansion facilitated the outbreak of cereal aphids during 1951–2010 in China

Zi-Hua Zhao · Fang Ouyang · Feng Ge

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**Abstract** Landscape-scale pattern could affect ecosystem service such as biocontrol of agricultural pests. Additionally, pest outbreak has been shown to be interwoven with land-use intensity. In the present research, we collected and analysed the 60-year data of cereal aphids and wheat area during 1951–2010 in China. Regression model was applied to analyse the relationship between pest damage and cropland expansion. Results showed that the percentage of cereal aphid outbreak area in wheat area increased rapidly during 1951–2010. It was 9 % during 1951–1960, while it was above 60 % during 2001–2010. In addition, effect of cropland expansion on damage of cereal aphids was significantly positive, which indicated that cropland expansion in agricultural landscape may enhance pest damage greatly. Finally, we concluded that cropland expansion was one of the most important drivers of increasing pest outbreak, which should be considered in sustainable management of cereal aphids combined with other factor (e.g. climate changes and resistant variety) at large spatiotemporal scale.

**Keywords** Agricultural intensification · Cereal aphids · Biocontrol · Ecosystem service · Scale

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Zi-Hua Zhao and Fang Ouyang contributed equally to this work.

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Z.-H. Zhao · F. Ouyang · F. Ge (✉)  
State Key Laboratory of Integrated Management of Pest Insects and Rodents, Institute of Zoology, Chinese Academy of Sciences, Beijing 100101, China  
e-mail: gef@ioz.ac.cn

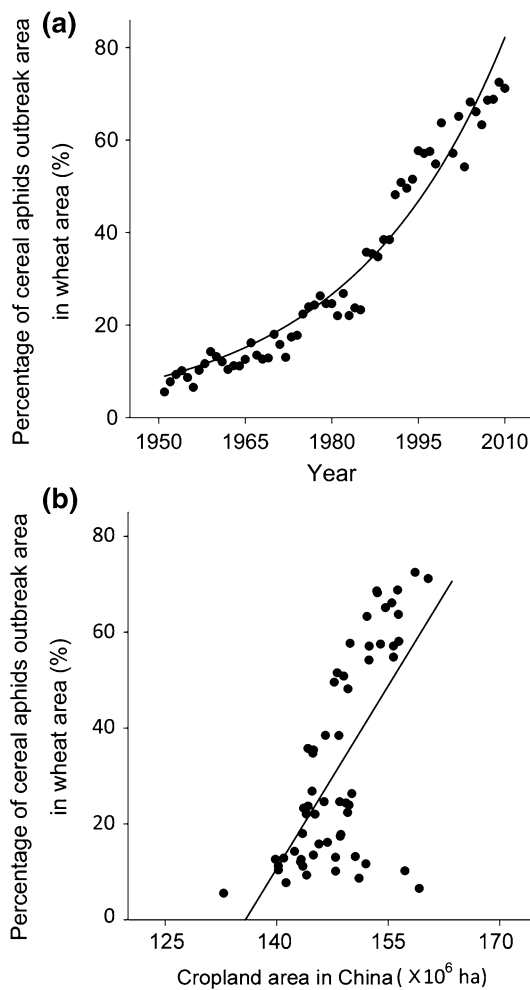
Z.-H. Zhao  
Department of Entomology, College of Agriculture and Biotechnology, China Agricultural University, Beijing 100193, China

In the past decades, the intensification of agriculture (e.g. cropland expansion) and fragmentation of semi-natural habitats are important drivers of biodiversity loss, which may simultaneously lead to the wide outbreak of many agricultural pests (e.g. cereal aphids and corn borers) [1]. Many researchers have reported that cropland expansion may be important causes of increasing pest damage at local spatial and short temporal scale [2]. However, the relationship between agricultural intensification and outbreak of agricultural pests (e.g. cereal aphid) at large spatiotemporal scale is poorly understood [3]. In the past decades, the effects of cropland expansion on pest abundance and damage at large spatiotemporal scale have received substantial attention from ecologist [4].

In the present research, we collected the 60-year data of wheat area and outbreak area of cereal aphids above economic threshold in China. Pest data (outbreak area above economic threshold) of cereal aphid during 1951–2000 were extracted from statistical yearbook of plant protection [5]; data of pest damage during the periods 2001–2010 were obtained from Agricultural Technology Extension Service Center, Ministry of Agriculture of China. Data on the wheat area and cropland area in China for the periods 1951–2010 were extracted from statistical list in Management Division of Plant Industry, Ministry of Agriculture of China (<http://www.zzys.moa.gov.cn/>). The pest damage (PD) of cereal aphids was transformed as the ratio of outbreak area in wheat area ( $PD = \text{AREA}_{\text{outbreak area}} / \text{AREA}_{\text{wheat area}}$ ). Parametric model (exponential function) was used to describe the dynamics of pest damage during 1951–2010. Additionally, linear regression analysis was used to assess the relationship between cropland expansion and pest damage on the data set gathered from 1951 to 2010. We examined the tendency of damage of cereal aphids and its relationship with expansion of cropland area in China.

Results showed that outbreak area of cereal aphids above economic threshold increased rapidly in the past decades. The outbreak area of cereal aphids accounted for only 9 % of the wheat area in 1951–1960. However, the percentage increased to above 60 % during 2001–2010 (Fig. 1a). Furthermore, the tendency of pest damage can be fitted well by exponential function ( $F_{1,58} = 28.63$ ,  $P < 0.001$ ; Fig. 1a). As expansion of the cropland area, the percentage of outbreak area in total wheat area also increased rapidly and their relationships were significantly positive ( $F_{1,58} = 6.69$ ,  $P < 0.001$ ; Fig. 1b). Therefore, the cropland expansion is an important factor, which may enhance pest damage greatly by providing abundant food resources.

So far, cereal aphid has been the most important pest which has caused great damage to wheat crop in China. In our experiments, we found that the percentage of outbreak area in wheat area was significantly enhanced by cropland



**Fig. 1** Effects of cropland expansion on damage of cereal aphids in wheat field of China. **a** The tendency of cereal aphids' damage against time series from 1951 to 2010. **b** The relationship between percentage of outbreak area in wheat area and cropland area in China during 1951–2010

expansion in the past decade. Similarly, Meehan et al. [1] also reported that there was a positive relationship between crop pest abundance (*Rhopalosiphum maidis*, *Aphis glycines*, and *Rhopalosiphum padi*) and cropland area in several provinces of USA. However, some researchers suggested that increasing pest damage was caused by global warming at large spatial scale [6]. In previous study, we found that agricultural intensification can destabilize the interspecific relationship and lead to biodiversity loss. Additionally, increasing nitrogen fertilizer input could benefit cereal aphids more than their natural enemies, leading to biocontrol loss in agroecosystem [7]. Now, we found that another factor, cropland expansion (landscape change) could lead to pest outbreak at large spatiotemporal scale. This result was consistent with the resource concentration hypothesis. However, global warming was also an important factor influencing distribution range and dynamics of cereal aphids [8]. Therefore, both global warming and cropland expansion should be considered together to interpret the wide outbreak of cereal aphids in recent years, which could balance multiple ecosystem services and agricultural production [9]. In the future, cropland expansion combined with ecologically based pest management (e.g. resistant variety, diversified planting, rotation, and no-tillage) is a potential way to suppress pest population over time, which may be an effective mode to face the challenge caused by global changes [10].

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**Conflict of interest** The authors declare that they have no conflict of interest.

## References

- Meehan TD, Werling BP, Landis DA et al (2011) Proc Natl Acad Sci USA 108:11500–11505
- Jonsson M, Buckley HL, Case BS et al (2012) J Appl Ecol 49:706–714
- O'Rourke ME, Rienzo-Stack K, Power AG (2011) Ecol Appl 21:1782–1791
- Zhao ZH, Hui C, Hardev S et al (2014) J Econ Entomol 107:630–637
- Chen SD, Hu BH (2003) China Agr Press, pp 50–100 (in Chinese)
- Zhang ZB, Cazelles B, Tian HD (2009) Proc R Soc B Biol Sci 276:823–831
- Zhao ZH, Hui C, He DH et al (2015) Sci Rep 5:8024
- Zhao ZH, Shi PJ, Ouyang F et al (2013) Sci China Life Sci 56:758–766
- Zhou ZL, Harrington R, Woivod IP (1995) Glob Chang Biol 1:303–313
- Tscharntke T, Tylianakis JM, Rand TA et al (2012) Biol Rev 87:661–685