On the way: methods for quantitative risk assessment in China

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The 11th Meeting of the International Pest Risk Research Group
Aug. 29 – Sep. 1, 2017, Ottawa, Canada

Outline

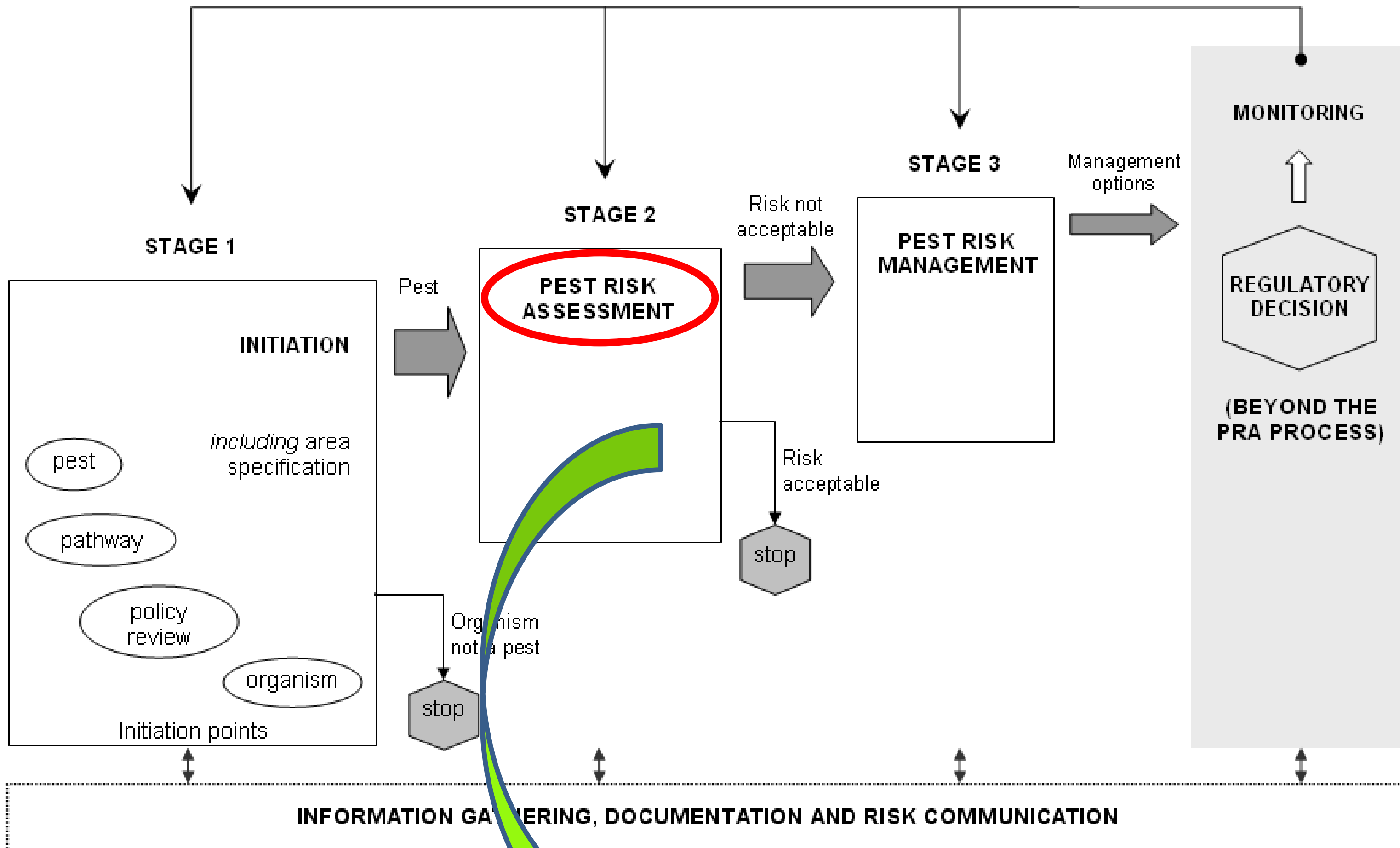
- The main methods for quantitative risk assessment in past four decades in China
- The recent practices of quantitative risk assessment on economically important fruit flies in China Agricultural University (CAU)
- Challenges, opportunities and prospects of PRA in China

中国農業大學
China Agricultural University

Ⅰ. The main methods for quantitative risk assessment in past four decades in China

APPENDIX 1

PEST RISK ANALYSIS FLOW CHART[7]



Qualitative assessment

Quantitative assessment

- **Over the past four decades, China has embraced the challenge to develop and integrate advanced Pest Risk Analysis methods, and to apply them systematically.**

- **The greatest attention has been paid to developing quantitative risk assessment methods including potential geographical distribution, potential loss and invasion risk.**

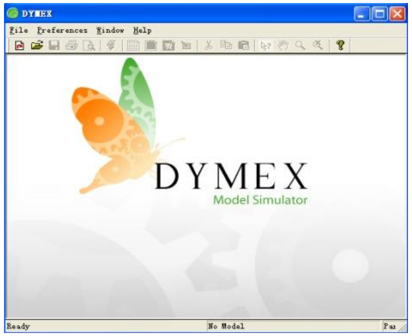
Potential Geographical Distribution

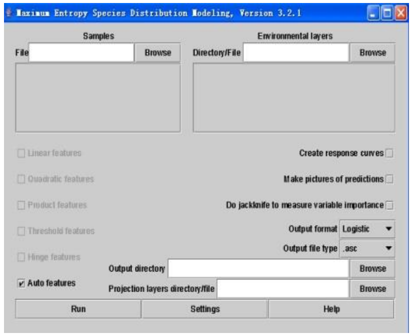
- **Three methods have mostly been practiced for estimating the PGD.**

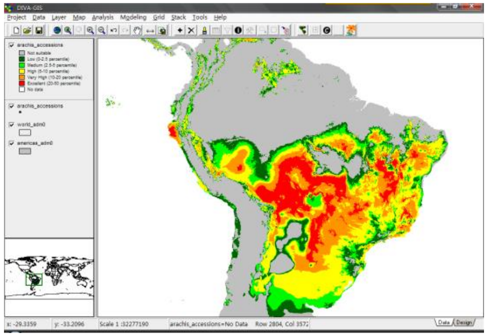
✓ The Bio-Climatic Analog Distance Database was established in the 1980s and was applied mostly from 1988 into the 1990s.

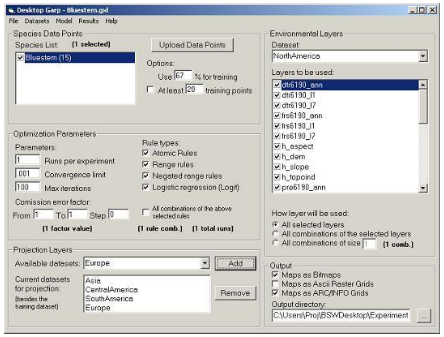
✓ The 'Bio-Model+GIS' was applied from 1994, mostly based on biological experiments.

✓ Models such as CLIMEX, Maxent, DIVA-GIS and GARP were introduced into China from the 1990s, with CLIMEX and Maxent the more popular in the last 10 years.









- The Bio-Climatic Analog Distance Database was established by Beijing Agricultural University (BAU, former one of CAU) in 1984.
  - ✓ It included 10 analog distances of 700 locations in China and 500 locations in the world.
  - ✓ It could be used especially for the prediction of variety introduction and pests distribution.

《农业气候相似距库》简介

我国幅员辽阔，地形复杂，农业气候资源十分丰富多样，但目前开发、利用程度相差甚远。如何进一步开发、利用，在不断增加很多投资情况下，获得品质优良的高额农畜产品，充分发掘每一个地方的农业生产潜力，这是众目所望的事。要能达到这样的目的，方法、途径很多，但其中，对农业气候相似的研究，研究中国各地之间，中国各地与世界各地之间的农业气候相似情况，取人之长，补己之短，用来发展自己国家和本地区的农业，是非常重要的。

相似距离计算内容如下：

1.本地与国内外平均气温的相似距（1——12月）
2.本地与国内外降水量的相似距（1——12月）
3.本地与国内外日照时数的相似距（1——12月）
4.本地与国内外蒸散量的相似距（1——12月）
5.本地与国内外平均气温与降水量的相似距（1——12月）
6.本地与国内外平均气温、日照时数与降水量的相似距（1——12月）
7.本地与国内外平均气温、降水、蒸散量的相似距（1——2月）
8.冬作物生长时期（头年9月——翌年6月上旬）有关因素的相似距。
9.春作物生长时期（4——10月上旬）有关因素的相似距。
10.中国长江以南各地与南半球各点的有关因素滑移相似距。

以上内容的相似距将逐项按省分别编辑成册，并附使用说明，方法简便易于掌握。

全国按二十六个省及自治区编辑成册，北京、上海、天津将列入地理所在的省份内，台湾省与福建省编入一个分册中。共二十六个分册，每册收成本费20元。如订购有关分册，可与北京农业大学农业资源环境及遥感研究所农业气候资源研究室联系。

（魏淑秋）

Wei Shuqiu. The introduction of Bio-Climatic Analog Distance Database. Acta Agriculturae Universitatis Pekinensis, 1984, 4:427-428.

利用气候相似距研究美国白蛾在我国的地理分布

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(北京农业大学)　(农业部植物检疫实验所)

研究危险性有害生物地理分布规律，明确它们在世界上和我国内的适生地区，是植物检疫工作的重要基础。利用我校建立的气候相似距库，可以为此研究提供一种快速可靠的方法。笔者根据美国白蛾 *Hyphantria cunea* 对温度和光周期的生态标准，应用气候相似距，在长城 0520 微机上进行计算，得出初步结果如下。

1、美国白蛾在我国的可能生存区，大体上分布于 26°～50°N、39°～132°E 范围内，包括 25 省（市、区）283 县（市、区）。

2、美国白蛾可以定居的地区（即 1～3 级生存区），大体分布于 27°～46°N、75°～129°E 范围内，包括 24 省（市、区）201 县（市、区）。

3、美国白蛾可以严重发生危害的地区（即 1～2 级生存区），大体上分布于 27°～45°N、75°～122°E 范围内，包括 19 省（市、区）114 县（市、区）。其中主要分布于 30°～40°N、100°～125°E 范围内，主要包括山东（几乎全省）、河南（几乎全省）、陕西（陕中和陕南）、河北（冀中和冀南）、北京、天津、山西（晋中和晋南）、江苏（苏北和苏中）、辽宁（辽南）、安徽（皖北）、甘肃（陇中和陇南）、宁夏（宁西）和湖北（鄂西北和西南）诸省（市）。这些地区应该特别警惕美国白蛾的侵入危害。

4、美国白蛾在我国的垂直分布范围，其全部可能生存区（即 1～4 级生存区）分布于海拔 2～2589M，平均海拔高度为 685.2M。其中 1～2 级生存区平均海拔 487.7M；3 级生存区平均海拔 845M；4 级生存区平均海拔 790.2M。说明 1～2 级生存区平均海拔高度低于总平均海拔高度，而 3～4 级生存区平均海拔高度高于总平均海拔高度。

植物保护　2014，40(1)：122-124　　Plant Protection

研　究　简　报
Research Notes

地中海白蜗牛在中国的潜在适生区预测

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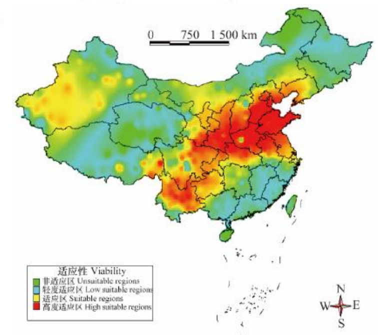
3. 海南出入境检验检疫局，海口　570311）

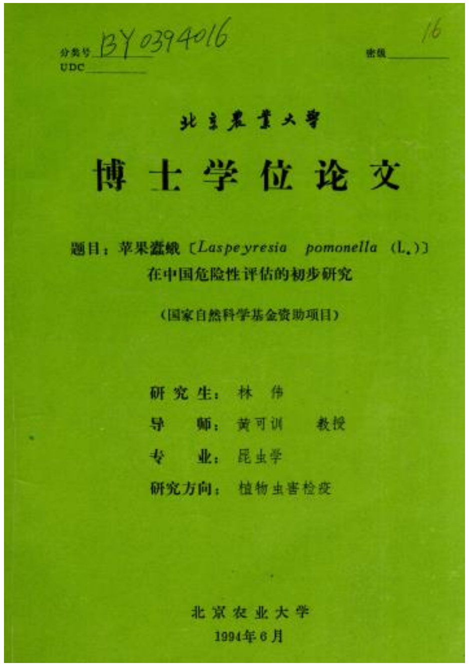
摘要　地中海白蜗牛[*Cernuella virgata* (Da Costa, 1778)]是中国 2012 年新增的检疫性有害生物，在中国没有分布。根据中国 670 个基准气象站点 30 年的气象数据，应用生物气候相似距方法，对地中海白蜗牛在中国的潜在适生区进行了预测。结果表明，该蜗牛在中国的适生性可区划为高度适生区、适生区、轻度适生区和非适生区，其中高度适生区和适生区面积约占全国的 45%，中国黄河流域、长江流域和西南地区为地中海白蜗牛的高度适生区，是防御该蜗牛入侵的重点地区。



- The above database was applied to evaluate the potential geographical distribution of *Hyphantria cunea*, with collaboration between BAU and Plant Quarantine Institute of MOA (Jin et al.. 1988)

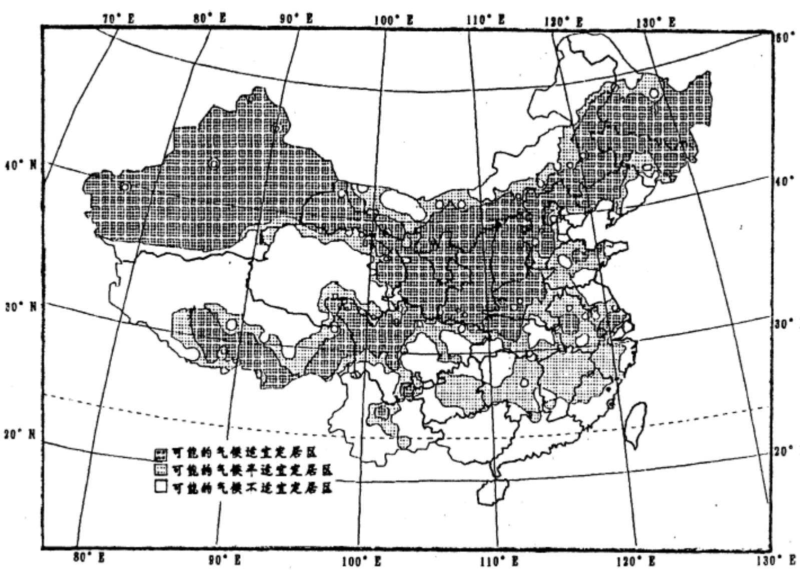
- The database was applied to evaluate the potential geographical distribution of *Cernuella virgata*, with collaboration between the Technical Centers of Fujian CIQ and Hainan CIQ (Zhou et al.. 2014)

- The **'Bio-Model+GIS'** was applied to evaluate the potential geographical distribution of ***Cydia pomonella*** in China by BAU (Lin, dissertation, 1994).

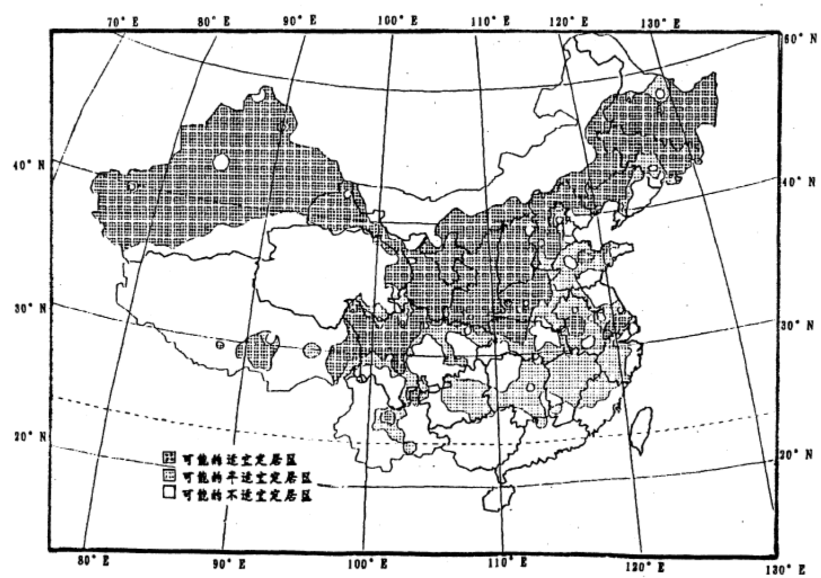


Ph. D. DISSERTATION

THE RISK ANALYSIS OF CODLING MOTH, *LASPEYRESIA POMONELLA* (L.) 〔LEPIDOPTERA: TORTRICIDAE〕, IN CHINA



Based on the main climate factors, including temperature and rainfall.



Based on the main climate factors and hosts distribution.

苜蓿黄萎病菌在我国的适生性分析研究

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摘要 本文以适生性评判指标分析为基础，采用生物学建模与 GIS 分析相结合的方法，依据我国 677 个气象站点的逐月气温数据以及全国土壤 pH 等值线图，对苜蓿黄萎病菌在我国的适生性作了分析研究。结果表明，苜蓿黄萎病菌在我国的适生性强，适生范围较广，每年 4～9 月份，该病菌在我国西北、东北以及华北地区的适生程度处于较高水平。鉴于此，我国应加强苜蓿黄萎病菌的植物检疫措施力度，严防该病的传入或扩散。

关键词 苜蓿黄萎病菌； 适生性分析； 地理信息系统
中图分类号 S 435.4

Analysis of the suitability of *Verticillium albo-atrum* in China

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(1. *College of Agronomy and Biotechnology, China Agricultural University, Beijing* 100094, *China*;
2. *Xinjiang Entry-Exit Inspection and Quarantine Bureau, Urumqi* 830063, *China*)

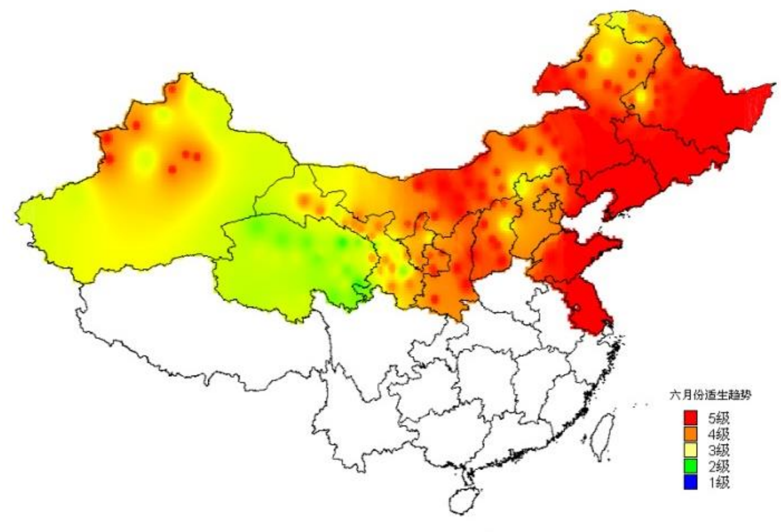
X:温度(℃)；Y:pH；Z:菌落生长量(g)(适生程度参数)。

当 $2 < X < 29 \cap 3.0 \leqslant Y \leqslant 12.5$ 时，$Z = 0.21X + 14.20Y - 1.69Y^2 + 0.06Y^3 - 31.88$。

复测定系数：$R^2 = 0.89$。显著性检验：$F_{0.05} = 222.31$，显著值 $p = 3.97E-53 < 0.05$，即在 95 %的置信区间内，显著值 p 小于 0.05 显著水平。

当 $(X \leqslant 2 \cup X \geqslant 29) \cup (Y > 12.5 \cup Y < 3.0)$ 时，$Z = 0$。

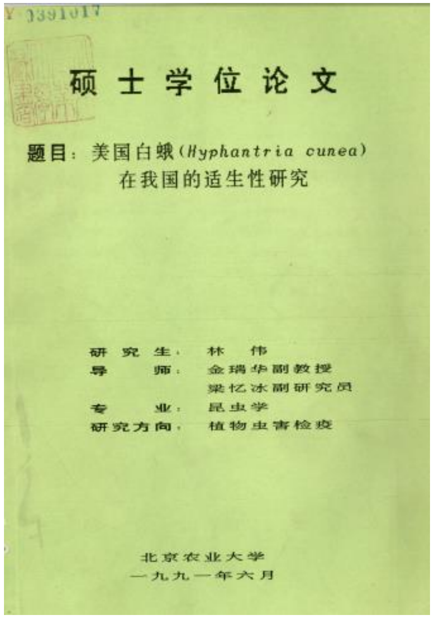
- The 'Bio-Model+GIS' was applied to evaluate the potential geographical distribution of *Verticillium albo-atrum* in China, with collaboration between the CAU and Xinjiang CIQ (Shao et al., 2006).



The potential distribution in June, which based on the temperature, PH of soil and host distribution.

- The **CLIMEX** and **GIS** was applied to predict the potential geographical distribution of ***Hyphantria cunea*** in China by BAU (Lin, thesis, 1991).

The Assessment of Potential Establishment of the Fall Webworm, Hyphantria cunea Drury, in China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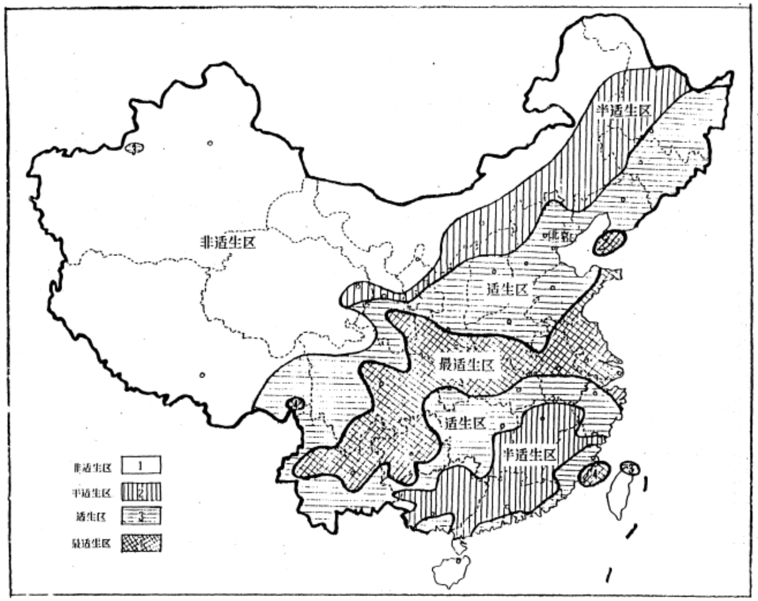
硕士学位论文

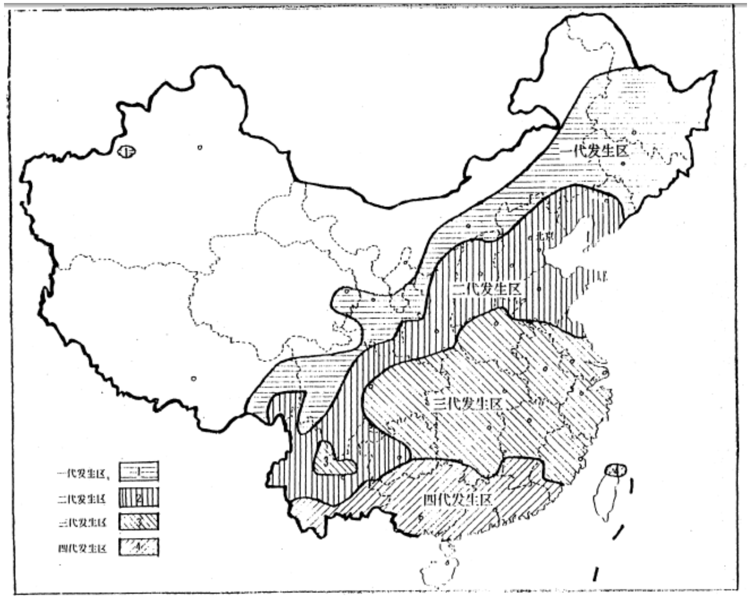
题目：美国白蛾(*Hyphantria cunea*)
在我国的适生性研究

研究生：林伟
导师：金瑞华副教授
梁忆冰副研究员
专业：昆虫学
研究方向：植物虫害检疫

北京农业大学
一九九一年六月



Based on EI values for 3-level regions.



Based on PDD for 1 to 4 generations.

Insect Science

Insect Science (2011) 18, 575–582, DOI 10.1111/j.1744-7917.2010.01402.x

ORIGINAL ARTICLE

Potential geographical distribution of *Rhagoletis pomonella* (Diptera: Tephritidae) in China

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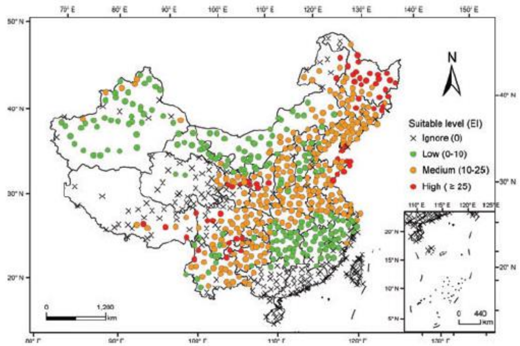

Fig. 2 The Ecoclimatic Index (EI) values distribution of meteorological stations in China. Predicted distributions estimated by CLIMEX EI are based on the parameters shown in Table 1 with the addition of 2.5 mm of irrigation per day. [GS(2010)1356]

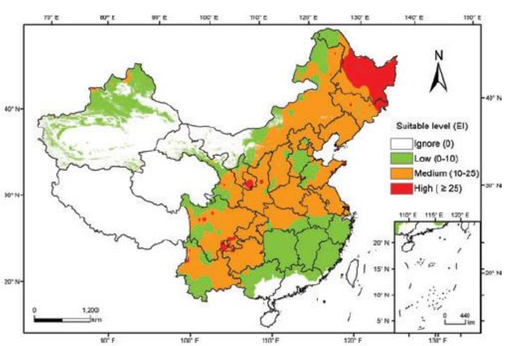

Fig. 3 The potential geographical distribution of apple maggot fly in China. Predicted distribution excludes areas without hosts or with inhospitable terrain estimated by CLIMEX Ecoclimatic Index (EI) based on the parameters shown in Table 1 with the addition of 2.5 mm of irrigation per day. [GS(2010)1356]

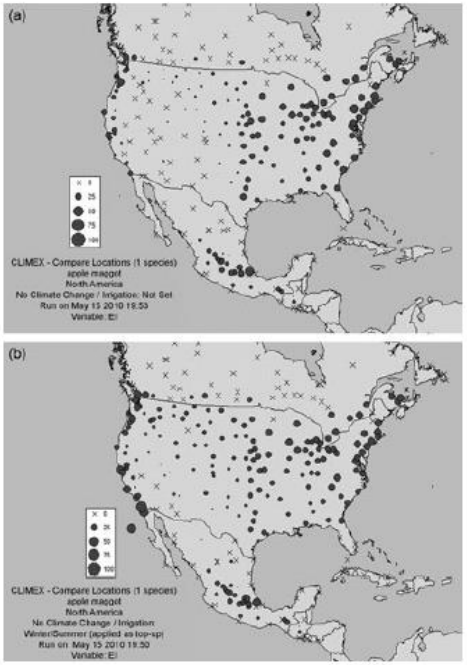

Fig. 1 The predicted geographical distribution of apple maggot fly in North America. (a) Predicted distribution estimated by CLIMEX based on parameters shown in Table 1. (b) Predicted distribution estimated by CLIMEX with 2.5 mm of irrigation per day included.

Table 1 CLIMEX parameter values giving the best fit to the present distribution of apple maggot fly.

Parameter description	Value
Moisture parameters	
Lower threshold of soil moisture (SM0)	0.2
Lower limit of optimal range of soil moisture (SM1)	0.6
Upper limit of optimal range of soil moisture (SM2)	1
Upper threshold of soil moisture (SM3)	1.5
Temperature parameters	
Lower threshold of temperature for population growth (DV0)	8.3°C
Lower optimal temperature for population growth (DV1)	15°C
Upper optimal temperature for population growth (DV2)	25°C
Upper threshold temperature for population growth (DV3)	31°C
Degree-days to complete one generation (PDD)	1 065
Diapause parameters (for winter diapause)	
Weekly day length that induces diapause (DPD0)	12.1
Weekly minimum temperature that induces diapause (DPT0)	20°C
Weekly minimum temperature that terminates diapause (DPT1)	5°C
The minimum number of days required for diapause development to be complete (DPD)	83
Cold stress (not used)	
Heat stress	
Threshold of heat stress (TTHS)	33°C
Weekly rate of accumulation of heat stress (THHS)	0.000 5
Dry stress	
Threshold of dry stress (SMDS)	0.2
Weekly rate of accumulation of dry stress (HDS)	−0.001
Wet stress	
Threshold of wet stress (SMWS)	1.5
Weekly rate of accumulation of wet stress (HWS)	0.02

Acknowledgments

The authors would like to thank Dr. Robert W. Sutherst, one of the inventors of CLIMEX, for his kindly guidance and advice on this research. We also thank Dr. Bruce

(Geng et al, 2011)

中国科学院研究生院
博士学位论文

我国严重威胁性外来入侵植物入侵与扩散历史过程重建及其潜在分布区的预测

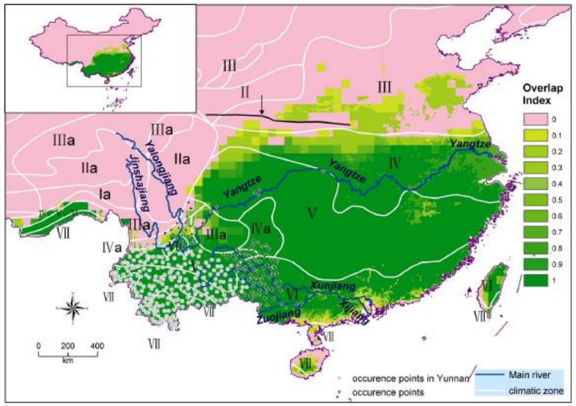

图 5 生态位模型预测紫茎泽兰在我国适生区图

中国农业科学 2007,40(11):2502-2506
Scientia Agricultura Sinica

相似穿孔线虫在中国的适生区预测

王运生[1,2]，谢丙炎[1]，万方浩[3]，肖启明[2]，戴良英[2]

([1]中国农业科学院蔬菜花卉研究所，北京 100081；[2]湖南农业大学生物安全科学技术学院，长沙 410128；[3]中国农业科学院植物保护研究所，北京 100081)

摘要：【目的】相似穿孔线虫（*Radopholus similis*）是中国一类检疫对象，随着国际贸易日益加剧，该线虫传入中国的风险也日益加大，急需对其适生性进行分析。【方法】利用已广泛用于物种潜在分布预测的 GARP 与 MAXENT 两种生态位模型预测相似穿孔线虫在中国的适生区，并对预测结果进行了阈值依赖和非阈值依赖比较。【结果】两个模型均能较好地预测相似穿孔线虫的潜在地理分布；预测在中国适生区主要分布在南方各省，包括海南、广东、福建、云南、台湾等省区；经检验 MAXENT 预测结果较 GARP 好。【结论】相似穿孔线虫可随花卉苗木的国际运输传入中国，并可在中国南方沿海地区及花卉进出口大省云南省等地区发生；上述地区的进出口口岸应加强对相似穿孔线虫的检疫工作。

关键词：相似穿孔线虫；生态位模型；GARP；MAXENT；适生区

Potential Geographic Distribution of *Radopholus similis* in China

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(*[1]Institute of Vegetables and Flowers, CAAS, Beijing 100081; [2]College of Bio-safety Science and Technology, Hunan Agricultural University, Changsha 410128; [3]Institute of Plant Protection, CAAS, Beijing 100081*)

- **The GARP were applied to assess the potential geographical distribution of *Ageratina adenophora* in China by Chinese Academy of Sciences (CAS) (Wang, dissertation, 2006).**
- **The MAXENT and GARP were applied to assess the potential geographical distribution of *Radopholus similis* in China by Chinese Academy of Agricultural Sciences (CAAS) etc. (Wang et al., 2007).**

SCIENTIFIC REPORTS

OPEN

Impact of climate and host availability on future distribution of Colorado potato beetle

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Accepted: 17 May 2017
Published online: 03 July 2017

Cong Wang[1,2], David Hawthorne[3], Yujia Qin[1], Xubin Pan[2], Zhihong Li[1] & Shuifang Zhu[2]

Colorado Potato Beetle (CPB) is a devastating invasive pest of potato both in its native North America and now across Eurasia. It also damages eggplant, tomato and feeds on several wild species in the

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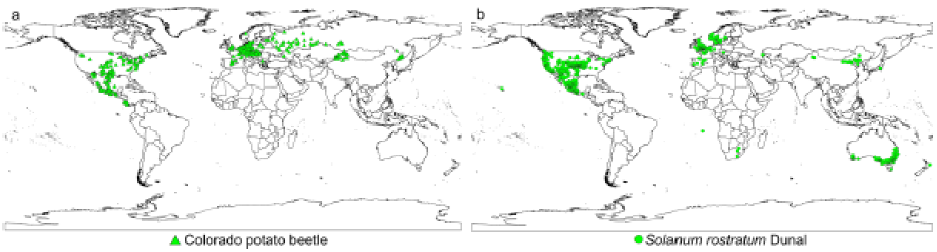

Figure 1. Global distribution data used to build and evaluate the MaxEnt models of two species. (a) 670 global distribution points of Colorado potato beetle (CPB); (b) 1090 global distribution points of *S. rostratum* Dunal (SR). Both maps are generated by using the tool of ArcGIS 10.2.2 (ESRI, Redlands, CA, USA, http://www.esri.com/).

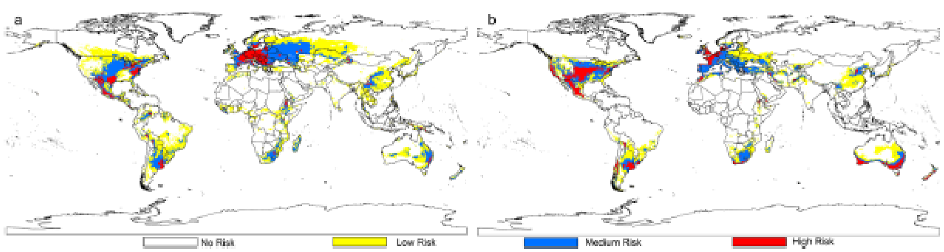

Figure 2. Potential global distribution maps for Colorado potato beetle (CPB) and *S. rostratum* Dunal (SR), which were produced by MaxEnt (v3.3.3k, http://biodiversityinformatics.amnh.org/open_source/maxent/) under current climate conditions. (**a**) Habitat suitability of CPB; (**b**) habitat suitability of SR. White color represents no risk areas, yellow color represents low risk areas, blue color represents medium risk areas and red color represents the high risk areas. The whole maps are generated by using the tool of ArcGIS 10.2.2(ESRI, Redlands, CA, USA, http://www.esri.com/).

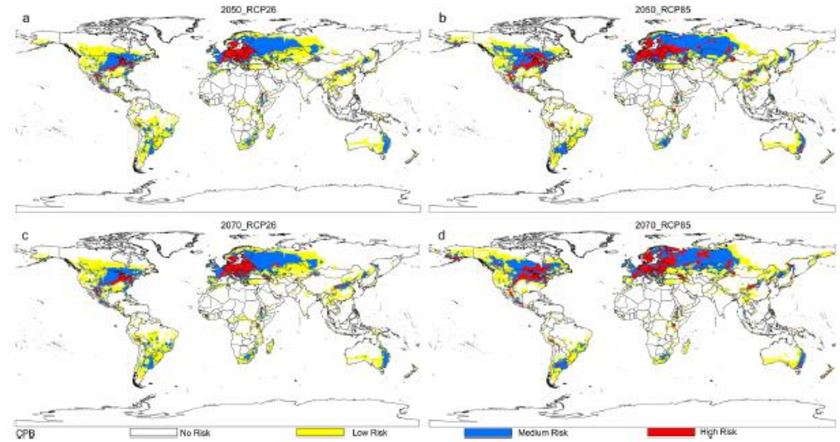

Figure 3. Potential global distribution maps for Colorado potato beetle under future climate conditions, which were produced by MaxEnt (v3.3.3k, http://biodiversityinformatics.amnh.org/open_source/maxent/). (**a**) Mean predicted result for four global climate models (GCMS): IPSL-CM5A-LR (IP), NorESM1-M (NO), HadGEM2-ES (HE) and MIROC-ESM-CHEM (MI), which was modeled under 2050-RCP26; (**b**) mean predicted result for four GCMS, which was modeled under 2050-RCP85; (**c**) mean predicted result for four GCMS, which was modeled under 2070-RCP26; (**d**) mean predicted result for four GCMS, which was modeled under 2070-RCP85. White color represents no risk areas, yellow color represents low risk areas, blue color represents medium risk areas and red color represents the high risk areas. The whole maps are generated by using the tool of ArcGIS 10.2.2(ESRI, Redlands, CA, USA, http://www.esri.com/).

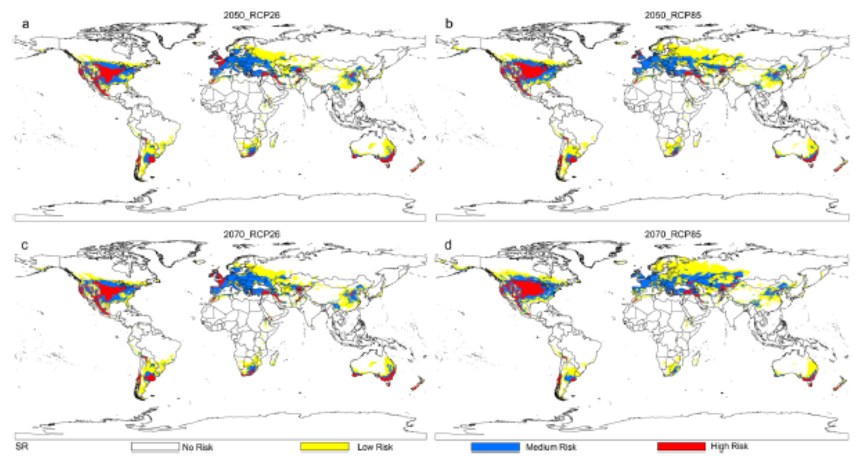

Figure 4. Potential global distribution maps for *S. rostratum* Dunal under future climate conditions, which were produced by MaxEnt (v3.3.3k, http://biodiversityinformatics.amnh.org/open_source/maxent/). (**a**) Mean predicted result for four global climate models (GCMS): IPSL-CM5A-LR (IP), NorESM1-M (NO), HadGEM2-ES (HE) and MIROC-ESM-CHEM (MI), which was modeled under 2050-RCP26; (**b**) mean predicted result for four GCMS, which was modeled under 2050-RCP85; (**c**) mean predicted result for four GCMS, which was modeled under 2070-RCP26; (**d**) mean predicted result for four GCMS, which was modeled under 2070-RCP85. White color represents no risk areas, yellow color represents low risk areas, blue color represents medium risk areas and red color represents the high risk areas. The whole maps are generated by using the tool of ArcGIS 10.2.2(ESRI, Redlands, CA, USA, http://www.esri.com/).

(Wang et al., 2017)

Potential Loss

- From the 2000's deterministic multi-index models were developed to estimate the potential impacts of representative pests of agriculture and forestry.
- Subsequently, stochastic models of potential loss based on @RISK model were developed.

中国森林病虫 2004年1月 第23卷 第1期 · 1 ·

森林病虫害灾害经济损失评估指标体系的研究

赵 杰，苏宏钧，

（国家林业局森林

摘要：文章从森林病虫害灾害的自然属
立进行了探索。在分析森林生态系统所
损失评估的指标体系。

关键词：自然灾害；森林病虫害；经济
中图分类号：S763 文献标识码：A

Evaluation system of the economic losses
of Forest Pest Management, State Forest

Abstract: Based on the natural proper
economic losses of forest pest disasters wa
forestry ecological system, the index sys
was determined.

Key words: natural disaster; forest pest

中国森林病虫 2004年5月 第23卷 第3期 · 1 ·

森林病虫灾害经济损失评估的原则和理论基础

苏宏钧，尤德康，常国彬，赵

（国家林业局森林病虫害防治总站，辽

摘要：文章阐述了森林病虫灾害经济损失评估的意义，提
则，以持续发展理论、森林多功能理论、森林生态资源核
评价的理论基础分析了森林病虫灾害经济损失的基本内

关键词：森林病虫害；经济损失；评估；理论
中图分类号：S763 文献标识码：A 文章编号：1671－0

Principle and theoretical basis of economic loss assessme
al. (General Station of Forest Pest Management, State Fo
China)

Abstract: Based on the theories of sustainable development,
culation, forest value and woodland asset value-potency an
basis of economic loss assessment of forest pest disasters w
ment was dealt with.

Key words: forest pest; economic loss; assessment; theory

中国森林病虫 2004年7月 第23卷 第4期 · 1 ·

森林病虫灾害经济损失计算方法研究

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（国家林业局森林病虫害防治总站，辽宁 沈阳 110034）

摘要：文章以科学态度及操作方法测算出全国11类树种平均林价，建立了森林病虫灾害直接经济损失计算式，提出某区域单位重量的生物量的生态效益可认为是一个相对稳定的值的观点，探讨了两种估算生态效益损失的方法。

关键词：森林病虫害；经济损失；估算
中图分类号：S763 文献标识码：A 文章编号：1671－0886(2004)04－0001－05

Estimate method for the economic losses of forest pest disasters/CHANG Gou-bin, et al. (General Station of Forest Pest Management, State Forestry Administration, Shenyang 110034, China)

Abstract: Based on the scientific attitude and operating method, the average forest-values of 11 groups of trees were calculated and the counting formulae for direct economic losses of forest pest disasters were founded. The viewpoint that the eco-benefit of unit weight biomass in some area was one relatively steady value was advanced, and two methods for estimating eco-benefit losses were discussed.

Key words: forest pest; economic loss; estimate

- The deterministic multi-index model was established in 2004 for economic loss of forestry pests based on 3-level index by State Forestry Administration (SFA) （Su et al., 2004; Chang et al., 2004; Zhao et al. 2004）.

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2007 年 3 月 JOURNAL OF BEIJING FORESTRY UNIVERSITY Mar., 2007

美国白蛾入侵损失评估指标体系的构建

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(1 国家林业局经济发展研究中心林业经济期刊社 2 北京林业大学经济管理学院)

摘要: 美国白蛾不仅破坏自然资源的物质量, 而且制约了寄主植物多种功能的充分发挥, 对人们的视觉、心理和日常生活等方面造成了损失. 以往的文献通过森林资源等实物变化来认识美国白蛾造成的危害, 忽视了社会和经济属性, 且危害程度的量化研究较少, 并未使社会各界充分认识到其危害与损失. 目前迫切需要科学定量评估美国白蛾入侵我国造成的损失, 客观反映美国白蛾造成的损失与人类、社会之间的关系. 该文遵循科学性、系统性与可比性等原则, 结合美国白蛾的自身特点, 在对美国白蛾入侵危害及损失进行系统研究的基础上, 首次系统构建了较为完善的美国白蛾损失评价指标体系. 共计 47 个指标, 其中包括 2 个一级指标, 9 个二级指标, 27 个三级指标, 并阐述了主要指标的内涵及其测度方法.

关键词: 美国白蛾, 损失, 评估指标体系
中图分类号: S763.42; F307.2 **文献标识码**: A **文章编号**: 1000-1522(2007)02-0156-05

ZHAO Tie-zhen[1]; GAO Lan[2]; KE Shui-fa[2]; WEN Ya-li[2]. **Establishment on the loss evaluation index system of *Hyphantria cunea* Drury's invading China**. *Journal of Beijing Forestry University* (2007) **29**(2) 156-160 [Ch, 9 ref.]

1 Editorial Office of Forestry Economics, China National Forestry Economics and Development Research Center, Beijing, 100102, P. R. China;
2 College of Economics and Management, Beijing Forestry University, 100083, P. R. China.

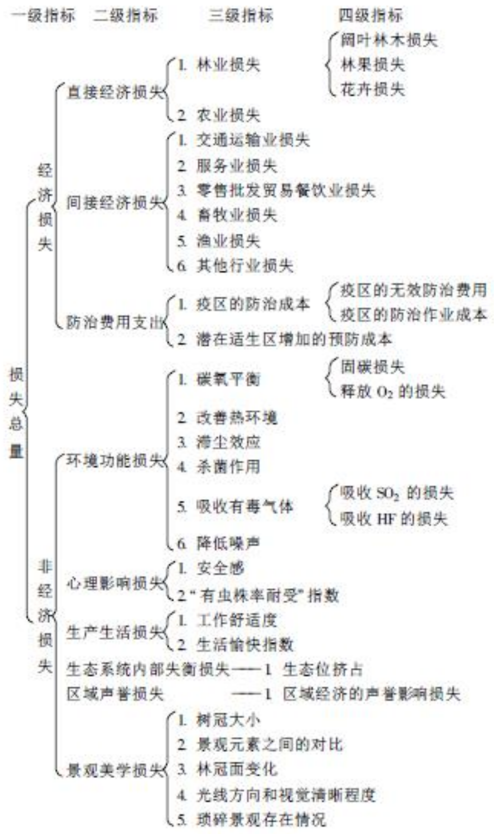


图 1 美国白蛾损失评估指标体系
FIGURE 1 Loss evaluation index system of *H. cunea*

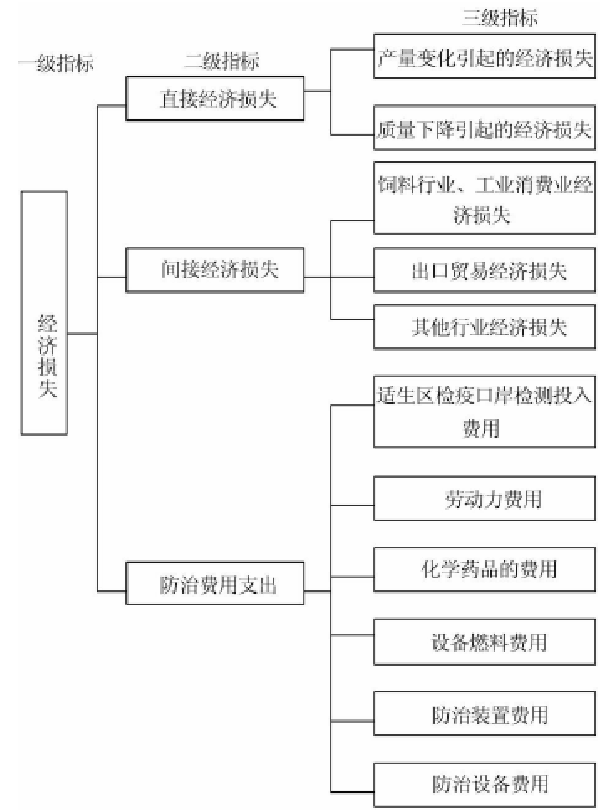
- The multi-index model was established in 2007 to evaluate the loss of *Hyphantria cunea* by SFA and Beijing Forestry University (BFU), including psychological impact loss and landscape aesthetics loss as the sub-index of noneconomic loss (Zhao et al., 2007)

2010年第 2期 植物检疫 PLANT QUARANTINE Vol 24 No 2

玉米褪绿斑驳病毒入侵损失指标体系及直接经济损失评估

饶玉燕[1] 尤 扬[1] 朱水芳[1*] 严 进[1] 黄冠胜[2] 魏国荣[3]
(1 中国检验检疫科学研究院, 北京 100029; 2 国家质量监督检验检疫总局 3 中国农业会计学会)

The potential geographical distribution of *Maize Chloroticmottle Virus* in China basing on CLIMEX



The 3-level multi-index model for economic loss of *Maize Chloroticmottle* Virus in China

- **The multi-index model was established in 2010 for evaluation of potential economic loss of *Maize Chlorotic Mottle Virus (MCMV)* by China Academy of Inspection and Quarantine (CAIQ) etc. based on prediction of potential geographical distribution (Rao et al., 2010).**

中国农业大学学报 2015,20(6):138-145
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http://xuebao.cau.edu.cn
DOI:10.11841/j.issn.1007-4333.2015.06.18

刺萼龙葵对中国玉米产业造成的潜在经济损失评估

吴志刚[1] 方 焱[2] 秦 萌[3] 秦誉嘉[4] 王 聪[4] 赵 谈[4] 李志红[4]

Potential economic loss assessment on maize industry of China caused by buffalobur (*Solanum rostratum*)

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2. Tianjin Entry-Exit Inspection and Quarantine Bureau, Tianjin 300461, China;
3. National Agro-technical Extension and Service Center, Beijing 100125, China;
4. College of Agriculture and Biotechnology, China Agricultural University, Beijing 100193, China)

Abstract In order to foresee and realize the risk of invasion of *Solanum rostratum*, We collected the relevant data published at national and international journals and by combining the @RISK software and the Monte Carlo stochastic simulation method, we built potential economic loss assessment model of the maize industry of China caused by buffalobur (*S. rostratum*) on direct economic losses and the cost of prevention and control. The results showed that the total economic loss was estimated to be 2.937 − 35.083 × 10^8 yuan, and the loss rat was estimated to be 0.83% −8.92%.

- **The stochastic model based on @RISK was developed in 2015 for evaluation of potential economic loss of *Solanum rostratum* to maize by CAU etc. (Wu et al., 2015).**

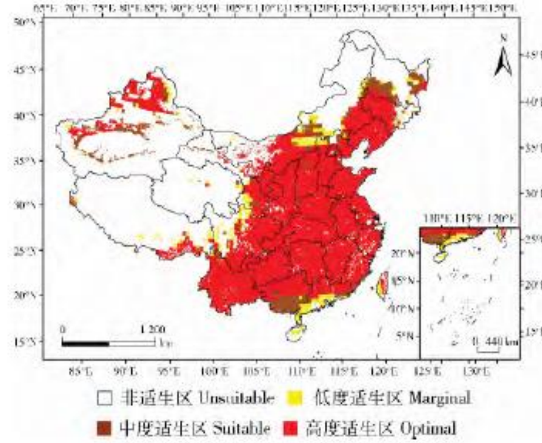
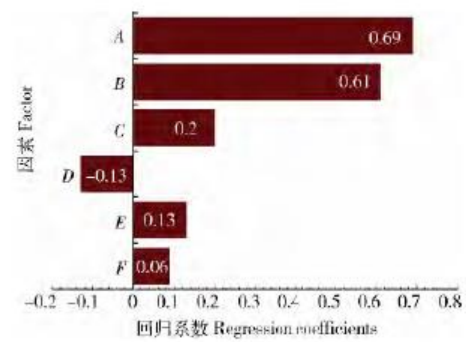


图 1 基于 GARP 的刺萼龙葵在中国的潜在适生区
Fig. 1 Potential distribution of *Solanum rostratum* on GARP



A,刺萼龙葵对玉米的感染率;B,受刺萼龙葵感染的玉米产量损失率;C,玉米的市场价格水平;D,品质下降的玉米价格水平;E,刺萼龙葵适生区内玉米年产量;F,单位玉米疫区防治成本。
A, Infection rate of *S. rostratum* to maize; B, Production loss rate after infection; C, Price level of maize; D, Price level of the quality declined maize; E, Annual output of maize in the suitable area of *S. rostratum*; F, Cost of prevention and control of unit area in the infected area.

图 2 刺萼龙葵对我国玉米产业造成的潜在经济损失评估灵敏性分析
Fig. 2 Sensitivity test of the potential economic impact of the maize industry caused by *Solanum rostratum*

Invasion Risk

- **The most popular method for estimating pest invasion risk in China is Multi-Index Integrated Assessment of Pests.**
  - ✓ PRA program from the end of 1980s.
  - ✓ It is a semi-quantitative method combining indices, standards and models.
  - ✓ It has become widely-used at national and provincial scales in China.
- **The 'Scenario models+@RISK' has been applied from 2000s.**

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有害生物危险性评价的定量分析方法研究

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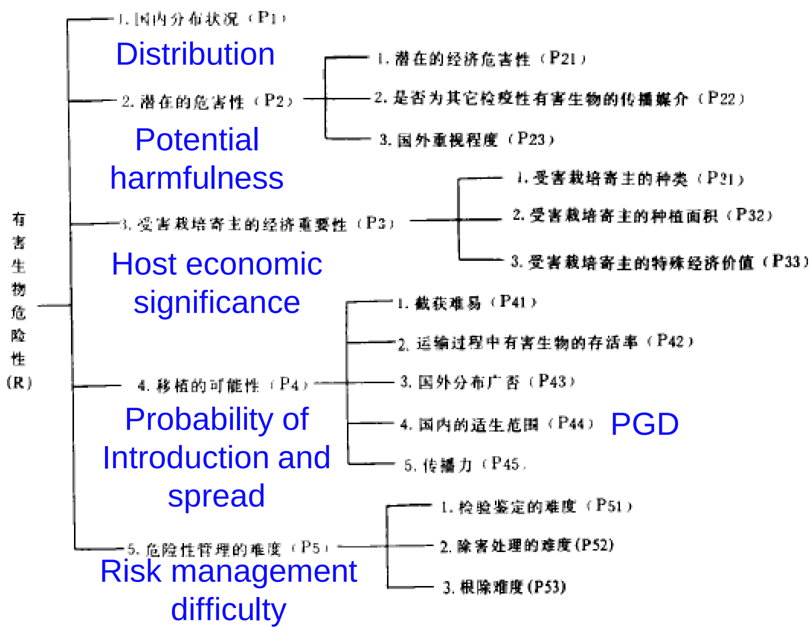

- The **Multi-Index Integrated Assessment Model** was published **in 1995** for pest invasion risk assessment **by Plant Quarantine Institute of MOA** (Jiang et al., 1995).

表　有害生物危险性的指标评判标准

序号	评判指标	评判标准
1.	国内分布状况 (P1)	国内无分布，P1＝3；国内分布面积占 0%～20%，P1＝2；占 20%～50%，P1＝1；大于 50%，P1＝0。
2.1	潜在的经济危害性(P21)	据预测，造成的产量损失达 20%以上，和／或严重降低作物产品质量，P21＝3；产量损失在 20%～5%之间，和／或有较大的质量损失，P21＝2；产量损失在 5%～1%之间，和／或有较小的质量损失，P21＝1；产量损失小于 1%，且对质量无影响，P21＝0。（如难以对产量／质量损失进行评估，可考虑用有害生物的为害程度进行间接的评判。）
2.2	是否为其它检疫性有害生物的传播媒介（P22）	可传带 3 种以上的检疫性有害生物，P22＝3；传带 2 种，P22＝2；传带 1 种，P22＝1；不传带任何检疫性有害生物，P22＝0。
2.3	国外重视程度（P23）	如有 20 个以上的国家把某一有害生物列为检疫对象，P23＝3；19～10 个，P23＝2；9～1 个，P23＝1；无，P23＝0。
3.1	受害栽培寄主的种类（P31）	受害的栽培寄主达 10 种以上，P31＝3；9～5 种，P31＝2；4～1 种，P31＝1；无，P31＝0。
3.2	受害栽培寄主的面积（P32）	受害栽培寄主的总面积达 350 万 hm^2 以上，P32＝3；350～150 万 hm^2，P32＝2；小于 150 万 hm^2，P32＝1；无，P32＝0。
3.3	受害栽培寄主的特殊经济价值（P33）	根据其应用价值、出口创汇等方面，由专家进行判断定级，P33＝3，2，1，0。

$$R = \sqrt[5]{P_1 * P_2 * P_3 * P_4 * P_5}$$

$$P_2 = 0.6P_{21} + 0.2P_{22} + 0.2P_{23}$$

$$P_3 = Max(P_{31}, P_{32}, P_{33})$$

$$P_4 = \sqrt[5]{P_{41} * P_{42} * P_{43} * P_{44} * P_{45}}$$

$$P_5 = \frac{P_{51} + P_{52} + P_{53}}{3}$$

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JOURNAL OF BIOSAFETY http://www.jbscn.org

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世界性害虫葡萄花翅小卷蛾入侵我国的风险分析

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Pest risk analysis of European grapevine moth *Lobesia botrana* in China

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Abstract: 【Aim】European grapevine moth, *Lobesia botrana* (Lepdoptera: Tortricidae), is listed as a quarantine pest in China. It can seriously hurt the grape and forestry industry if it were to invade China. The risk analysis of invasion in China can provide the basis for quarantine and early warning of the pest. 【Method】The morphological and biological characteristics of *L. botrana* were obtained based on the relevant literature. According to the general pest risk assessment method, qualitative and quantitative analyses of invasive risk were conducted based on the distribution of the pest, potential hazards, economic importance of its host, the possibility of spreading and the management difficulty. 【Result】*L. botrana* is a great potential threat to China with the risk value of 2.14, which indicate that it is highly dangerous pest. 【Conclusion】It is suggested that the quarantine departments should strengthen quarantine actions in the provinces and autonomous regions such as Xinjiang in order to prevent its introduction to China.

- The Multi-Index Integrated Assessment Model was applied in 2017 to evaluate the invasion risk of *Lobesia botrana* in China by Xinjiang Agricultural University (Li et al., 2017).

分枝(瓜)列当在新疆的分布、危害及其风险评估

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Distribution, harmfulness and its assessment of *Orobanche aegyptiaca* in Xinjiang province. Zhang Xuekun, Yao Zhaoqun, Zhao Sifeng*, Ding Lili, Du Juan (Shihezi University, Xingjiang 832003, China)

Abstract *Orobanche aegyptiaca* is obligate root parasites weeds in Xinjiang, which resulted in the serious damage on melon, watermelon and processing tomato. It is clarified that the parasitic weeds belong to height dangerous harmful orgnism through the suitable analysis and risk assessment in Xinjiang. Advised that it should strengthen quarantine management and epidemic situation prevention, prevent *O. aegyptiaca* spread constantly.

表 2 有害生物综合评价值 R 分级标准

风险值(R)	3.0~2.5	2.5~2.0	2.0~1.5	1.5~1.0
危险级别	特别危险	高度危险	中度危险	低度危险

所用到计算公式[7]如下：

$$P_1 = 2$$

$$P_2 = 0.6P_{21} + 0.2P_{22} + 0.2P_{23} = 0.6 \times 3 + 0.2 \times 0 + 0.2 \times 3 = 2.4$$

$$P_3 = \mathrm{Max}(P_{31}, P_{32}, P_{33}) = \mathrm{Max}(3, 1, 3) = 3$$

$$P_4 = \sqrt[5]{P_{41} \times P_{42} \times P_{43} \times P_{44} \times P_{45}} = \sqrt[5]{2 \times 3 \times 1 \times 3 \times 3} = \sqrt[5]{54} = 2.221$$

$$P_5 = (P_{51} + P_{52} + P_{53})/3 = (2 + 3 + 3)/3 = 8/3 = 2.667$$

$$R = \sqrt[5]{P_1 \times P_2 \times P_3 \times P_4 \times P_5} = \sqrt[5]{2 \times 2.4 \times 3 \times 2.221 \times 2.667} = \sqrt[5]{85.297} = 2.433$$

- The Multi-Index Integrated Assessment Model was applied in 2012 to evaluate the invasion risk of *Orobanche aegyptiaca* in Xinjiang province by Shihezi University (Zhang et al., 2012).

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有害生物的定性与定量风险分析

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Qualitative and Quantitative Pest Risk Analysis. Chen Ke, Fan Xiaohong, Li Weimin (Animal and Plant Quarantine Institute, General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China, Beijing 100029)

Abstract Beginning from the history and latest development of Pest Risk Analysis (PRA), this article discussed the concepts of qualitative and quantitative PRA, and their relationship, advantages and shortcomings. It introduced some theories and methods to conduct quantitative PRA. A quantitative PRA example, Risk Assessment for the Importation of U.S. Wheat Containing Teliospores of *Tilletia controversa* (TCK) into China, was also included.

Keywords Pest Risk Analysis (PRA), qualitative, quantitative, *Tilletia controversa* Kühn

摘要　本文从有害生物风险分析的历史及最新发展探讨了定性与定量有害生物风险分析的概念、关系及各自的优缺点，介绍了定量有害生物风险分析理论及其实施的过程、方法等，最后给出一个定量方法的实例：中国进口美国小麦的 TCK 风险分析。

Risk of Introducing Exotic Fruit Flies, *Ceratitis capitata*, *Ceratitis cosyra*, and *Ceratitis rosa* (Diptera: Tephritidae), Into Southern China

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J. Econ. Entomol. 103(4): 1100–1111 (2010); DOI: 10.1603/EC09217

ABSTRACT Exotic fruit flies (*Ceratitis* spp.) are often serious agricultural pests. Here, we used pathway analysis and Monte Carlo simulations to assess the risk of introduction of *Ceratitis capitata* (Wiedemann), *Ceratitis cosyra* (Walker), and *Ceratitis rosa* Karsch, into southern China with fruit consignments and incoming travelers. Historical data, expert opinions, relevant literature, and archives were used to set appropriate parameters in the pathway analysis. Based on the ongoing quarantine/inspection strategies of China, as well as the interception records, we estimated the annual number of each fruit fly species entering Guangdong province undetected with commercially imported fruit, and the associated risk. We also estimated the gross number of pests arriving at Guangdong ports with incoming travelers and the associated risk. Sensitivity analysis also was performed to test the impact of parameter changes and to assess how the risk could be reduced. Results showed that the risk of introduction of the three fruit fly species into southern China with fruit consignments, which are mostly transported by ship, exists but is relatively low. In contrast, the risk of introduction with incoming travelers is high and hence deserves intensive attention. Sensitivity analysis indicated that either ensuring all shipments meet current phytosanitary requirements or increasing the proportion of fruit imports sampled for inspection could substantially reduce the risk associated with commercial imports. Sensitivity analysis also provided justification for banning importation of fresh fruit by international travelers. Thus, inspection and quarantine in conjunction with intensive detection were important mitigation measures to reduce the risk of *Ceratitis* spp. introduced into China.

- The **Scenario models+@RISK** was applied preliminarily in **2002** to evaluate **the invasion risk of *Tilletia controversa* (TCK) in China** by Animal and Plant Quarantine Institute of AQSIQ (Chen et al., 2002).

- The **Scenario models+@RISK** was applied in **2010** to evaluate **the introduction risk of 3 species of *Ceratitis* into southern China** by Guangdong CIQ etc. (Li et al., 2010).

The Collaboration Program

- **A national international collaboration program during 2012-2014 introduced 'SOM+Matlab', CLIMEX, and 'Scenario models+@RISK' into China systematically.**

✓ Prof. Dr. Zhihong Li as the leading scientist.

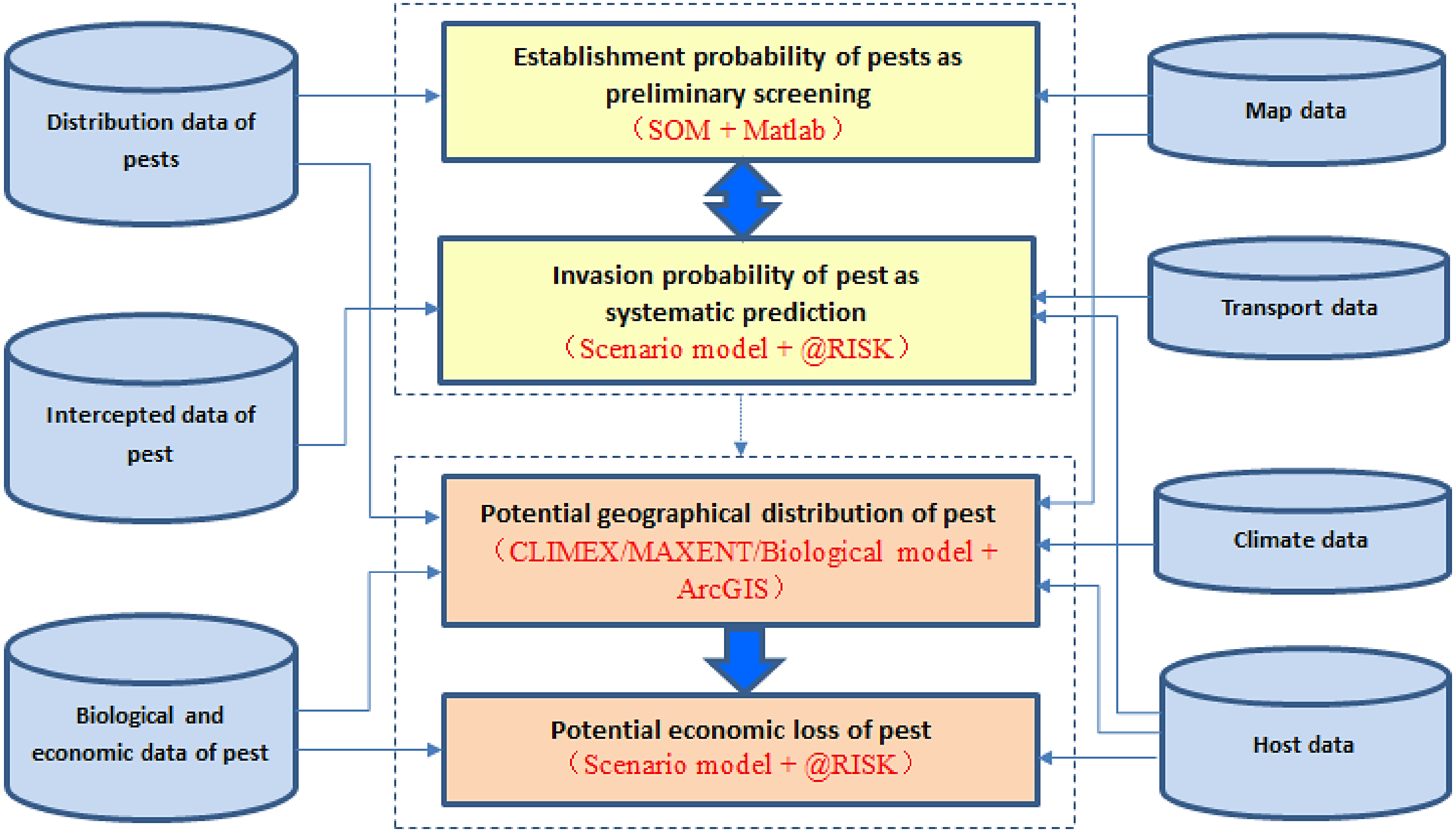
✓ Collaborations from CAU+CSIRO+USDA-APHIS-CPHST+MOA-NATESC etc..

✓ How about the suitable quantitative methods to China?

Visit of CAUPQL and training of PRA tech., Dr. Caton and Dr. Fowler (from CPHST), Jun. 2012

Visit of CAUPQL and training of PRA tech., Dr. Kriticos and Dr. Paini (from CSIRO), Sep. 2012

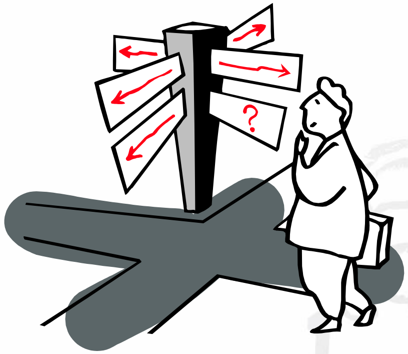
- More recently, an integrated technical method of quantitative risk assessment has been practiced.



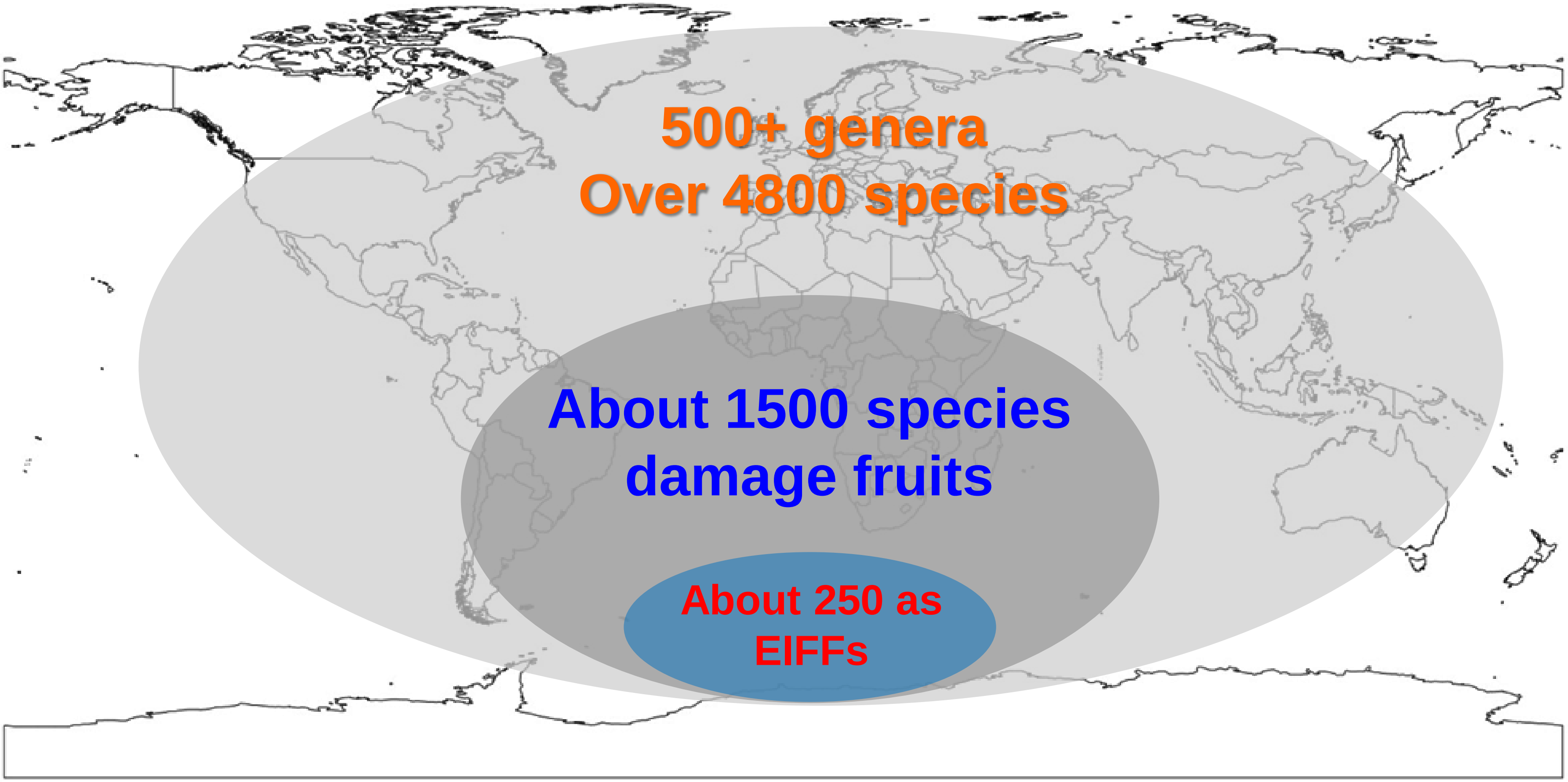
The quantitative technical system of pests risk assessment in China

(Li et al., unpublished)

Ⅱ. The recent practices of quantitative risk assessment on economically important fruit flies in CAU



- In the trends of economic globalization and integration, EIFFs are spread more quickly and widely in the world, which are causing significant economic and biological losing of fruits.



■ The quarantine fruit flies regulated by China:

Import quarantine FFs: 5 genera + 5 species, by AQSIQ, 2007

- ✓ *Anastrepha*
- ✓ *Bactrocera*
- ✓ *Ceratitis*
- ✓ *Dacus* spp. (non-Chinese)
- ✓ *Rhagoletis* spp. (non-Chinese)
- ✓ *Carpomya incompleta*
- ✓ *Carpomya vesuviana*
- ✓ *Monacrostichus citricola*
- ✓ *Myiopardalis pardalina*
- ✓ *Toxotrypana curvicauda*

Export regulated FFs: 1 genus + 1 species, by AQSIQ

- ✓ *Bactrocera, eg. B. dorsalis, B. cucurbitae*
- ✓ *Drosophila suzukii*

Domestic quarantine FF of agriculture: 1 species, by MOA, 2009

- ✓ *Bactrocera tsuneonis*

Domestic quarantine FF of forestry: 1 species, by SFA, 2009

- ✓ *Carpomya vesuviana*

- **Main Techniques*: technical system of quantitative risk assessment***, **realized the decision support for quarantine.**

- ✓ ***Establishment probability:*** *'SOM + Matlab', 180 EI fruit flies in 118 countries (Qin et al., 2015, PLoS ONE).*
- ✓ ***Invasion probability:*** *'Scenario model +@RISK', 2 EI fruit flies of Bactrocera (Ma et al., 2012, Sessor Letters; Fang, 2015, thesis)*
- ✓ ***Potential geographical distribution:*** *CLIMEX/ Maxent/Bio-model + ArcGIS', 42 EI fruit flies (Ni et al., 2012, Bulletin of Entomological Research; Fu et al.,2014, Insect Science; Qin et al., 2015, Applied Entomology and Zoology; Li et al., 2015, CAU Press; Qin, 2017, dissertation).*
- ✓ ***Potential economic loss:*** *'Scenario model + @Risk', 1 species of Bactrocera (Fang et al.,2015, Plant Quarantine).*

PLOS | ONE

RESEARCH ARTICLE

Global Establishment Risk of Economically Important Fruit Fly Species (Tephritidae)

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Abstract

The global invasion of Tephritidae (fruit flies) attracts a great deal of attention in the field of plant quarantine and invasion biology because of their economic importance. Predicting which one in hundreds of potential invasive fruit fly species is most likely to establish in a region presents a significant challenge, but can be facilitated using a self organising map (SOM), which is able to analyse species associations to rank large numbers of species simultaneously with an index of establishment. A global presence/absence dataset including 180 economically significant fruit fly species in 118 countries was analysed using a SOM. We compare and contrast ranked lists from six countries selected from each continent, and also show that those countries geographically close were clustered together by the SOM analysis because they have similar fruit fly assemblages. These closely clustered countries therefore represent greater threats to each other as sources of invasive fruit fly species. Finally, we indicate how this SOM method could be utilized as an initial screen to support prioritizing fruit fly species for further research into their potential to invade a region.

Table 2. Top ten ranked fruit fly species by establishment index for six countries. Only those species currently absent from a country and a known pest of a host commercially grown in that country were included (for full list see S1 Table).

China	SOM Index	South Africa	SOM Index	The United States	SOM Index
Bactrocera albistrigata	0.58	*Bactrocera cucurbitae*	0.55	*Anastrepha obliqua*	0.83
Bactrocera carambolae	0.48	*Dacus momordicae*	0.41	*Anastrepha striata*	0.79
Bactrocera umbrosa	0.48	*Ceratitis anonae*	0.39	*Anastrepha bezzii*	0.60
Bactrocera zonata	0.40	*Acanthiophilus helianthi*	0.21	*Anastrepha pickeli*	0.58
Bactrocera papayae	0.37	*Dacus telfaireae*	0.20	*Anastrepha antunesi*	0.52
Adrama determinata	0.37	*Dacus humeralis*	0.20	*Anastrepha grandis*	0.51
Bactrocera arecae	0.29	*Bactrocera latifrons*	0.11	*Anastrepha leptozona*	0.50
Monacrostichus citricola	0.29	*Dacus vansomereni*	0.10	*Anastrepha macrura*	0.45
Ceratitis capitata	0.20	*Bactrocera zonata*	0.09	*Anastrepha sororcula*	0.45
Bactrocera musae	0.19	*Ceratitis malgassa*	0.08	*Anastrepha rheediae*	0.38
Argentina	**SOM Index**	**Italy**	**SOM Index**	**Australia**	**SOM Index**
Anastrepha obliqua	0.74	*Rhagoletis cingulata*	0.30	*Bactrocera latifrons*	0.75
Anastrepha serpentina	0.69	*Carpomya pardalina*	0.21	*Bactrocera tau*	0.72
Anastrepha striata	0.65	*Rhagoletis indifferens*	0.08	*Bactrocera dorsalis*	0.58
Anastrepha distincta	0.62	*Dacus ciliatus*	0.06	*Bactrocera caudata*	0.56
Anastrepha manihoti	0.47	*Bactrocera invadens*	0.03	*Dacus longicornis*	0.54
Toxotrypana curvicauda	0.43	*Dacus frontalis*	0.02	*Bactrocera carambolae*	0.48
Anastrepha sororcula	0.41	*Ceratitis cosyra*	0.02	*Bactrocera umbrosa*	0.48
Anastrepha bezzii	0.37	*Ceratitis quinaria*	0.02	*Bactrocera zonata*	0.40
Anastrepha antunesi	0.33	*Ceratitis rosa*	0.02	*Bactrocera pedestris*	0.39
Anastrepha leptozona	0.31	*Bactrocera zonata*	0.01	*Bactrocera papayae*	0.39

doi:10.1371/journal.pone.0116424.t002

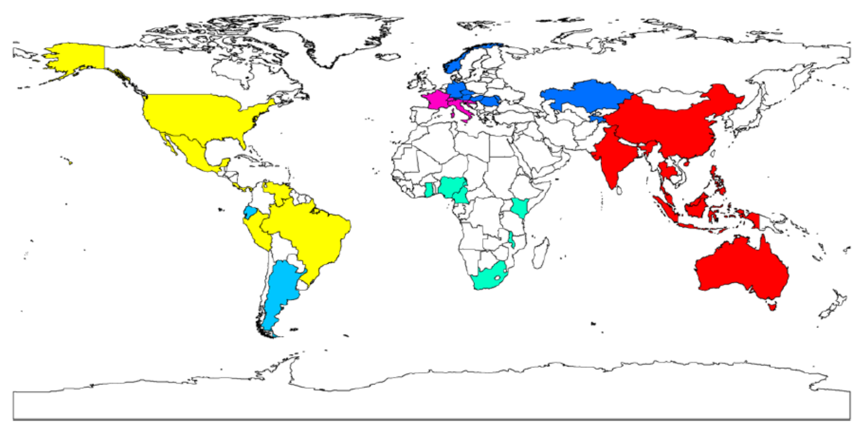

Figure 1. Countries clustering based on fruit fly species assemblages. Map of world showing those countries that were allocated to the same neuron in a SOM analysis (same colour) and hence those countries that have the most similar fruit fly species assemblages.

doi:10.1371/journal.pone.0116424.g001

Table 1. Numbers of fruit fly species in each continent (except for the Antarctic).

	Anastrepha	*Bactrocera*	*Ceratitis*	*Dacus*	*Rhagoletis*	others	Total
Asia	0	33	2	8	2	15	60
Africa	0	5	12	14	0	13	44
North America[a]	26	5	1	0	15	7	55
South America	36	0	1	0	6	1	44
Europe	0	1	1	0	4	5	11
Oceania	0	25	1	3	0	3	32
world	44	51	12	19	22	32	180

The representative paper of establishment probability based on 'SOM+Matlab'

(Qin et al, PLoS ONE, 2015)

SENSOR LETTERS
Vol. 10, 586–591, 2012

RESEARCH ARTICLE

Using Decision Tools Suite to Estimate the Probability of the Introduction of *Bactrocera correcta* (Bezzi) Into China via Imported Host Fruit

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The guava fruit fly, *Bactrocera correcta* (Bezzi) (Diptera: Tephritidae), originates from the tropical and subtropical regions of Asia and affects a large variety of fruits. It is regarded as a dangerous fruit fly and is regulated by quarantine measures in China. This study assessed the introduction risk of the guava fruit fly associated with the importation of host fruit into China. The risk assessment based on historical data, expert opinions, relevant literature and archives was used to determine appropriate parameters in the pathway analysis. With a computational model, Monte Carlo simulations were conducted using Decision Tools Suite 5.5 Industrial Edition to estimate the probability of the introduction of the guava fruit fly. Risk management options were incorporated and risk analysis was performed to determine how the risk could be reduced. The study indicated the probability of introduction into China of the guava fruit fly via imported host fruit with current quarantine measures is very low at 1.06E−12. In contrast, the probability is high at 0.1049 without entry detection. Sensitivity analysis was performed to assess the model stability and the impact of parameter changes. Based on the sensitivity analysis, the most critical input was entry detection, followed by mitigation treatment and the number of guava fruit flies per ton of infested host fruit, respectively. We concluded that intensive detection in conjunction with maintaining mitigation treatment would significantly reduce the risk of introduction.

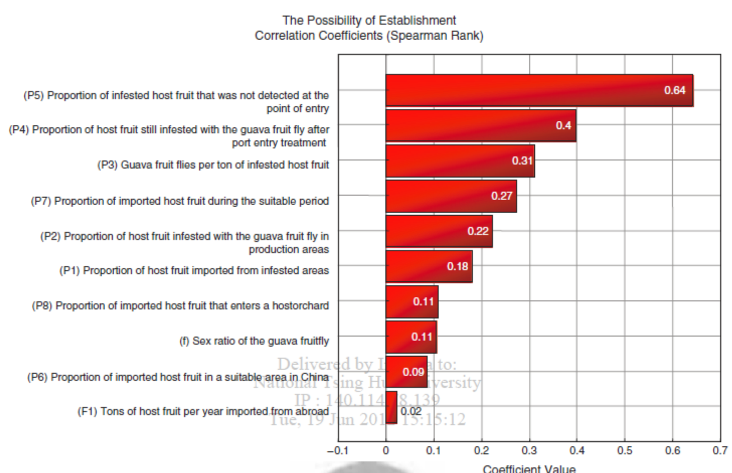

Table I. Scenario: The probability of introduction of *Bactrocera correcta* (Bezzi) via host fruit imported into China.

Step	Value	Pathway parameter	Min.	MI.	Max.	Expected value	5th percentile	95th percentile	Derived pathway parameter	Mean values
1	F1	Tons of host fruit per year imported from abroad	67956.038	80968.296	90300.405	80354.95	73207.08	86998.68	Tons of host fruit per year imported from abroad = (F1)	80354.95
2	P1	Proportion of host fruit imported from infested areas	0.0153	0.0626	0.1484	0.0690166	0.03113399	0.1120847	Tons of host fruit imported from infested areas = (F1 * P1)	5545.829959
3	P2	Proportion of host fruit infested with the guava fruit fly in production areas	= RiskBeta (4.5, 500)			0.00891956	0.003306843	0.01671442	Tons of host fruit infested with the guava fruit fly in production areas = (F1 * P1 * P2)	49.46726426
4	P3	Guava fruit fly per ton of infested host fruit	16000	56000	424000	110666.3	28027.6	236425.6	–	–
5	P4	Proportion of host fruit still infested with the guava fruit fly after port entry treatment	0	0.0001	0.001	0.0002333318	2.99606E-05	0.000541867	Annual no. of guava fruit flies in infested fruit after port entry treatment X′=(F1 * P1 * P2 * P3 * P4)	1277.35469
6	P5	Proportion of infested host fruit that was not detected at the port of entry	= RiskUniform (0, RiskBeta (4.5, 500)* RiskPert (0, 0.0001, 0.001))			1.03784E-06	3.27263E-08	3.44785E-06	Annual no. of guava fruit flies that were not detected at the port of entry X = (F1 * P1 * P2 * P3 * P4 * P5)	0.001329259
7	P6	Proportion of imported host fruit introduced into a suitable area in China	= RiskTriang (0.33, 0.75, 0.8)			0.6266667	0.429287	0.7657046	Probability of that the guava fruit fly enters a host orchard after being introduced into a suitable area during a suitable period Q = (P6 * P7 * P8)	0.001041833
8	P7	Proportion of imported host fruit during a suitable period	= RiskTriang (0, 0.33, 1)			0.443333	0.1283524	0.8168027		
9	P8	Proportion of imported host fruit entering a host orchard	= RiskUniformAlt (5%, 0.0025, 95%, 0.005)			0.00375	0.002499988	0.00499975		
10	f	Sex ratio of the guava fruit fly = (f)	= RiskTriang (0.3, 0.5, 0.8)			0.5333334	0.3706803	0.7133279	–	–

The representative paper of invasion probability based on 'Scenario model +@RISK' *(Ma et al, Sessor Letters, 2012)*

Insect Science

Insect Science (2014) 21, 234–244, DOI 10.1111/1744-7917.12018

ORIGINAL ARTICLE

The current and future potential geographic range of West Indian fruit fly, *Anastrepha obliqua* (Diptera: Tephritidae)

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[1]*College of Agriculture and Biotechnology, China Agricultural University, and* [2]*General Administration of Quality Supervision, Inspection and Quarantine of People's Republic of China, Beijing, China*

Abstract The West Indian fruit fly, *Anastrepha obliqua* (Macquart), is one of the most important pests throughout the Americas. CLIMEX 3.0 and ArcGIS 9.3 were used to model the current and future potential geographical distribution of this pest. Under current climatic conditions, *A. obliqua* is predicted to be able to establish throughout much of the tropics and subtropics, including not only North and South America, where it has been reported, but also southern Asia, northeastern Australia and Sub-Saharan Africa. The main factors limiting the pest's range expansion may be cold stress. Climate change expands the potential distribution of *A. obliqua* poleward as cold stress boundaries recede, but the predicted distribution in northwestern Australia and northern parts of Sub-Saharan Africa will decrease because of heat stress. Considering the widely suitable range for *A. obliqua* globally and in China, enhanced quarantine and monitoring measures should be implemented in areas that are projected to be suitable for the establishment of the pest under current and future climatic conditions.

Table 2 Parameters used in the CLIMEX model for *Anastrepha obliqua*.

Index	Parameter	Value[†]
Temperature	DV0 = the lower temperature threshold	10°C
	DV1 = the lower optimum temperature	20°C
	DV2 = the upper optimum temperature	30°C
	DV3 = the upper temperature threshold	36°C

Table 1 Selected climate change scenarios used in CLIMEX analyses.

Year	Temperature (°C)	Rainfall (%)
2020	+1.70	+2.5
2050	+2.80	+6.0
2100	+4.45	+14.0

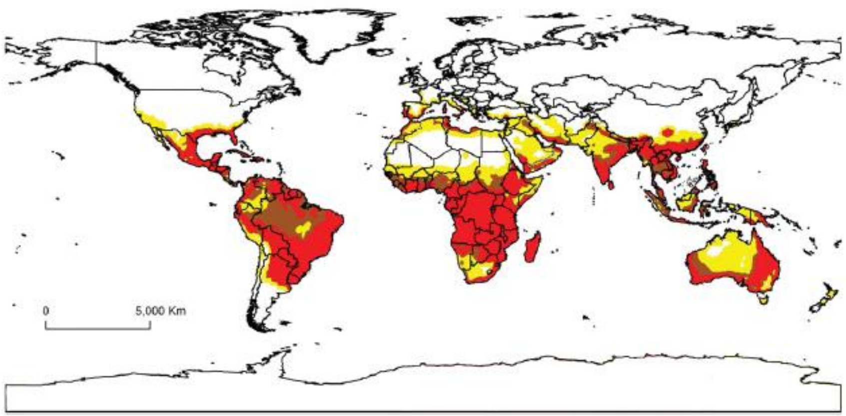


Fig. 4 The global climatic suitability (EI) for *Anastrepha obliqua* in the 2020s projected using CLIMEX™ □, unsuitable (0.00–0.49); ■, marginal (0.50–9.99); ■, suitable (10–19.99); ■, optimal (20.00+). [GS(2012)1601].

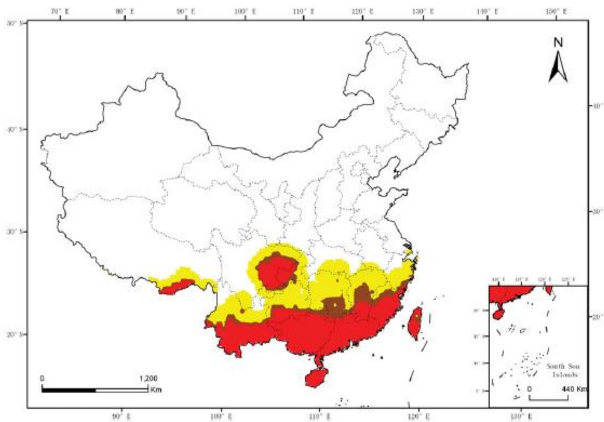
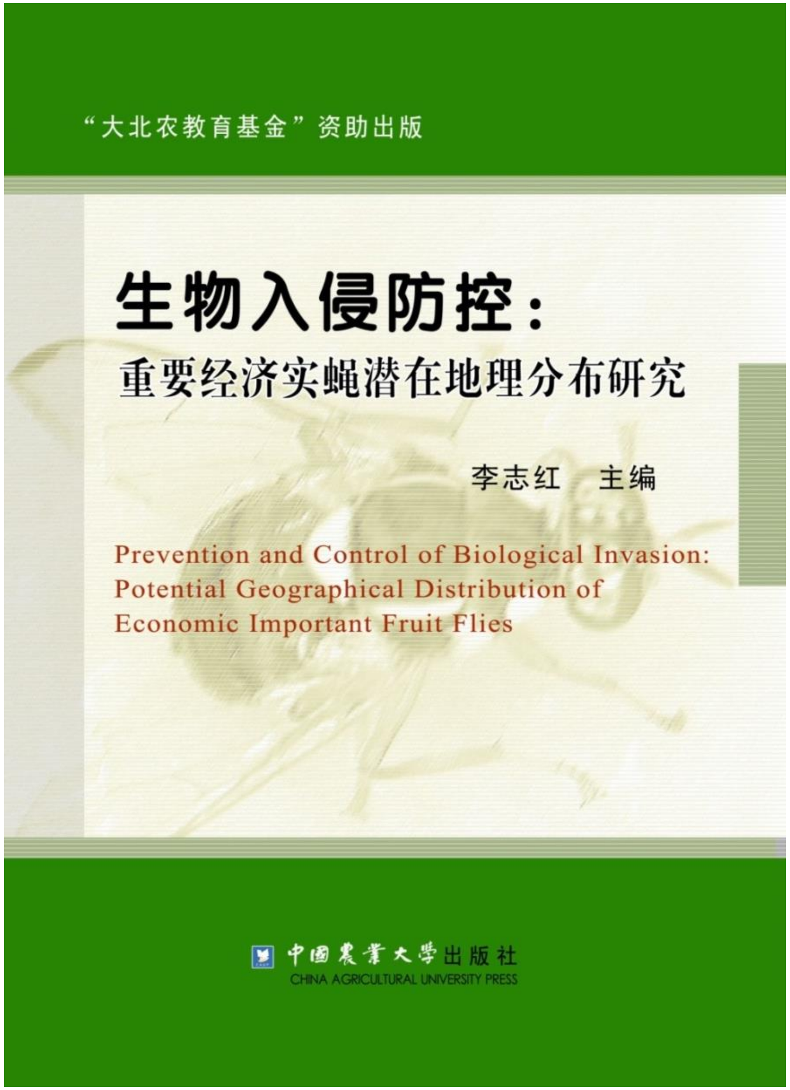


Fig. 5 The projected distribution for *Anastrepha obliqua* in China in the 2020s projected using CLIMEX™ □, unsuitable (0.00–0.49); ■, marginal (0.50–9.99); ■, suitable (10–19.99); ■, optimal (20.00+). [GS(2012)1601].

The representative paper of potential geographical distribution based on 'CLIMEX+ArcGIS' *(Fu et al, Insect Science, 2014)*



The representative book of potential geographical distributions of 42 fruit flies based on ‘CLIMEX+ArcGIS’

(Li, chief editor, CAU Press, 2015, in Chinese)

表 2-1-1 本研究所涉及的 42 种重要经济实蝇基本信息

Table 2-1-1 The basic information of 42 species of economic important fruit flies in this research

序号	属名	拉丁学名	中文名
1	按实蝇属 *Anastrepha*	*Anastrepha fraterculus* (Wiedemann)	南美按实蝇
2		*Anastrepha ludens* (Loew)	墨西哥按实蝇
3		*Anastrepha obliqua* (Macquart)	西印度按实蝇
4		*Anastrepha serpentina* (Wiedemann)	山榄按实蝇
5		*Anastrepha suspensa* (Loew)	加勒比按实蝇
6	果实蝇属 *Bactrocera*	*Bactrocera albistrigata* (de Meijere)	蒲桃果实蝇
7		*Bactrocera aquilonis* (May)	番荔枝果实蝇
8		*Bactrocera carambolae* Drew & Hancock	杨桃果实蝇
9		*Bactrocera caryae* (Kapoor)	胡桃果实蝇
10		*Bactrocera caudata* (Fabricius)	普通果实蝇
11		*Bactrocera correcta* (Bezzi)	番石榴果实蝇
12		*Bactrocera cucurbitae* (Coquillett)	瓜实蝇
13		*Bactrocera dorsalis* (Hendel)	橘小实蝇
14		*Bactrocera jarvisi* (Tryon)	澳洲果实蝇
15		*Bactrocera kirki* (Froggatt)	柯氏果实蝇
16		*Bactrocera latifrons* (Hendel)	辣椒果实蝇
17		*Bactrocera minax* (Enderlein)	橘大实蝇
18		*Bactrocera neohumeralis* (Hardy)	褐肩果实蝇
19		*Bactrocera occipitalis* (Bezzi)	芒果实蝇
20		*Bactrocera oleae* (Gmelin)	油橄榄果实蝇
21		*Bactrocera scutellata* (Hendel)	宽带果实蝇
22		*Bactrocera tau* (Walker)	南亚果实蝇
23		*Bactrocera tryoni* (Froggatt)	昆士兰果实蝇
24		*Bactrocera tsuneonis* (Miyake)	蜜柑大实蝇
25		*Bactrocera tuberculata* (Bezzi)	短尾果实蝇
26		*Bactrocera umbrosa* (Fabricius)	面包果实蝇
27		*Bactrocera zonata* (Saunders)	桃果实蝇
28	咔实蝇属 *Carpomya*	*Carpomya vesuviana* Costa	枣实蝇
29	小条实蝇属 *Ceratitis*	*Ceratitis anonae* Graham	黑羽小条实蝇
30		*Ceratitis capitata* (Wiedemann)	地中海实蝇
31		*Ceratitis cosyra* (Walker)	芒果小条实蝇
32		*Ceratitis discussa* Munro	南非小条实蝇
33		*Ceratitis malgassa* Munro	马达加斯加小条实蝇
34		*Ceratitis quinaria* (Bezzi)	五点小条实蝇
35		*Ceratitis rosa* Karsch	纳塔耳小条实蝇
36	寡鬃实蝇属 *Dacus*	*Dacus bivittatus* (Bigot)	葫芦寡鬃实蝇
37		*Dacus ciliatus* Loew	埃塞俄比亚寡鬃实蝇
38		*Dacus vertebratus* Bezzi	西瓜寡鬃实蝇
39	绕实蝇属 *Rhagoletis*	*Rhagoletis pomonella* (Walsh)	苹绕实蝇
40	锤腹实蝇属 *Monacrostichus*	*Monacrostichus citricola* Bezzi	橘实锤腹实蝇
41	新小条实蝇属 *Neoceratitis*	*Neoceratitis cyanescens* (Bezzi)	番茄实蝇
42	长尾实蝇属 *Toxotrypana*	*Toxotrypana curvicauda* Gerstaecker	番木瓜长尾实蝇

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DOI 10.1007/s13355-015-0344-9

CrossMark

ORIGINAL RESEARCH PAPER

The potential geographic distribution of *Bactrocera correcta* (Diptera: Tephrididae) in China based on eclosion rate model

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Abstract The guava fruit fly, *Bactrocera correcta* (Bezzi) (Diptera: Tephritidae), is an invasive pest of fruit and vegetable crops that primarily inhabits Southeast Asia and which has the potential to become a major threat within both the Oriental and Australian oceanic regions, as well as California and Florida. In light of the threat posed, it is important to know the potential geographic distribution of this pest in quarantine work in order to provide an early warning and to prevent its widespread invasion effectively. In this study, the eclosion rate model was constructed from empirical biological data and analyzed using stepwise regression, based on the soil temperature and moisture data of Chinese meteorological stations, and mapped with ArcGIS. Using this information, the potential geographic distribution of *B. correcta* from January to December in China was predicted. The results showed that most regions in China were optimally suitable for *B. correcta* from May to September. Monitoring measures in the north parts of China should be taken from April to October, and as for Guangdong, Guangxi, Yunnan, and Hainan provinces, the measures should be strengthened through the whole year.

Keywords *Bactrocera correcta* · Potential geographic distribution · Eclosion rate · ArcGIS · Plant quarantine

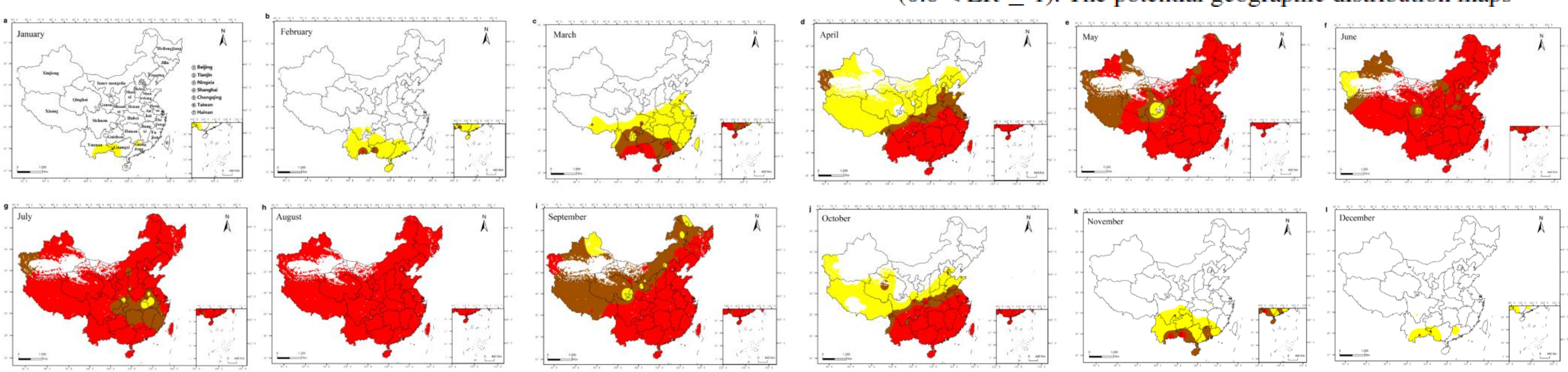
Introduction

The crossover design experiment specified 7 soil temperature grades: 10, 15, 20, 25, 30, 35 and 40 °C. Six relative water content grades included 0, 20, 40, 60, 80, and 100 %. Experiments consisted of 42 treatments, every treatment had 3 replications and every box had 60 pupae. All pupae were placed 2 cm under the soil and held in artificial climate boxes. Water was added as needed (Wu et al. 1991). The experiment data were obtained and the eclosion rate (ER) model was derived by stepwise regression (SPSS 13.0).

$$Z = -0.00346313X^2 - 0.0000811Y^2 + 0.16755X + 0.00939Y - 1.448,$$

where: Z is the ER (eclosion rate) of *B. correcta*, X is the soil temperature, and Y is the soil moisture.

The ER of *B. correcta* for every month and every meteorological station in China were calculated (Table S1). For each station, the suitability was categorized into 4 levels (Sutherst et al. 2004, 2007): unsuitable (where the *B. correcta* is unable to occur and survive) (ER = 0), marginal (0 < ER ≤ 0.3), suitable (0.3 < ER ≤ 0.6) and optimal (0.6 < ER ≤ 1). The potential geographic distribution maps



The representative paper of monthly potential geographic distribution based on 'Bio-model + ArcGIS' *(Qin et al, Applied Entomology and Zoology, 2015)*

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南亚果实蝇对我国南瓜产业的潜在经济损失评估

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The potential economic impact of the pumpkin industry caused by *Bactrocera tau* (Walker). Fang Yan[1,4*], Li Zhihong[1*], Qin Meng[2], Wu Zhigang[1], Zhao Shouqi[2], Wu Lifeng[2], Zhao Zhonghua[2], Chen Ke[3], Qin Yujia[1], Wang Cong[1], Zhao Tan[1] (1. Department of Entomology, College of Agriculture and Biotechnology, China Agricultural University, Beijing 100193, China; 2. National Agro-technical Extension and Service Center; 3. Chinese Academy of Inspection and Quarantine; 4. Tianjin Entry-Exit Inspection and Quarantine Bureau)

Abstract *Bactrocera tau* is a quarantine pest in China, seriously affect the yield and quality of cucurbitaceous plants and fleshy fruits, like pumpkin. In this study, we looked at some article and used their economic loss assessment model as a useful reference, then combine them with the @RISK software, from the direct economic losses, the indirect economic losses and the cost of prevention and control to do the assessment of the economic losses caused by *Bactrocera tau* in China. The results show that total economic losses was estimated to be from 37.42~23 157.83 million Yuan.

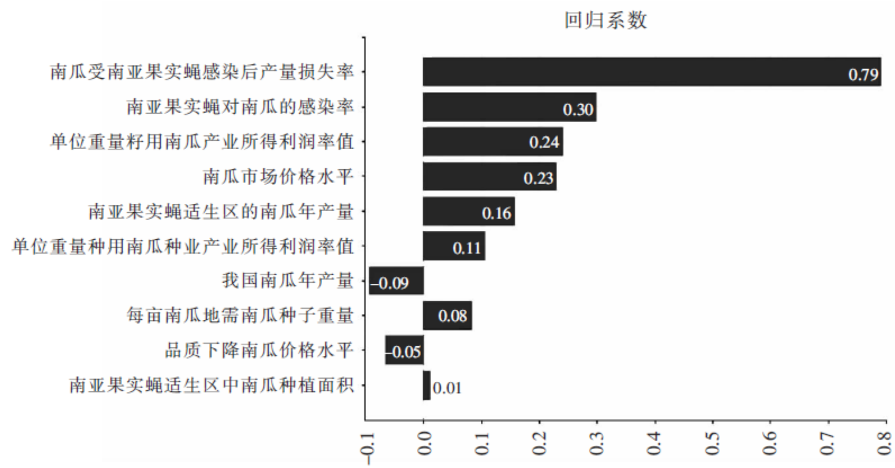

图 1　南亚果实蝇对我国南瓜产业的潜在经济损失评估的灵敏性分析结果

表 1　南亚果实蝇对我国南瓜产业的潜在经济损失评估结果(单位:元)

标记	输出项	公式	最小值	平均值	最大值
F_1	南亚果实蝇对我国南瓜产业的潜在经济损失（直接经济损失）	$F_1=F_{11}+F_{12}$	3 502 672.47	777 875 564.28	4 150 362 739.29
F_2	南亚果实蝇对我国南瓜产业的潜在经济损失（间接经济损失）	$F_2=F_{21}+F_{22}+F_{23}$	1 011 875.19	1 721 026 788.95	21 651 387 305.32
F_3	南亚果实蝇对我国南瓜产业的潜在经济损失（防治费用）	$F_3=S\times I\times C$	1 788.06	12 335 056.92	41 673 689.40
F	南亚果实蝇对我国南瓜产业的潜在经济损失（总量）	$F=F_1+F_2+F_3$	37 415 042.07	2 522 419 830.95	23 157 830 826.71

The representative paper of potential economic loss for industry based on ‘Scenario model +@RISK’

(Fang et al, Plant Quarantine (in Chinese), 2015)

How about the questions we are facing for the PRA of EIFFs?

- **Establishment probability:** by 'SOM+Matlab', especially the synonym and novel species, e.g., *Bactrocera dorsalis*.
- **Invasion probability:** by 'Scenario model+@RISK', especially the unclear spread process, e.g., the flying ability and model.
- **Potential geographical distribution:** by 'CLIMEX/Maxent/Bio-model+ArcGIS', especially the pest adaptation and evolution, e.g., thermal plasticity.
- **Potential economic loss:** by 'Scenario model+@RISK', especially the indirect economic loss, e.g., basic data.

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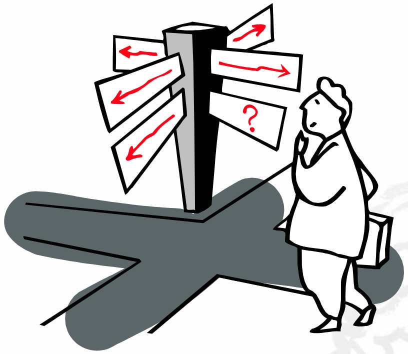
III. Challenges, opportunities and prospects of PRA in China



■ <u>3 main challenges:</u>

- ✓ **Trade, travel and E-commerce:** especially the development of Silk Road Economic Belt and the 21st Century Maritime Silk Road. **For pests: So free trip!**
- ✓ **Pest data and quantitative methods:** especially the species taxonomy, invasion mechanism, predictability and uncertainty. **For scientists: So long way!**
- ✓ **Phytosanitary measures:** especially the regulated pests lists and sampling based on ALOP. **For quarantine workers: So urgent requirement!**

species complex + cryptic species + invasion mechanism

If they are so strong ……
(some part of TAAO's logo).

3 main opportunities:

- ✓ **Education and research:** a big team and financial support of plant quarantine and invasion biology, e.g. CAU, CAIQ, CAAS, BFU etc.
- ✓ **Prevention and management:** regulation revision and regulate system of national and local levels, e.g., regulated pests list, common activities.
- ✓ **International collaboration:** collaborations of international organizations especially on plant quarantine, e.g., FAO-IPPC, FAO-APPPC etc.

FAO-IPPC workshop, Nov. 2016

APPPC training, Jun. 2016

■ 3 main prospects:

- ✓ **To strengthen the education and research:** especially the **postgraduates + national database + invasion mechanism + quantitative models** as the basis of PRA.
- ✓ **To streamline the official prevention and control system:** especially the **revisions of regulated pest lists + sampling standards + other phytosanitary measures** based on PRA among AQSIQ-MOA-SFA.
- ✓ **To promote the national, regional and international collaborations:** especially the **national programs + ICBI 2017 + IPRRG meeting in Taiwan and Mainland of China + ISPMs on PRA**.

http://english.aqsiq.gov.cn/

http://english.agri.gov.cn/

http://english.forestry.gov.cn/

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BEST WISHES FROM CAU!
LOOKING FORWARD TO MORE COLLABORATIONS
AND PROGRESS ON PRA!
热烈祝贺2011届毕业生圆满完成学业