The Education System of Plant Health in China

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Formulation Workshop on the IPPC Project of Capacity Development under the Framework of FAO-China South-South Cooperation (SSC) Programme
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Outline

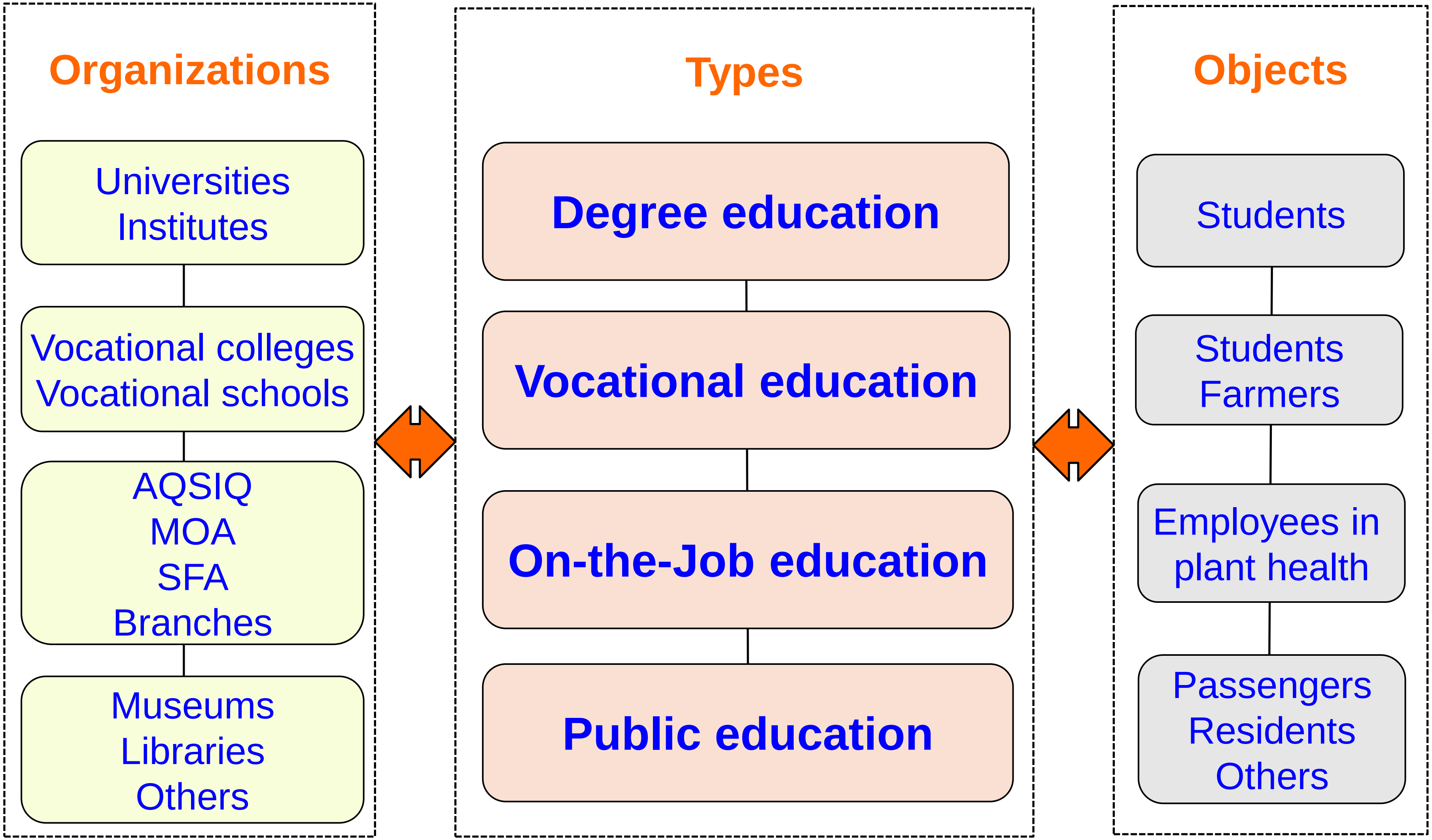
- The general situation of education system of plant health in China
- The education practice of plant quarantine and invasion biology in China: CAU as an example
- The challenges, opportunities and prospects of plant health education

中國農業大學
China Agricultural University

Ⅰ. The general situation of education system of plant health in China

- The professional education of **plant health** in China has a history dated back **1905**.
- In the trends of economic globalization and integration, **pests are spread more quickly and widely in the world**, which are causing significant economic and biological losing of plants and plant products.
- China pays high attention to **the education of plant health**, especially the **Plant Quarantine and Invasive Alien Species management** in recent decades.

The Four-in-one Education System

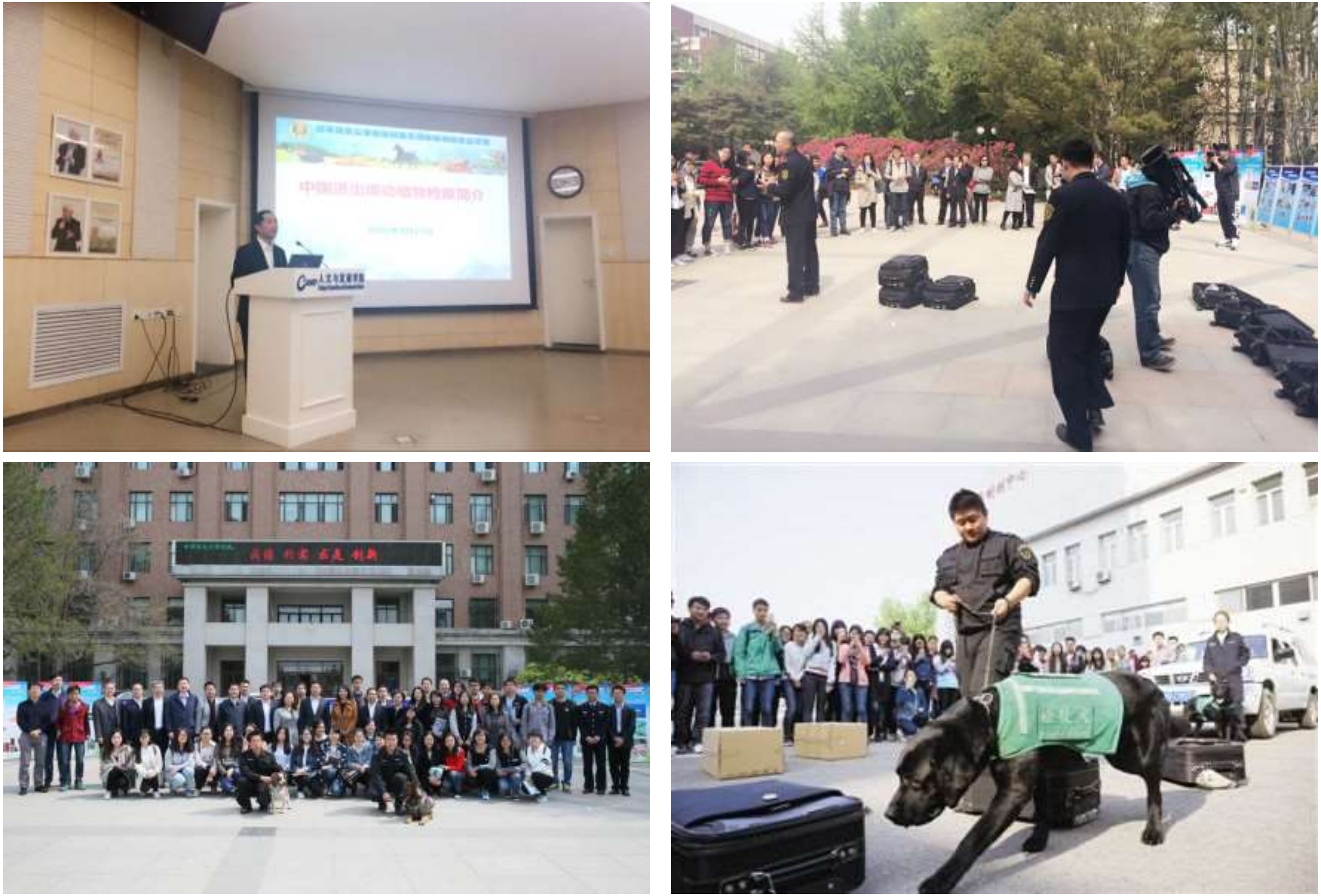


Public education: governments and universities mainly

- Passengers, regular program.
- Residents and other publics, periodical program.

The public education of plant health in China: plant pests and phytosanitary regulations

(Photos cited from the related news of plant health on internet)



The public education of plant health in China: biological security education on the 1st National Security Education Day (Apr. 15, 2016)

On-the-job education: AQSIQ, MOA, SFA and branches mainly

- Civil servants of plant quarantine, periodical program.
- Technicians of plant protection, periodical program.

The on-the-job education of plant health in China:
national and regional technical training of plant quarantine and IPM

(Photos cited from the related news of plant health on internet)

The on-the-job education of plant health in China: national and regional technical training of plant quarantine and IPM in lab and field

(Photos cited from the related news of plant health on internet)

Vocational education: vocational colleges and schools mainly

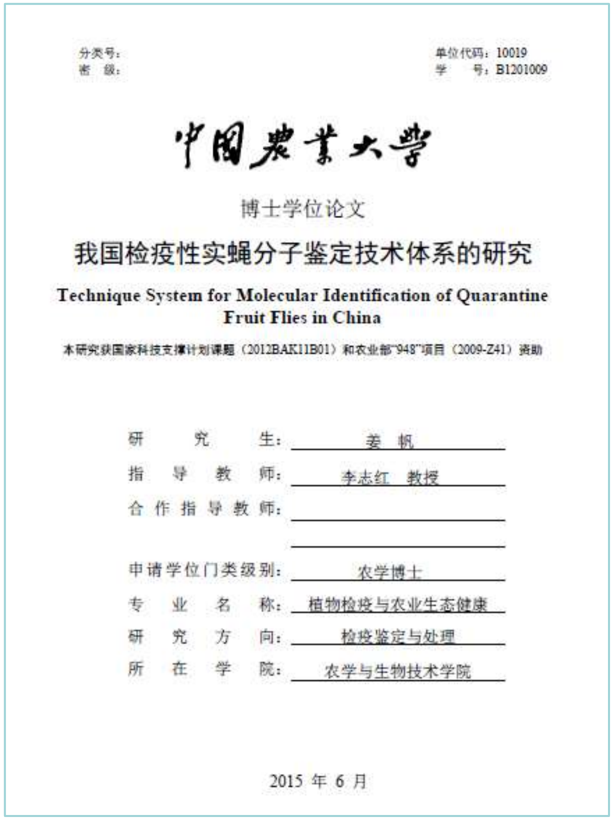
- Junior college students, 3-year program.
- Farmers, periodical program.

The farmer education of plant health in China: IPM and techniques

http://www.crdenet.net.cn/

Degree education: 50+ universities and institutes

- Undergraduates, 4-year program, Bachelor D.
- Postgraduates, 2-year program and 3-year program, Master D.
- Postgraduates, 3-year program, 4-year program, 5-year program, PhD.



分类号：
密 级：

单位代码：10019
学 号：B1201009

中国农业大学

博士学位论文

我国检疫性实蝇分子鉴定技术体系的研究

Technique System for Molecular Identification of Quarantine Fruit Flies in China

本研究获国家科技支撑计划课题（2012BAK11B01）和农业部"948"项目（2009-Z41）资助

研 究 生：姜 帆
指 导 教 师：李志红 教授
合 作 指 导 教 师：
申请学位门类级别：农学博士
专 业 名 称：植物检疫与农业生态健康
研 究 方 向：检疫鉴定与处理
所 在 学 院：农学与生物技术学院

2015 年 6 月

The degree education of plant health in China: script, thesis, dissertation.

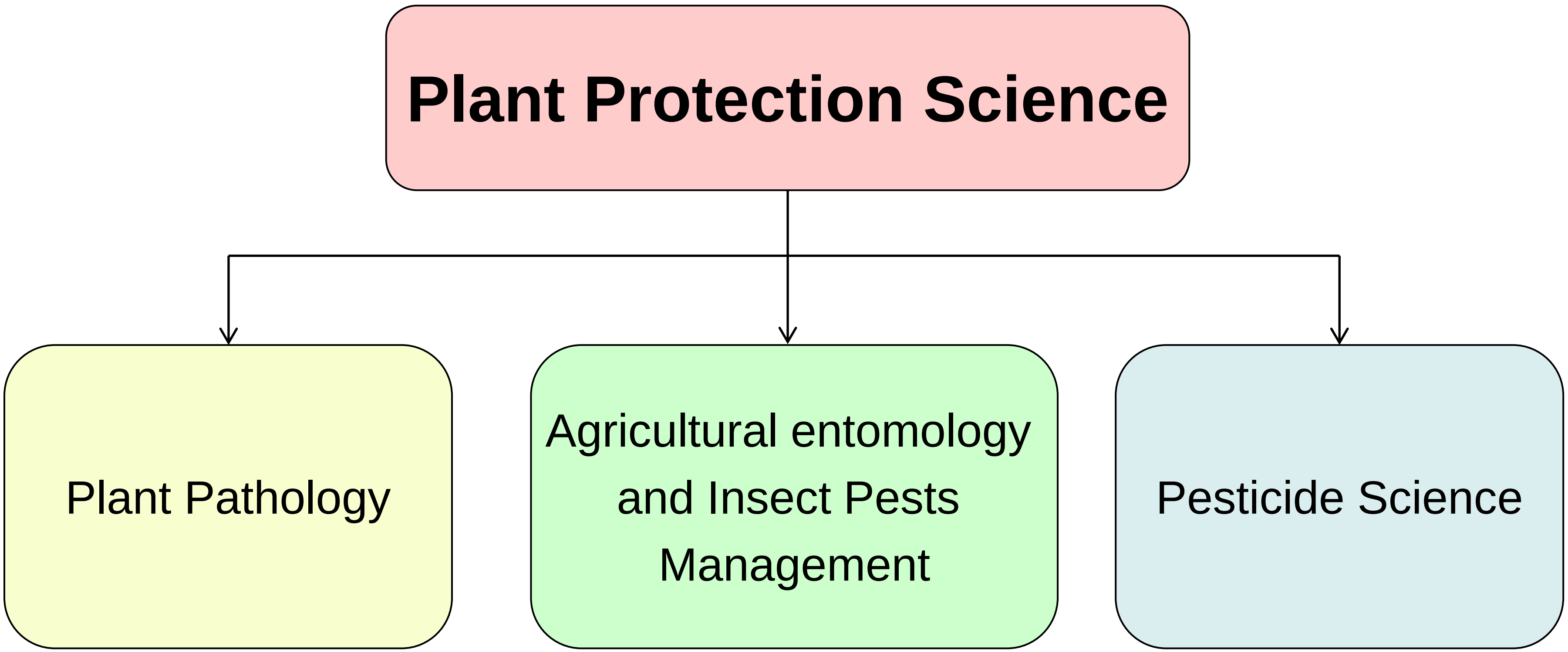
The degree education of plant health in China: more practices in classroom, laboratory, field and international platform.

The Universities and Institutes with Plant Protection Discipline

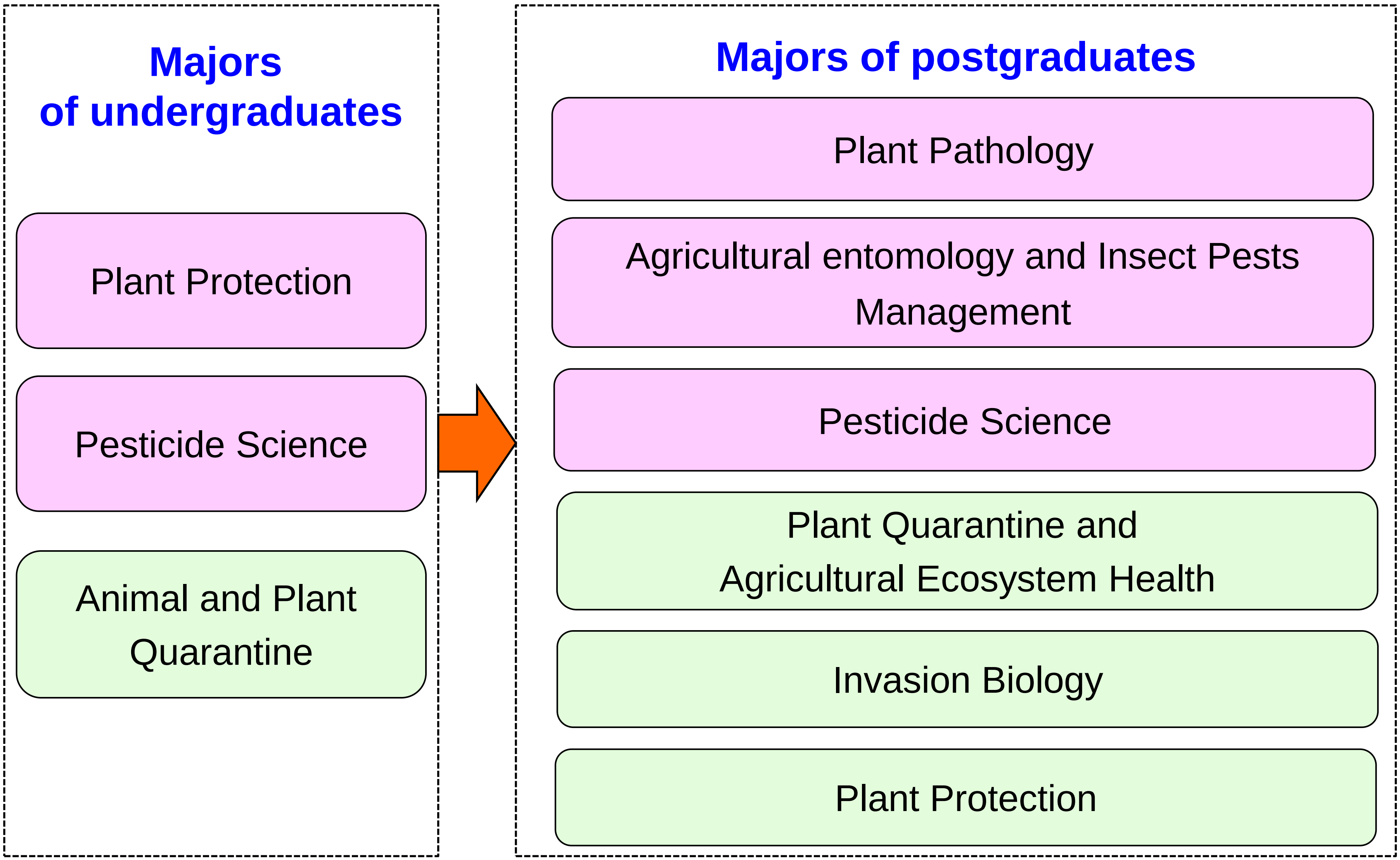
- There are 50+ universities and institutes with the discipline of plant protection in China, 46 with Master Degree program and 24 with PhD program.

Top 10 universities and institutes of PP: ranking by MOE, 2012

- China Agricultural University (985 program), score: 92.
- Zhejiang University (985 program) , score: 90.
- Chinese Academy of Agricultural Sciences, score: 88.
- Nanjing Agricultural University, score: 84.
- Northwest Agriculture and Forestry University (985 program), score: 84.
- Fujian Agriculture and Forestry University, score: 80.
- South China Agricultural University, score: 80.
- Nankai University (985 program), score: 78.
- Huazhong Agricultural University, score: 78.
- Yunnan Agricultural University, score: 78.



The two-class discipline structure of plant health in the degree education in China



The two-level major structure of plant health in the degree education in China

China Agricultural University

中國農業大學
China Agricultural University

Ⅱ. The education practice of plant quarantine and invasion biology in China: CAU as an example

- **Faculties: 108 faculties**, including 54 professors, 46 associate professors.
- **Students: 1533 students**, including 794 undergraduates, 412 Master Degree students, 327 PhD students.
- **Directions: 15 directions** , for research and the education of postgraduates, including Plant Quarantine and Invasion Biology.

（http://cpp.cau.edu.cn/）

The Origin and Development of PQIB

- **From 1990 to 1995:** Specialization of plant quarantine, leading by Prof. Ruihua Jin and Dr. Hong Chen.
- **From 2001 to now:** Laboratory of plant quarantine and invasion biology (CAUPQL), leading by Dr. Zhihong Li.
- **From 2004 to now:** Direction of plant quarantine and invasion biology (PQIB), leading by Dr. Zhihong Li, especially the education of postgraduates.

The Missions of PQIB

- **Teaching:** educating the undergraduates and postgraduates with advanced theory, method and technology of plant quarantine and invasion biology.
- **Research:** studying the techniques, measures and mechanism of prevention and control of quarantine pests and invasive alien species.
- **Service:** providing the technical guidance, decision supports and outstanding professionals of plant quarantine and IAS management to government and other organizations.



The Education of postgraduates and undergraduates

The team of PQIB

- **3 Faculties:** 1 Prof. + 2 Lecturers
- **5 visiting Profs:** from China Academy of Inspection and Quarantine (CAIQ), collaboration program
- **8 supervisors**
  - 2 for PhD students
  - 6 for Master degree students
- **38 postgraduates and undergraduates**
  - 16 PhD students (4-year program and 5-year program, 1 student from Bangladesh of English education)
  - 14 Master degree students (2-year program)
  - 8 undergraduates (1-year program, scripts)

The main courses of PQIB

- Plant Quarantine: 32 hours, for undergraduates, required course of plant protection major, from 1980s.
- Outline of Animal and Plant Quarantine: 32 hours, for undergraduates, elective course, from 2001.
- Treatment Technology of Plant Quarantine: 32 hours, for undergraduates, elective course, from 2006.
- Outline of Plant Protection: 32 hours, in English, for undergraduates, elective course, from 2006.
- Principles and Techniques of Plant Quarantine: 48 hours, for postgraduates, elective course, from 2003.
- IPPC and Plant Quarantine: 32 hours, in English, for postgraduates, elective course, from 2006.
- Invasion Biology: 32 hours, in English, for postgraduates, elective course, from 2011.
- Professional English and Scientific Writing of Plant Quarantine and Agricultural Ecosystem Health: 16 hours, for postgraduates, required course, from 2013.




More practices of plant quarantine during courses

guided by the quarantine officers and experts of AQSIQ and Beijing CIQ etc.

The professional practice programs

More practices of plant quarantine during the thesis and dissertation

guided by the quarantine officers and experts of NATESC and CIQs etc.

More international training of advanced techniques

Quantitative assessment training by Dr. Kriticos and Dr. Paini (CSIRO, Australia) , DNA barcoding training by Dr. Norman Bar (USDA-APHIS-CPHIST, USA)

More opportunities of international research collaboration and communication

for students and faculties of plant quarantine and invasion biology.

The international education programs

Chinese-teaching program:

- Language: learning Chinese, 1 year
- Courses: 1 year
- Thesis/dissertation: 1 year/3 years
- Funds: CSC/Beijing and other scholarship + research program

English-teaching program

- Courses: 1 year
- Thesis/dissertation: 1 year/3 years
- Funds: CSC/Beijing and other scholarship + research program

International students from Thailand, South Africa and etc., guided by the quarantine experts .

The graduates of PQIB during 2001-2016

- From 2001 to 2016, 59 BDs.
- From 2005 to 2016, 85 MDs (5 international graduates)
- From 2007 to 2016, 16 PhDs (1 international graduate)

61.39% graduates (56.47% for MDs and 87.50% for PhDs)
are working at the important organizations in the fields of plant quarantine and invasion biology, e.g., AQSIQ and CIQs, MOA and Plant Protection Stations, Universities and Technical Centers.

The Research Directions of PQIB

- Pest Risk Analysis: quantitative assessment especially, techniques such as SOM, @Risk, CLIMEX/MaxEnt, ArcGIS etc.
- Pests Identification: molecular identification especially, techniques such as DNA Barcoding, PCR, Real-time PCR, Chip etc.
- Pests Treatment: environmentally friendly treatment especially, techniques such as fumigation, irradiation, heat and cold treatment etc.
- Pests Invasion Mechanism: invasive fruit flies and viruses especially, techniques such as genome, transcriptome, RNAi, informatics etc.


MOLECULAR ECOLOGY RESOURCES

Existence of species complex largely reduced barcoding success for invasive species of Tephritidae: a case study in *Bactrocera* spp.


Journal of Insect Physiology

Thermal plasticity is related to the hardening response of heat shock protein expression in two *Bactrocera* fruit flies

Jun-tao Hu, Bing Chen, Zhi-hong Li

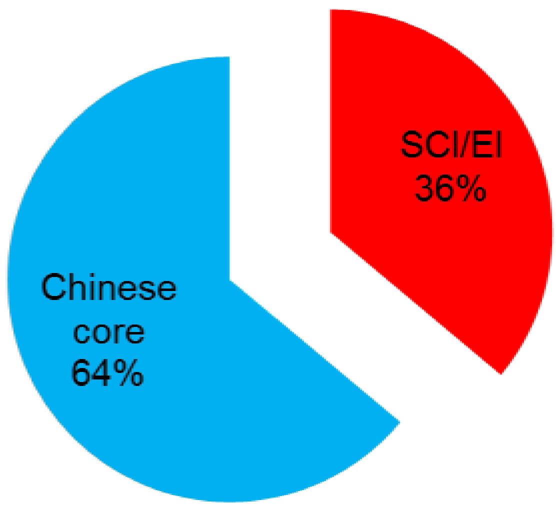

Bacterial communities associated with invasive populations of *Bactrocera dorsalis* (Diptera: Tephritidae) in China

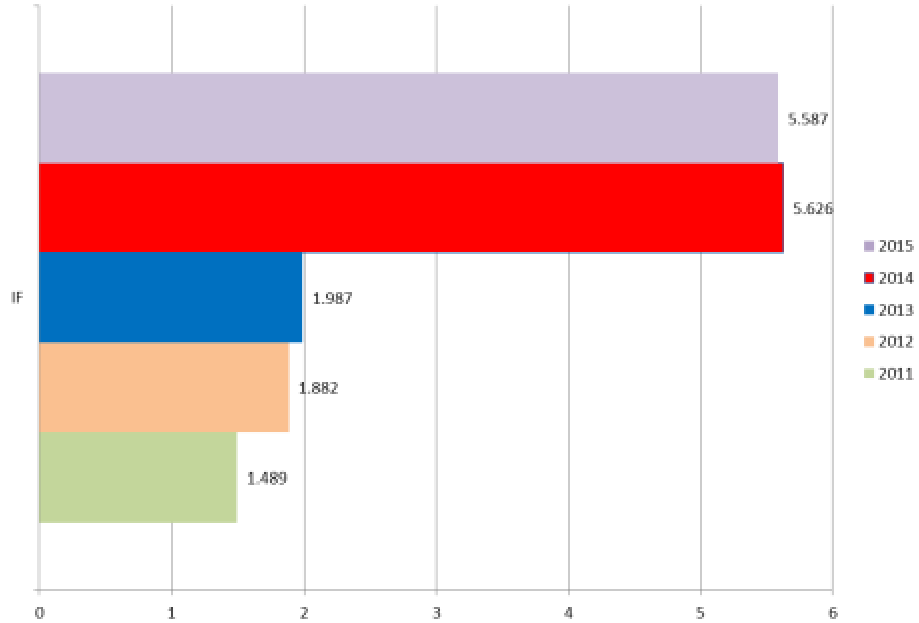
L.J. Liu, I. Martinez-Sañudo, L. Mazzon, C.S. Prabhakar, V. Girolami, Y.L. Deng, Y. Dai and Z.H. Li

Abstract

The main research achievements

- From 2001 to 2016, 122 papers, CAU as the first institute.
- SCI/EI journals: 44 papers (5 papers with IF>5)
- Chinese core journals: 78 papers





The papers and related impact factors during 2001-2015

PLOS ONE

RESEARCH ARTICLE

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

Yujia Qin[1], Dean R. Paini[2]*, Cong Wang[1], Yan Fang[1], Zhihong Li[1]*

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OPEN ACCESS

Citation: Qin Y, Paini DR, Wang C, Fang Y, Li Z (2015) Global Establishment Risk of Economically Important Fruit Fly Species (Tephritidae). PLoS ONE 10(1): e0116424. doi:10.1371/journal.pone.0116424

Academic Editor: Christian Wegener, University of Würzburg, GERMANY

Received: July 12, 2014

Accepted: December 9, 2014

Published: January 14, 2015

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.

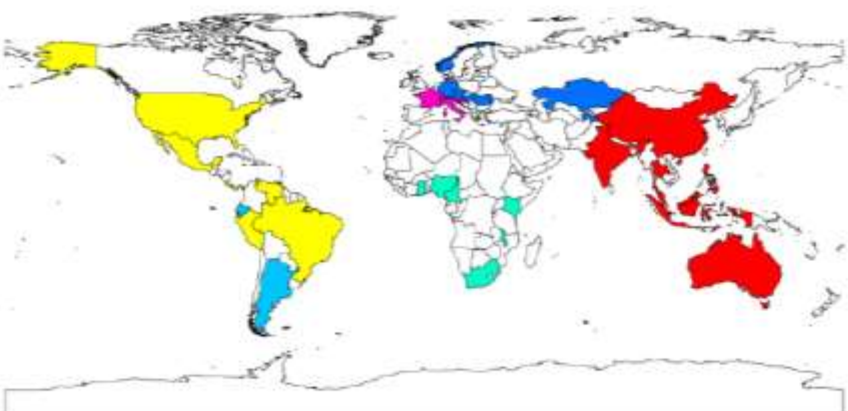

Figure 1. Countries clustering based on fruit fly species assemblages. Map of world showing those countries that were allocated to the same neuron in a SOM analysis (same colour) and hence those countries that have the most similar fruit fly species assemblages.

doi:10.1371/journal.pone.0116424.g001

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)

Liao Fu[1], Zhi-Hong Li[1], Guan-Sheng Huang[2], Xing-Xia Wu[2], Wen-Long Ni[1] and Wei-Wei Qü[1]

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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.

Key words *Anastrepha obliqua*, ArcGIS, climatic change, CLIMEX, potential geographic distribution

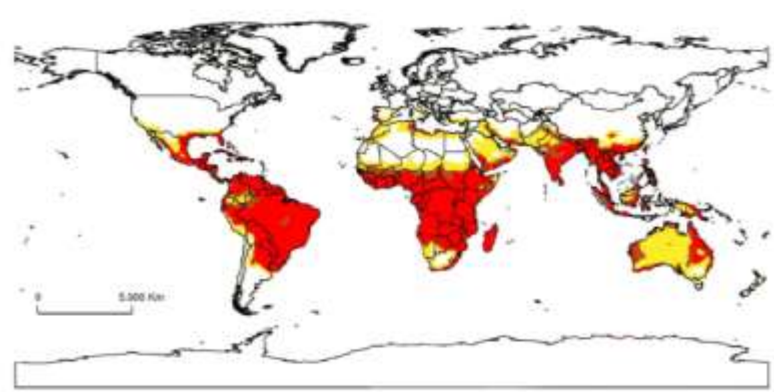

Fig. 2 The global climatic suitability (EI) for *Anastrepha obliqua* under the reference climate (1961–1990 averages) projected using CLIMEX™ □, unsuitable (0.00–0.49); ■, marginal (0.50–9.99); ■, suitable (10–19.99); ■, optimal (20.00+). [GS(2012)1601].

The representative papers of Pest Risk Analysis in CAU

MOLECULAR ECOLOGY RESOURCES
Molecular Ecology Resources (2014) doi: 10.1111/1755-0998.12259

Existence of species complex largely reduced barcoding success for invasive species of Tephritidae: a case study in *Bactrocera* spp.

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Abstract

Fruit flies in the family Tephritidae are the economically important pests that have many species complexes. DNA barcoding has gradually been verified as an effective tool for identifying species in a wide range of taxonomic groups, and there are several publications on rapid and accurate identification of fruit flies based on this technique; however, comprehensive analyses of large and new taxa for the effectiveness of DNA barcoding for fruit flies identification have been rare. In this study, we evaluated the COI barcode sequences for the diagnosis of fruit flies using 1426 sequences for 73 species of *Bactrocera* distributed worldwide. Tree-based [neighbour-joining (NJ)]; distance-based, such as Best Match (BM), Best Close Match (BCM) and Minimum Distance (MD); and character-based methods were used to evaluate the barcoding success rates obtained with maintaining the species complex in the data set, treating a species complex as a single taxon unit, and removing the species complex. Our results indicate that the average divergence between species was 14.04% (0.00–25.16%), whereas within a species this was 0.81% (0.00–9.71%); the existence of species complexes largely reduced the barcoding success for Tephritidae, for example relatively low success rates (74.4% based on BM and BCM and 84.8% based on MD) were obtained when the sequences from species complexes were included in the analysis, whereas significantly higher success rates were achieved if the species complexes were treated as a single taxon or removed from the data set – BM (98.9%), BCM (98.5%) and MD (97.5%), or BM (98.1%), BCM (97.4%) and MD (98.2%).

Table 2 Identification success based on Best Match (BM), Best Close Match (BCM) and Minimum Distance (MD) plus fuzzy set

	Species complex existing	Species complex as a single taxon unit	Species complex removed
BM			
Success (95% CI)	74.4% (72.07–76.60)	98.87% (98.21–99.32)	98.08% (96.83–98.87)
Ambiguous	23.14%	0.21%	0.4%
Misidentification	2.45%	0.91%	1.5%
BCM			
Success (95% CI)	74.4% (72.07–76.60)	98.52% (97.73–99.01)	97.4% (95.98–98.33)
Ambiguous	23.0%	0.06%	0.13%
Misidentification	2.1%	0.35%	0.54%
No match	0.49%	1.05%	1.91%
Threshold	5.03%	1.69%	1.51%
MD			
Success (95% CI)	84.8% (81.39–87.68)	97.5% (95.73–98.55)	98.2% (96.61–99.05)

MOLECULAR ECOLOGY RESOURCES
Molecular Ecology Resources (2016) doi: 10.1111/1755-0998.12542

A high-throughput detection method for invasive fruit fly (Diptera: Tephritidae) species based on microfluidic dynamic array

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*College of Plant Protection, China Agricultural University, Beijing 100193, China, †Institute of Plant Quarantine, Chinese Academy of Inspection and Quarantine, Beijing 100176, China, ‡School of Earth, Environmental and Biological Sciences, Queensland University of Technology (QUT), G.P.O. Box 2434, Brisbane 4000, Qld, Australia, §Faculty of Agriculture, Padjadjaran University, Jatinangor, 40600 West Java, Indonesia

Abstract

Invasive species can be detrimental to a nation's ecology, economy and human health. Rapid and accurate diagnostics are critical to limit the establishment and spread of exotic organisms. The increasing rate of biological invasions relative to the taxonomic expertise available generates a demand for high-throughput, DNA-based diagnostics methods for identification. We designed species-specific qPCR primer and probe combinations for 27 economically important tephritidae species in six genera (*Anastrepha, Bactrocera, Carpomya, Ceratitis, Dacus* and *Rhagoletis*) based on 935 COI DNA barcode haplotypes from 181 fruit fly species publically available in BOLD, and then tested the specificity for each primer pair and probe through qPCR of 35 of those species. We then developed a standardization reaction system for detecting the 27 target species based on a microfluidic dynamic array and also applied the method to identify unknown immature samples from port interceptions and field monitoring. This method led to a specific and simultaneous detection for all 27 species in 7.5 h, using only 0.2 μL of reaction system in each reaction chamber. The approach successfully discriminated among species within complexes that had genetic similarities of up to 98.48%, while it also identified all immature samples consistent with the subsequent results of morphological examination of adults which were reared from larvae of cohorts from the same samples. We present an accurate, rapid and high-throughput innovative approach for detecting fruit flies of quarantine concern. This is a new method which has broad potential to be one of international standards for plant quarantine and invasive species detection.

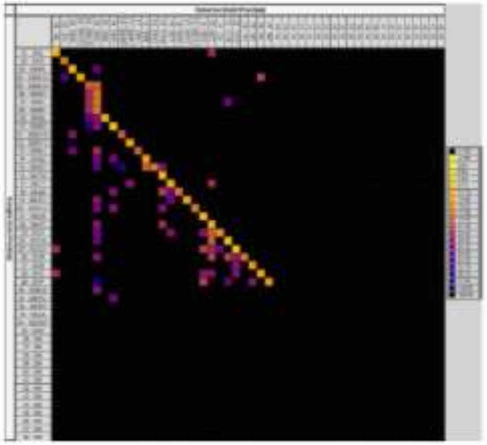

Fig. 1 Specificity of the primer and probe sets of 27 fruit fly species based on a IFC chip. The detector line represented the preprinted primer and probe, and the sample row represented the placement of the DNA. The meaning of the codes in the detector line and the sample row were consistent with Table S5 (Supporting information).

The representative papers of molecular identification on quarantine pests in CAU

Effect of Low-Temperature Phosphine Fumigation on the Survival of *Bactrocera correcta* (Diptera: Tephritidae)

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J. Econ. Entomol. 108(4): 1624–1629 (2015); DOI: 10.1093/jee/tov150

ABSTRACT This laboratory-based study examined the effects of low-temperature phosphine fumigation on the survival of the eggs and larvae of the guava fruit fly, *Bactrocera correcta* (Bezzi). Individual flies at different developmental stages, from 6-h-old eggs to third instars, were exposed to 0.92 mg/liter phosphine for 1–7 d at 5°C. We found that 12-h-old eggs and third instars were the most tolerant to phosphine. Increasing phosphine concentrations from 0.46 to 4.56 mg/liter increased mortality in these two stages. However, increased exposure times were required to achieve equal mortality rates in 12-h-old eggs and third instars when phosphine concentrations were ≥4.56 and ≥3.65 mg/liter, respectively. $C^n t = k$ expression was obtained at 50, 90, and 99% mortality levels, and the toxicity index (n) ranged from 0.43 to 0.77 for the two stages. The synergistic effects of a controlled atmosphere (CA) with elevated CO_2 levels were also investigated, and we found that a CO_2 concentration between 10% and 15% under CA conditions was optimal for low-temperature phosphine fumigation.

Table 4. Synergistic effects of different CA conditions and 1.82 mg/liter of phosphine on *B. correcta* 12-h-old eggs and third instars at 5°C

Stage	CA condition	Slope ± SE[a]	No. of insects	Hetero.	LT_{50} (d) (95% CI)	LT_{90} (d) (95% CI)	LT_{99} (d) (95% CI)	SR
12-h-old eggs	Atmospheric	3.18 ± 0.19	1748	0.53	1.13 (1.02, 1.25)	2.87 (2.58, 3.24)	6.11 (5.19, 7.47)	1
	2.5% CO_2	3.10 ± 0.22	1659	0.60	1.14 (1.03, 1.24)	2.95 (2.64, 3.38)	6.42 (5.31, 8.20)	0.95
	5% CO_2	3.31 ± 0.23	1590	0.74	0.93 (0.83, 1.02)	2.26 (2.04, 2.55)	4.67 (3.94, 5.82)	1.31
	10% CO_2	3.36 ± 0.25	1732	0.58	0.75 (0.66, 0.83)	1.81 (1.63, 2.04)	3.70 (3.12, 4.61)	1.65
	15% CO_2	3.24 ± 0.25	1628	0.75	0.73 (0.64, 0.81)	1.82 (1.64, 2.06)	3.82 (3.21, 4.81)	1.60
3rd instars	Atmospheric	2.45 ± 0.21	1750	0.30	0.56 (0.45, 0.66)	1.86 (1.62, 2.19)	4.97 (3.93, 6.78)	1
	2.5% CO_2	2.35 ± 0.23	1638	0.32	0.49 (0.38, 0.59)	1.71 (1.50, 2.01)	4.76 (3.71, 6.81)	1.04
	5% CO_2	2.49 ± 0.26	1594	0.45	0.43 (0.33, 0.53)	1.41 (1.24, 1.64)	3.70 (2.92, 5.19)	1.34
	10% CO_2	2.87 ± 0.32	1580	0.76	0.39 (0.29, 0.47)	1.09 (0.95, 1.26)	2.51 (2.02, 3.44)	1.98
	15% CO_2	2.98 ± 0.33	1646	0.30	0.40 (0.31, 0.48)	1.08 (0.95, 1.24)	2.41 (1.95, 3.27)	2.06

[a] Mean ± SE.

Table 5. Regression analysis for effects of CO_2 concentrations on synergistic ratio values in *B. correcta* 12-h-old eggs and third instars fumigated with 1.82 mg/liter of phosphine at 5°C

Stage	Regression curves	R^2	$(CO_2\ conc)_{optimal}$ (%)	SR_{max}
12-h-old eggs	$Y = -952.80X^3 + 180.49X^2 - 1.49X + 0.97$	0.965	12.20	1.75
3rd instars	$Y = -1233.80X^3 + 252.09X^2 - 2.96X + 0.99$	0.999	13.00	2.16

Y, synergistic ratio value; X, CO_2 concentration.

Commodity Treatment and Quarantine Entomology

Gamma Irradiation as a Phytosanitary Treatment of *Bactrocera tau* (Diptera: Tephritidae) in Pumpkin Fruits

ZHAN GUOPING,[1] REN LILI,[1] SHAO YING,[2] WANG QIAOLING,[3] YU DAOJIAN,[4] WANG YUEJIN,[1,5] and LI TIANXIU[1]

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ABSTRACT The fruit fly *Bactrocera tau* (Walker) is an important quarantine pest that damages fruits and vegetables throughout Asian regions. Host commodities shipped from infested areas should undergo phytosanitary measures to reduce the risk of shipping viable flies. The dose–response tests with 1-d-old eggs and 3-, 5-, 7-, 8-d-old larvae were initiated to determine the most resistant stages in fruits, and the minimum dose for 99.9968% prevention of adult eclosion at 95% confidence level was validated in the confirmatory tests. The results showed that 1) the pupariation rate was not affected by gamma radiation except for eggs and first instars, while the percent of eclosion was reduced significantly in all instars at all radiation dose; 2) the tolerance to radiation increased with increasing age and developmental stage; 3) the estimated dose to 99.9968% preventing adult eclosion from late third instars was 70.9 Gy (95% CL: 65.6–78.2, probit model) and 71.8 Gy (95% CL: 63.0–87.3, logit model); and iv) in total, 107,135 late third instars cage infested in pumpkin fruits were irradiated at the target dose of 70 Gy (62.5–85.0, Gy measured), which resulted in no adult emergence in the two confirmatory tests. Therefore, a minimum dose of 85 and 72 Gy, which could prevent adult emergence at the efficacy of 99.9972 and 99.9938% at the 95% confidence level, respectively, can be recommended as a minimum dose for phytosanitary treatment of *B. tau* in any host fruits and vegetables under ambient atmospheres.

Table 2. Linear regressions on mortality to adult stage when eggs and larval stages of *B. tau* were irradiated at 7–63 Gy

Stage	Observations	y-intercept (mean ± SE)	Slope (mean ± SE)	R^2	Predicted dose for 100% mortality (Gy)
Egg	15	−25.78 ± 6.00	3.50 ± 0.26	0.9340	33.1
L_1	12	−62.43 ± 11.81	4.43 ± 0.46	0.9028	34.4
L_2	15	−56.08 ± 9.39	3.30 ± 0.32	0.8931	44.3
L_3	18	−43.13 ± 11.64	2.66 ± 0.29	0.8414	50.1
Late L_3	18	−44.21 ± 7.78	2.58 ± 0.19	0.9179	52.0

The representative papers of treatment on quarantine pests in CAU

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CrossMark

ORIGINAL RESEARCH PAPER

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

Yujia Qin[1] · Wenlong Ni[2] · Jiajiao Wu[3] · Zihua Zhao[1] · Hongjun Chen[4] · Zhihong Li[1]

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

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

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

1. from January to December: including Yunnan, Guangxi, Guangdong, and Hainan;
2. from March to November: including Sichuan, Guizhou, Hunan, and Chongqing, Jiangxi;
3. from March to October: Hubei, Fujian, Taiwan, Tibet, Shaanxi, Henan, Anhui, Zhejiang, Jiangsu, and Shanghai;
4. from April to October: including Xinjiang, Qinghai, Gansu, Shanxi, Hebei, Liaoning, Beijing and Tianjin;
5. from May to September: Ningxia, Heilongjiang, Jilin, and Inner Mongolia.

Combined trap of monitoring in China
(photo provided by Dr. Jiajiao Wu, GDIQTC)

CFMFRS for EIFFs monitoring in China

The representative paper and patents of surveillance on quarantine pests in CAU

MOLECULAR ENTOMOLOGY

Microsatellite Markers Reveal Population Structure and Low Gene Flow Among Collections of *Bactrocera cucurbitae* (Diptera: Tephritidae) in Asia

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J. Econ. Entomol. 104(3): 1065–1074 (2011); DOI: 10.1603/EC10395

ABSTRACT The melon fruit fly, *Bactrocera cucurbitae* (Coquillett) (Diptera: Tephritidae), is widespread agricultural pest, and it is known to have the potential to establish invasive populations in various tropical and subtropical areas. Despite the economic risk associated with a putative stable presence of this fly, the population genetics of this pest have remained relatively unexplored in Asia, the main area for distribution of this pest. The goals for this study were to employ nuclear markers to examine geographic collections for population genetic structure and quantify the extent of gene flow within these Southeast Asian and Chinese populations. To achieve these goals, we used 12 polymorphic microsatellite markers. A low level of genetic diversity was found among collections from China and higher levels were seen in Southeast Asia collections. Three genetically distinct groups, Southeast Asia, southwest China, and southeast China, were recovered by Bayesian model-based clustering methods, the phylogenetic reconstruction and the principal coordinate analysis. The Mantel test clearly shows geographical distance contributed in the genetic structuring of *B. cucurbitae*'s populations. No recent bottlenecks for any of the populations examined. The results of clustering, migration analyses, and Mantel test, strongly suggest that the regional structure observed may be due to geographical factors such as mountains, rivers, and islands. We found a high rate of migration in some sites from the southwest China region (cluster 1) and the southeast China region (cluster 2), suggesting that China-Guangdong-Guangzhou (GZ) may be the center of melon fruit fly in the southeast China region.

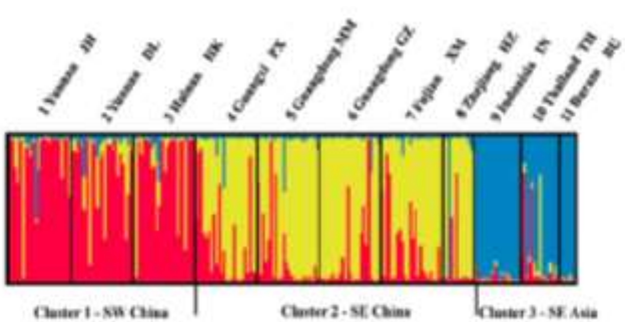

Fig. 3. DISTRUCT plot for 11 *B. cucurbitae* populations at K3 after averaging structure runs with CLUMPP. Individuals are grouped by collection site (1–8, Chinese populations; 9–11, Southeast Asian populations). Population codes (e.g., JH) according to Table 1. Each individual is represented by a vertical bar displaying membership coefficients. (Online figure in color.)

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Thermal plasticity is related to the hardening response of heat shock protein expression in two *Bactrocera* fruit flies

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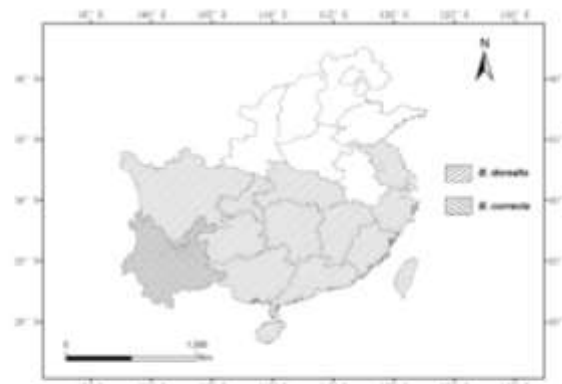
ABSTRACT

It is generally believed that widely distributed species differ in their thermal plasticity from narrowly distributed species, but how differences in thermal plasticity are regulated at the molecular level remains largely unknown. Here, we conducted a comparative study of two closely related invasive fruit fly species, *Bactrocera correcta* and *Bactrocera dorsalis*, in China. The two species had overlapping distributions, but *B. dorsalis* had a much wider range throughout the country and a longer invasive history than *B. correcta*. We first examined the effects of thermal acclimation on the ability of the two fruit flies to survive heat stress. The heat shock tolerance of *B. dorsalis* was significantly enhanced by heat hardening at 35, 37, 39 and 41 °C, but that of *B. correcta* was only enhanced by heat hardening at 39 °C and 41 °C. Thus, the more widespread species has a higher thermal plasticity than the narrowly distributed species. We then determined the expression of Hsp70 and Hsp90 during different developmental stages and their responses to thermal hardening. The expression of both Hsp70 and Hsp90 in larvae was upregulated in response to heat hardening, starting at 35 °C for *B. dorsalis* and at 39 °C for *B. correcta*. The two species exhibited a highly consistent pattern of thermal response in terms of their heat shock survival rates and levels of Hsp gene expression. The results suggest that the difference in thermal plasticity may be responsible for the different distributions of the two species and that Hsp expression may be involved in the regulation of thermal plasticity. Our findings have important implications for the prediction of the thermal limits and ecological responses of related species in nature.



The representative papers of population genetic structure and invasion mechanism of *Bactrocera* in CAU

The Society Services

- Technical support in China: PRA of import fruits and seeds, species identification of fruit flies, stored insect pests and virus etc..
- Decision support in China: plant quarantine measures and standards for AQSIQ, MOA, etc..
- International services: ISPMs of IPPC, Member of International and regional steering committee of pests (e.g. TAAOSC), Editors of international journals etc.



International and national services: technical support, decision support, training, review, workshop etc.

中国農業大學
China Agricultural University

III. The challenges, opportunities and prospects of plant health education

The Challenges of Plant Health Education

- **Global changing:** especially the development of climate change and nitrogen deposition. For pests: So suitable environment!
- **Trade increasing:** especially the development of globalization and e-commerce . For pests: So free trip!
- **Pests evolving:** especially the development of invasive mechanism of pests. For pests: So happy life!

If the earth was a plant and under the control of pests, what will happen for human beings?

(cited from TAAO's logo).

The Opportunities of Plant Health Education

- **Pubic awareness:** more attentions on the importance of plant health in eco-system, e.g., biological invasion and quarantine.
- **More supports:** more funds and programs provided by governments and industries of plant health, e.g., scholarships.
- **International collaboration:** more platforms of common actions based on FAO-IPPC etc., e.g., ISPMs.

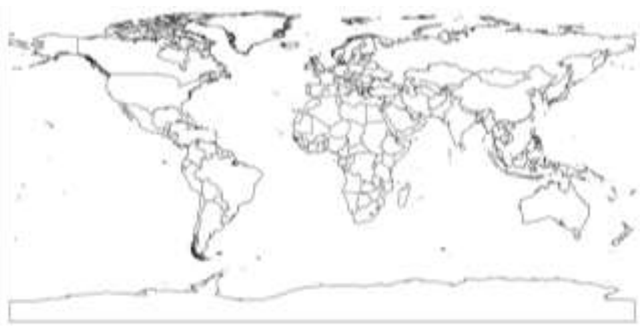
APPPC training on FFM, Jun. 2016

The 1st Symposium of TAAO, Aug. 2016

The Prospects of Plant Health Education

- **To strengthen the four-in-one education system:** especially the public education and the postgraduates education as the basis of prevention and control of pests.
- **To establish the international platform of education:** especially the international collaboration center of plant health education.
- **To develop and share the education resources:** especially the international courses, textbooks, and remote system of plant health education.

species complex + cryptic species, molecular identification + invasion mechanism



International education system of plant health

Outline

- The general situation of education system of plant health in China
- The education practice of plant quarantine and invasion biology in China: CAU as an example
- The challenges, opportunities and prospects of plant health education

BEST WISHES FROM CAU!
LOOKING FORWARD TO MORE COLLABORATIONS AND PROGRESS ON PLANT HEALTH!