南方农业学报 Journal of Southern Agriculture 2015,46(3):447-451
ISSN 2095-1191; CODEN NNXAAB http://www.nfnyxb.cn

DOI:10.3969/j:issn.2095-1191.2015.3.447

# Risk analysis of alien invasive *Lissorhoptrus oryzophilus* in rice producing areas of Guangxi

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**Abstract**: 【Objective】The present study was conducted to analyze the adaptability in China and invasive risk of *Lissorhoptrus oryzophilus* Kuschel in Guangxi rice producing areas in order to provide references for its control. 【Method】The distributing adaptability in China and risk analysis in Guangxi of *L. oryzophilus* was analyzed through DK-GARP model. 【Result】The results showed that RWW was found to distribute in 20 cities and provinces of Northeast, Northwest, North China, Central China, East China, and Southwest China at present. The main distributing regions of RWW were nearer to the coastal cities and some inland provinces *viz.*, Jilin, Liaoning, Zhejiang, Beijing, Tianjing and Hunan, which were fit for rice production. The neighbor provinces of Guangxi such as Hunan, Yunnan and Guizhou also appeared RWW. The 28 provinces (regions) in China were the high-risk regions of RWW invasion. With the rapid development of economy and international trade and commerce between China and Association of Southeast Asian Nations, the spread paths and opportunity of RWW became more and more. Furthermore, the advantageous geography and weather conditions of Guangxi are much fit for growth and reproduction of *L. oryzophilus*, Guangxi had become the high-risk spread area of *L. oryzophilus*. 【Conclusion】Guangxi must be on the alert and strengthen inspection and quarantine of *L. oryzophilus*, and should cut off epidemic situation from source in order to prevent *L. oryzophilus* to invade Guangxi.

**Key words**: *Lissorhoptrus oryzophilus* Kuschel; invasive pest; risk analysis; suitable adaptability area; Guangxi

**CLC number**: S435.112.6 **Document code**: A **Article**:2095-1191(2015)03-0447-05

# 外来害虫稻水象甲入侵广西水稻主产区的风险分析

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**摘要**:【目的】分析稻水象甲在全国的适生性和入侵广西水稻主产区的风险,为制定其防治措施提供参考依据。【方法】运用DK-GARP模型分析稻水象甲在全国的适生性,分析其在广西的扩散风险。【结果】目前,稻水象甲已蔓延到我国东北、西北、华北、华中、华东、西南等20个省(市),主要为近沿海城市和部分内陆城市;在广西周边省份如湖南、云南、贵州均已有该虫分布。预测结果表明,28个省(区)将成为稻水象甲的高风险区。随着中国与东盟国家的经济及国际贸易的发展,稻水象甲在广西扩散的途径和机会越来越多;此外,广西优越的地理和气候条件非常适合稻水象甲的生长繁殖。【建议】广西已成为稻水象甲扩散的高风险地区,必须提高警惕,加强检验检疫,从源头上堵截疫情,严防稻水象甲入侵。

**关键词**: 稻水象甲; 入侵害虫; 风险评价; 适生区; 广西

## 0 Introduction

【Research significance】The rice water weevil (RWW), *Lissorhoptrus oryzophilus* Kuschel (Coleoptera:Curculionidae), also has other names such as

**Received date**:2014-12-01
**Foundation item**:Special Fund for Agro-scientific Research in the Public Interest(201503323-06);Key Project of Science and Technology Development Fund of Guangxi Academy of Agricultural Sciences(2012JZ08);Scientific and Technological Projects of Nanning Municipal Science and Technology Bureau(20132308)
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American water weevil or lesser water weevil and so on. RWW is native to Northern America and is widely distributed in Southeastern USA. RWW causes great menace to the rice main producing areas. Guangxi occupies irreplaceable location in rice production of nationwide, though RWW has not been found in Guangxi at present, but the neighbor provinces of Guangxi such as Hunan, Yunnan, Guizhou and Taiwan have been found, the risk that RWW invasive to Guangxi was very higher. Therefore, to forecast the potential distribution of RWW and evaluate its invasive risk in Guangxi would play very important role on its control. [Research progress] RWW is an invasive pest and attack rice mainly, and has became a serious pest of rice in rice producing provinces in China(Jiao et al., 2011; Yang et al., 2014). RWW was found firstly in Tanghai of Hebei province in 1998, and now it distributed in 20 cities and provinces in China at present (Wang and Liu, 1997; Chen et al., 2001; Chen et al., 2005; Li et al., 2006; Qiu et al., 2007; Xiao et al., 2008; Zhao and Lin, 2008; Wang and Wang, 2010; Xiang et al., 2010; Wei et al., 2011; Qi et al., 2012; Zhang et al., 2014). Gong et al.(2007) analyzed and predicted normal region of RWW using Arcview model, which involved 29 provinces and municipalities distributed in East China, Southwest, Northwest, Central China, Southern China, North China and so on, and Xinjiang was also reported (Guo et al, 2011). Qi et al.(2012) reported that most optimum potential areas of RWW were Bohai Rim areas and provinces of South China. [Research breakthrough point]Till now, very little is known about the risk of RWW in Guangxi, therefore, it's necessary to research the risk of invasion and diffusion of RWW in Guangxi. [Solving problems]Risk analysis of *L. oryzophilus* in Guangxi was conducted through DK-GARP model in order to provide references for studying its spread, prevention and control measures.

# 1 Materials and methods

## 1.1 Experimental materials

*L. oryzophilus* was used as the investigated objective in the present study. The used software package included Desktop GARP(DK-GARP) with versioning Arcgis Desktop 9.3, and Google Earth - search tool with versioning 6.0.2.2074.

## 1.2 Statistical methods

RWW distributed data of source area were collected from China and other regions through various pathway, and followed by coordinating distributed data and establishing species distribution database.

Genetic algorithm for fule-set prediction(GARP) ecological niche model was used for predicting RWW normal region in China. GARP is a model to judge species ecological requirement and forecast potential distribution through operating distributed data and environmental data of species and obtaining different regular combinations(Stockwell and Peters, 1999). The last model was projected to the geographic space and formed digital map that was fit to species distribution(Stockwell and Peters, 1999), which was used for forecasting RWW distribution.

The results from GARP model will be difference on account of nonrandom relation between species known distribution environment characteristic and survey unknown region. The 100 repetitive operations were run in order to select the optimal model. Ten optimal models were chosen base on the method of Andersonet et al.(2003). The 10 optimal models were output using grid format and then overlap the forecast results with the help of ArcGIS extended module, and calculate the overlap index(OI)($0 \leqslant OI \leqslant 10$), the predicted areas were divided into 3 types, just as optimum area($OI \geqslant 7$), feasible area($5 \leqslant OI < 7$) and inaptitude area($OI < 5$).

# 2 Results and analysis

## 2.1 Spatial distribution of RWW in China

Distribution map of RWW in China was obtained using Arcgis Desktop 9.3 (Fig.1). The results showed that RWW was found to distribute in 20 provinces and cities of Northeast, Northwest, North China, Central China, East China, Southwest China at present, which included Heilongjiang, Jilin, Tianjin, Beijing, Liaoning, Anhui, Shanxi, Zhejiang, Fujian, Yunnan, Sichuan, Guizhou provinces and so on. The main distributing regions of RWW were nearer to the coastal cities and some inland provinces *viz.*, Jilin, Liaoning, Zhejiang, Beijing, Tianjing and Hunan. The neighbor provinces of Guangxi such as Hunan, Yunnan and Guizhou also appeared RWW. We could found that most of these RWW distributing regions in China were fit for rice production.

## 2.2 High-risk regions forecast analysis of RWW

The forecast result of RWW high-risk regions in China through GARP analysis were shown on Fig.2. Overlap index (OI) ranged from 0 to 10, and the larger the number, the greater the risk was. We found that the OI of half of whole country ranged from 9-10, which indicated that there were all high-risk regions, including Heilongjiang, Jilin, Liaoning, Beijing, Tianjing, Hebei, Shanxi, Shandong, Henan, Ningxia, Jiangsu, Anhui, Shanghai, Zhejiang, Hubei, Chongqing, Sichuan, Guizhou, Hunan, Jiangxi, Fu-

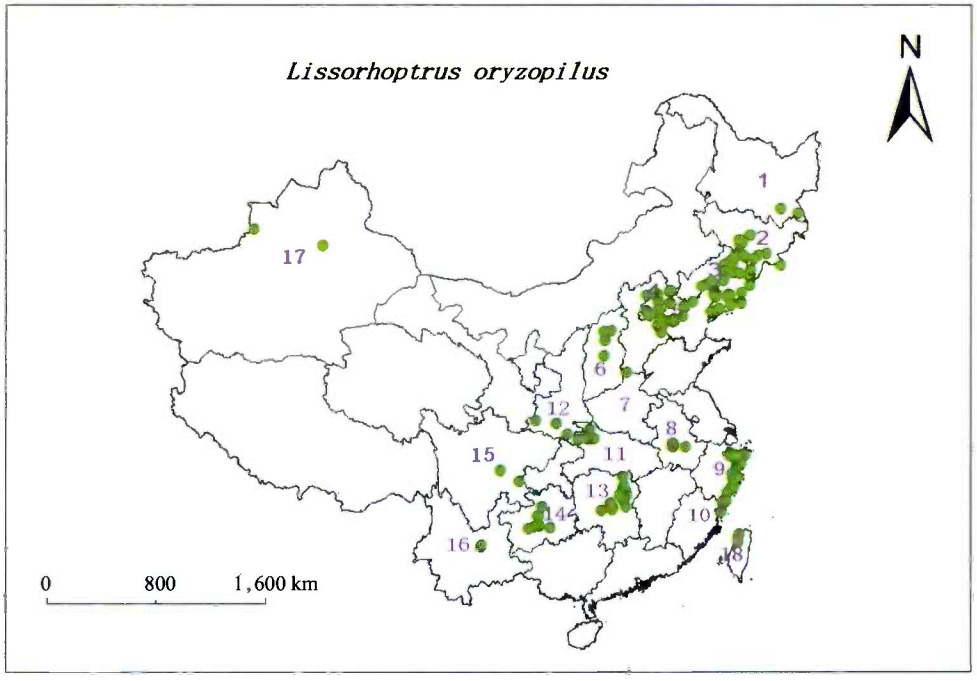


**Fig.1 Distribution map of RWW in China**

1: Heilongjiang; 2: Jilin; 3: Liaoning; 4: Beijing; 5: Tianjin; 6: Shanxi; 7: Henan; 8: Anhui; 9: Zhejiang; 10: Fujiang; 11: Hubei; 12: Shaanxi; 13: Hunan; 14: Guizhou; 15: Sichuan; 16: Yunnan; 17: Sinkiang; 18: Taiwan

jian, Guangdong, Yuannan, Hainan, Hongkong, Taiwan, Macao, and Guangxi. Although some provinces such as Guangdong, Hainan, Gansu, Jiangsu, and Ningxia had no records at present (Fig.1), they also were high-risk regions(Fig.2). And obviously, Guangxi belongs to high-risk region because it has natural advantageous geographical conditions for invaded species. Several cities of Guangxi *viz.*, Guilin, Baise and Hechi should be paid attention to prevent invasion of RWW.

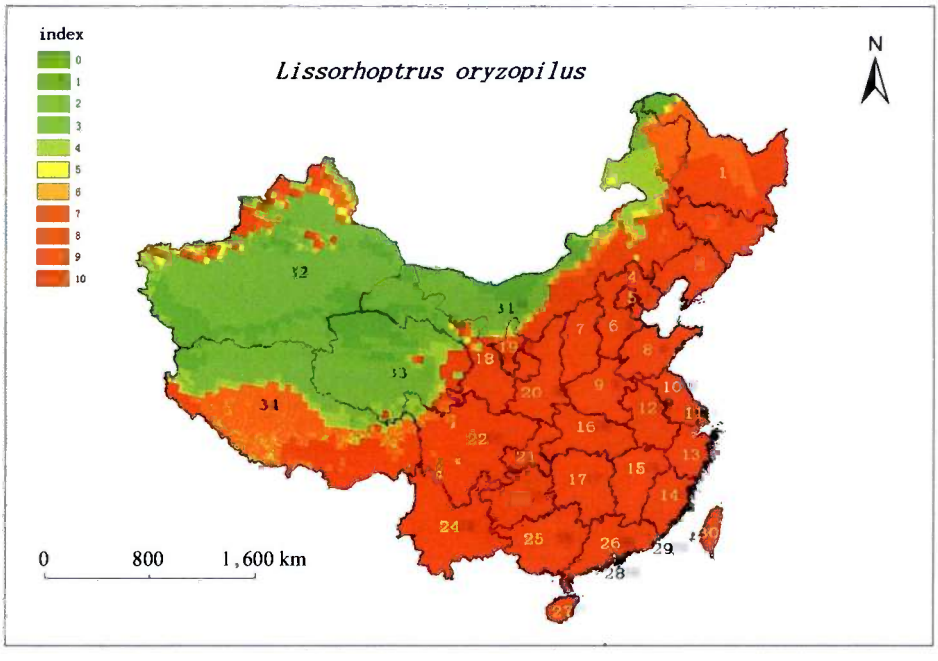


**Fig.2 Forecast result of RWW normal region in China**

1: Heilongjiang; 2: Jilin; 3: Liaoning; 4: Beijing; 5: Tianjin; 6: Hebei; 7: Shanxi; 8: Shandong; 9: Henan; 10: Jiangsu; 11: Shanghai; 12: Anhui; 13: Zhejiang; 14: Fujian; 15: Jiangxi; 16: Hubei; 17: Hunan; 18: Gansu; 19: Ningxia; 20: Shanxi; 21: Chongqin; 22: Sichuan; 23: Guizhou; 24: Yunnan; 25: Guangxi; 26: Guangdong; 27: Hainan; 28: Macao; 29: Hongkong; 30: Taiwan; 31: Inner Mongolia; 32: Sinkiang; 33: Qinhai; 34: Tibet

## 3 Risk analysis of *L. oryzophilus* in Guangxi

### 3.1 Invasive risk come from economic and trade exchanges of Guangxi

In USA, RWW reproduced sexually. However, RWW reproduced parthenogenetically since it was introduced into northern California in 1959 (Lange and Grigarick, 1959; Grigarick and Beards, 1965; Grigarick, 1993) and Japan in the 1970s (Iwata, 1976; Zhu et al., 2005), following by the Korean Peninsular, Taiwan and mainland China (Yang et al., 2009). The spread of RWW was so fast being parthenogenetical reproduction, and it could spread 30 km each year (Jiao et al., 2011). In recent years, with the rapid development of economy and international trade and commerce between China and Association of Southeast Asian Nations, the spread paths and opportunity of RWW became more and more, as well the opportunity and possibility of invasion in Guangxi.

### 3.2 Possibility of colonization and spread

RWW has many characteristics, such as reproducing parthenogenesis, strong stress resistance and widely host. It also has following peculiarity as migration flight, phototaxis, cybotaxis, huddle, tending towards young and feigndeath. In Guangxi, there are abundant plant resources, agroecological environment diversity, advantageous geographical and weather conditions that are well fit for growth and reproduction of RWW. Therefore, RWW could reproduce and spread quickly through finding fitted space and residence once invading to Guangxi.

RWW has widely host. It reported that RWW adults feed 10 families 64 species plants, especially liking rice, grass family and cyperaceae weed; larva feed 5 families 15 species plants, the larva bite host root and cause death of host plant. Food crop such as rice, corn and sorghum were affected severely (Yu et al., 2006).

RWW has strong stress resistance and widely physiological and ecological adaptability, especially for strong heat-resistant and cold-resistant. RWW can exist and overwinter from Hainan of north latitude 18 ° to Heilongjiang of north latitude 50 °. It has stronger viability and can endure hunger above one month. RWW can overwinter in many conditions for example cropland ditch, forest belt, paddy field, thick growth of grass and wasteland. Its survival rate is very higher after overwintering. The survival rate reaches 100% in irrigation canals and ditches that take shelter from the wind and sunny, 91.6% in wild grass ground, 71.0% in cropland ditch. Rice variety influences the selectivity of RWW to rice, and the population quantity of RWW is different in different rice varieties. However, it was reported that there was no resistant variety to RWW (Lu et al., 2002). It also reported that no any natural enemy of RWW was found.

Furthermore, the migratory flight ability of RWW is very stronger, its flight distance reaches 4-6 km at a time (Zou, 1989), which can be propagated through sea, land and sky. Flight, crawl and swimming are the major ways at short range of RWW, at the same time, it can spread in the help of wind power and running water, for example, adult RWW can migrate 10 km with the aid of airflow. The anthropochory through rice, haulm, packing material and means of conveyance was the major way of RWW spreading from a great distance (Lin, 2008).

## 4 Control suggestion

The results showed that Guangxi is the most optimum potential area to RWW, it will colonize and diffuse if no prevention measures is taken. Therefore, invasive precaution measures must be recommended as follows.

### 4.1 Early warning mechanism of RWW should be established and strengthened

Many cities and counties of Guangxi, which are neighbor to Yunan, Guizhou and Hunan provinces, should set up perennial monitoring point, strengthen general survey and quarantine. Early warning mechanism of RWW should be established to strengthen early warning and monitoring. On account of many neighbor provinces of Guangxi have been found this insect, Guangxi should built inspection and quarantine cooperative mechanism with inspection and quarantine institutions of neighbor provinces to cut off epidemic from source for preventing invasion of RWW.

### 4.2 Strengthening epidemic situation advertising and preventing technical training

To reinforce the epidemic situation advertising of RWW, enhancing the training of basic level quarantine officer and improving professional skill are necessary for preventing RWW diffusion. The farmers should enhance own precaution awareness to prevent RWW through propagandizing, the farmers and merchants should avoid to purchase rice seed and other rice products privately in order to interdict epidemic situation spreading from insect source (Zhu et al., 2013).

### 4.3 Enhancing plant quarantine, preventing anthropochory and setting up block band

The inspection and quarantine laws and regulations should be established to eradicate completely man-made spreading RWW. The quarantine of straw and rice seed coming from epidemic area should be strengthened, and the transport machine and other filling materials should be steamed and disinfected timely.

The vital communication line such as highway, railway and waterway from Yunnan, Guizhou and Hunan to Guangxi must be set up block band, for example planting non-host plant (Xu et al., 2013;

He et al., 2013), setting up black light lamp to intercept and trap and kill RWW, which could prevent RWW to invade Guangxi.

## 4 Conclusion

It is concluded that Guangxi is faced with hazard of RWW invasion. Guangxi must be on the alert and strengthen inspection and quarantine of *L. oryzophilus*, and should cut off epidemic situation from source in order to prevent *L. oryzophilus* to invade Guangxi.

**Reference:**


Anderson R P, Lew D, Peterson A T. 2003. Evaluating predictive models of species' distributions: criteria for selecting optimal models[J]. Ecological Modelling, 162(3): 211-232.

Chen C L, Zhang J L, Zhang X Y, Chen X Y. 2001. *Lissorhoptrus oryzophilus* Kuschel was found in Beijing[J]. Plant Quarantine, 15(6):343.

Chen H, Chen Z M, Zhou Y S. 2005. Rice water weevil (Coleoptera: Curculionidae) in mainland China: invasion, spread and control[J]. Crop Protection, 24(8):695-702.

Gong W R, Du Y Z, Dai L, Cai Z, Diao C Y. 2007. Study on the suitable establishment area of rice water weevil, *Lissorhoptrus oryzophilus* (Kuschel) in China[J]. Journal of Yangzhou University(Agricultural and Life Science Edition), 28(1):79-82.

Grigarick A A, Beards G W. 1965. Ovipositional habits of rice water weevil in California as related to a greenhouse evaluation of seed treatments[J]. Journal of Economic Entomology, 58(6): 1053-1056.

Grigarick A A. 1993. Study of the rice water weevil, past, present, and future in the United States with emphasis on California[M]//Hirai K. Establishment, Spread, and Management of the Rice Water Weevil and Migratory Rice Insect Pests in East Asia. Tsukuba, Japan: NARC.

Guo W C, Tuerxun, Li J, Wei Z X, Wu J, Aliya, WANG J. 2011. The first discovery of significant invasive pest of paddy *Lissorbqptrus oryzqphilus*(Kuschel) in Xinjiang[J]. Xinjiang Agricultural Sciences, 48(1):70-74.

He Y F, Liao G H, Jin J X, Cheng Y, Zhang Z M, Yuan J, Chen X J, Jiang Z C, Hu J. 2013. Spatial distribution type of *Lissorhoptrus oryzophilus* larva on rice roots[J]. Southwest China Journal of Agricultural Sciences, 26(3):1006-1009.

Iwata T. 1976. Occurrence of the American rice water weevil in Japan[J]. International Rice Research Newsletter, 1: 2-17.

Jiao X D, Shui G Y, Zhang Y, Zhang Q F, Liu X H. 2011. Risk analysis on rice water weevil going north invading other rice producing areas of Heilongjiang province[J]. Plant Quarantine, 25(4):51-53.

Lange W H, Grigarick A A. 1959. Rice water weevil: beetle pest in rice growing areas of southern states discovered in California[J]. California Agriculture, (13): 10-11.

Li Z Q, Yu F Q, Tian C H, Sun F Y, Li W L. 2006. Genetic variability and its importance of rice water weevil (*Lissorhoptrus oryzophilus*) from different areas in Liaoning Province[J]. Liaoning Agricultural Sciences, (1):1-3.

Lin X Z. 2008. Risk and control of *Lissorhoptrus oryzophilus* Kuschel in Hainan[J]. Bulletin of Agricultural Science and Technology, (4):36-37.

Lu X J, Fang Y J, Xia W Q. 2002. Seasonal fluctuation of *Lissorhoptrus oryzophilus* in paddy fields in Southern Zhejiang province[J]. Wuyi Science Journal, 18(4):302-305.

Qi G J, Gao Y, Huang D C, Lv L H. 2012. Historical invasion, expansion process and the potential geographic distributions for the rice water weevil, *Lissorhoptrus oryzophilus* in China based on MAXENT[J]. Acta Phytophylacica Sinica, 39(2):129-126.

Qiu L M, Wei H, Fu J W, Wu W, Li J Y, Zhang Z X. 2007. Distribution and occurrence of rice water weevils in Fujian[J]. Fujian Journal of Agricultural Sciences, 22(2): 172-175.

Stockwell D R B, Peters D P. 1999. The GARP modeling system: problem and solutions to automated spatial prediction [J]. International Journal of Geographic Information Systems, 13(2): 143-158.

Wang J W, Liu D H. 1997. Potential geographic distributions and quarantine for the rice water weevil, *Lissorhoptrus oryzophilus*[J]. Plant Quarantine, 11(S):38-40.

Wang S W, Wang S L. 2010. Occur and comprehensive control of *Lissorhoptrus oryzophilus* Kuschel[J]. Jilin Agriculture, 247(2):68-69.

Wei W, Yang D X, Peng B F, Yang M F, Liao Q R, Yang H, Chen W L. 2011. Preliminary investigation and analysis on Hibernate habitat of *Lissorhoptrus oryzophilus*in in Guizhou[J]. Guizhou Agricultural Sciences, 39(6):90-93.

Xiao S Y, Chen X X, Ma J. 2008. Current situation and control of invasive species on Hunan[J]. Environmental Sanitary Engineering, 16(5):18-20.

Xiang Z J, Yang Y Z, He T. 2010. Occurrence and damage law, and control strategies of *Lissorhoptrus oryzophilus* Kuschel in Fangcounty of Hubei[J]. Hubei Plant Protection, 117(1):14-15.

Xu J, Yang M F, Shi P Q, Yang D X, Shang X L, Zou X. 2013. Effect of Beauveria bassiana YS03 on the rice water weevil adults in feeding[J]. Guangdong Agricultural Sciences, (20):73-76.

Yang P, Zhou W W, Zhang Q, Cheng J A, Zhu Z R, Way M O. 2009. Differential gene expression profiling in the developed ovaries between the parthenogenetic and bisexual female rice water weevils, *Lissorhoptrus oryzophilus* Kuschel (Coleoptera: Curculionidae)[J]. Chinese Science Bulletin, 54(20): 3822-3829.

Yang S X, Yang H, Zhang J C, Wu J L, Wang H. 2014. Population occurrence of rice water weevil (*Lissorhoptrus oryzophilus* Kuschel) in Shanxi[J]. Acta Agriculturae Boreali-Occidentalis Sinica, 23(1):108-112.

Yu S W, Yang C D, Li X M. 2006. Occurrence of *Lissorhoptrus oryzophilus*in and its research progress[J]. China Rice, (6):10-12.

Zhang F, Xu G P, Song J H. 2014. Population dynamics analysis of rice water weevil in double rice regions in Poyang Lake Plain of Jiangxi Province[J]. Acta Agriculturae Universitatis Jiangxiensis, 36(1):84-90.

Zhao L, Lin Y B. 2008. Occurrence and comprehensive control of *Lissorhoptrus oryzophilus* Kuschel in Zhejiang province [J]. China Rice, (6):70-71.

Zhu Z L, Wang D S, Hu G C, Yang J X, Cao S H. 2013. Occur damage characteristics and comprehensive control of *Lissorhoptrus oryzophilus*[J]. Hubei Plant Protection, 139(5):43, 48.

Zhu Z R, Shang H W, Jiang M X. 2005. The rice water weevil[M]//Wan F H, Zheng X B, Guo J Y. Biology and Management of Invasive Alien Species in Agriculture and Forestry. Beijing: Science Press.

Zou Q. 1989. *Echinocnemus squameus* and *Lissorhoptrus oryzophilus*[J]. Plant Protection, (1):50-51.


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