IPM in staple and horticultural crops

Sunday Ekesi

icipe

Presentation outline

- Examples of *icipe* IPM strategies on staple and horticultural pests
  - ✓ Push pull technology - Staples
  - ✓ Fruit fly IPM - Horticulture

Target pest on staple and horticultural crops

Stemborers

30% yield loss
$1.5 billion loss annually
Khan et al. 2017

Fall armyworm

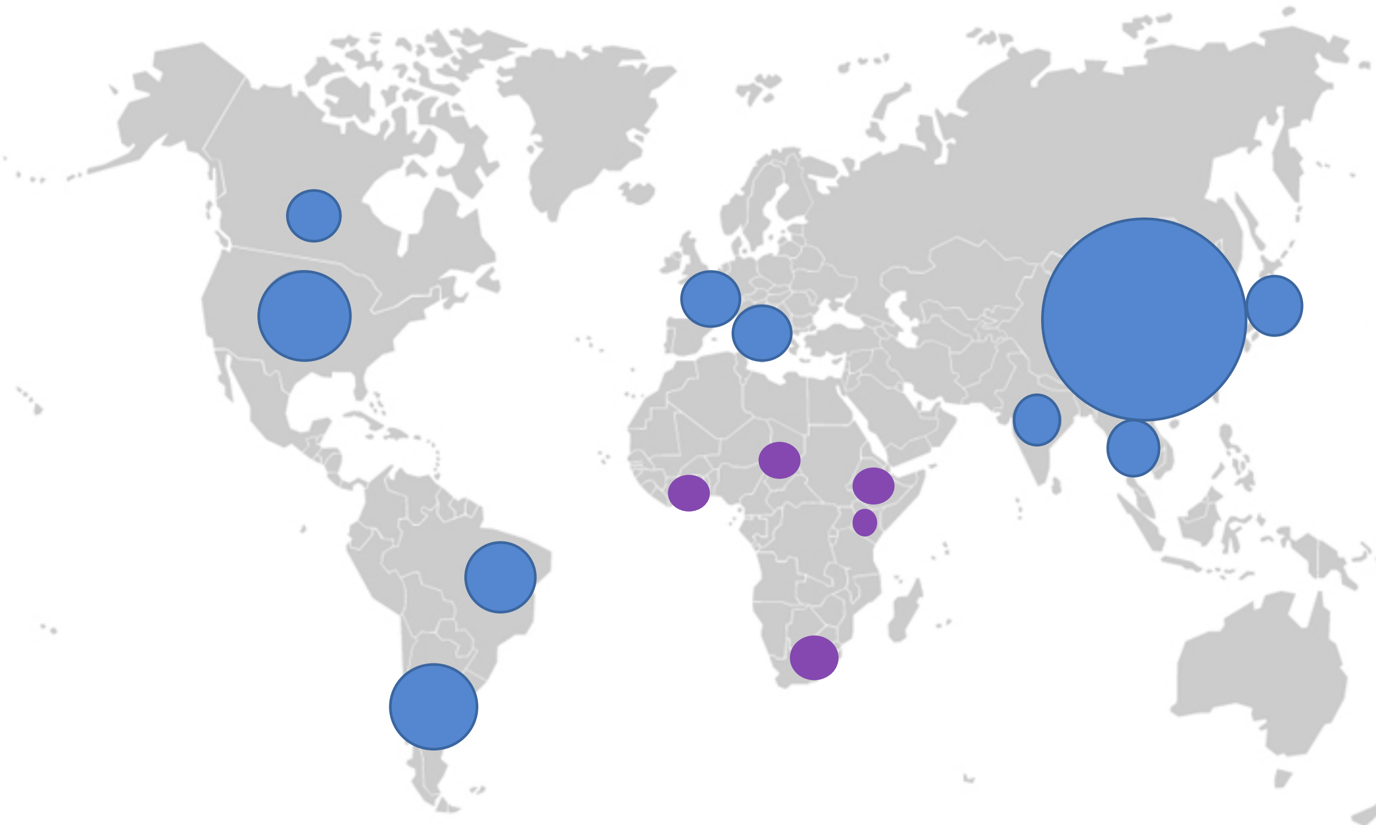
40-80% yield loss
$6 billion loss annually
CABI, 2017

Fruit flies

30-80% yield loss
$2 billion loss annually
Ekesi et al. 2016

Global volume of pesticides applied on crops

Annual pesticide consumption worldwide – 3.5 billion kg AI per year



Sources: Pretty and Bharucha, *Insects*, 2015, FAOSTAT, OECD.

Top consumers

- China 1,806*
- USA 386
- Argentina 265
- Thailand 87
- Brazil 76
- Italy 63
- France 62
- Canada 54
- Japan 52
- India 40
- S/Africa 27
- Ghana 15
- Cameroun 11
- Ethiopia 4
- Kenya 1.6

*Millions of kg

The push-pull technology

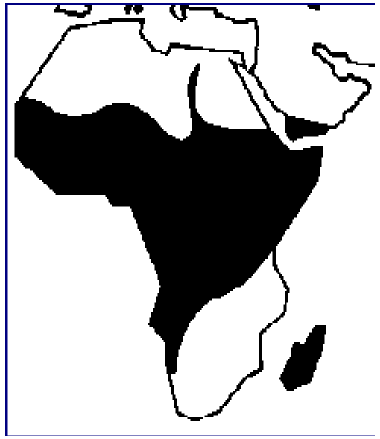
Stemborers, FAW, striga, soil fertility, aflatoxin, fodders

Stemborers

Cereal stemborers cause ~30% yield loss in maize production in Africa

Kfir, Overholt, **Khan,** and Polaszek, 2002, *Annu. Rev. Entomol*. 47: 701-31

Striga



The parasitic witchweeds, *Striga* spp, threaten the lives of over 100 m people in Africa and infest 40% of arable land in the savannah region causing an annual loss of $7-$13 billion in African agricultural economy.

Khan et al (2008) Field Crops Res 106:224–233
Khan et al (2006) Crop Prot 25:989–995

Push pull field

1 cereal + 2 perennial companion crops

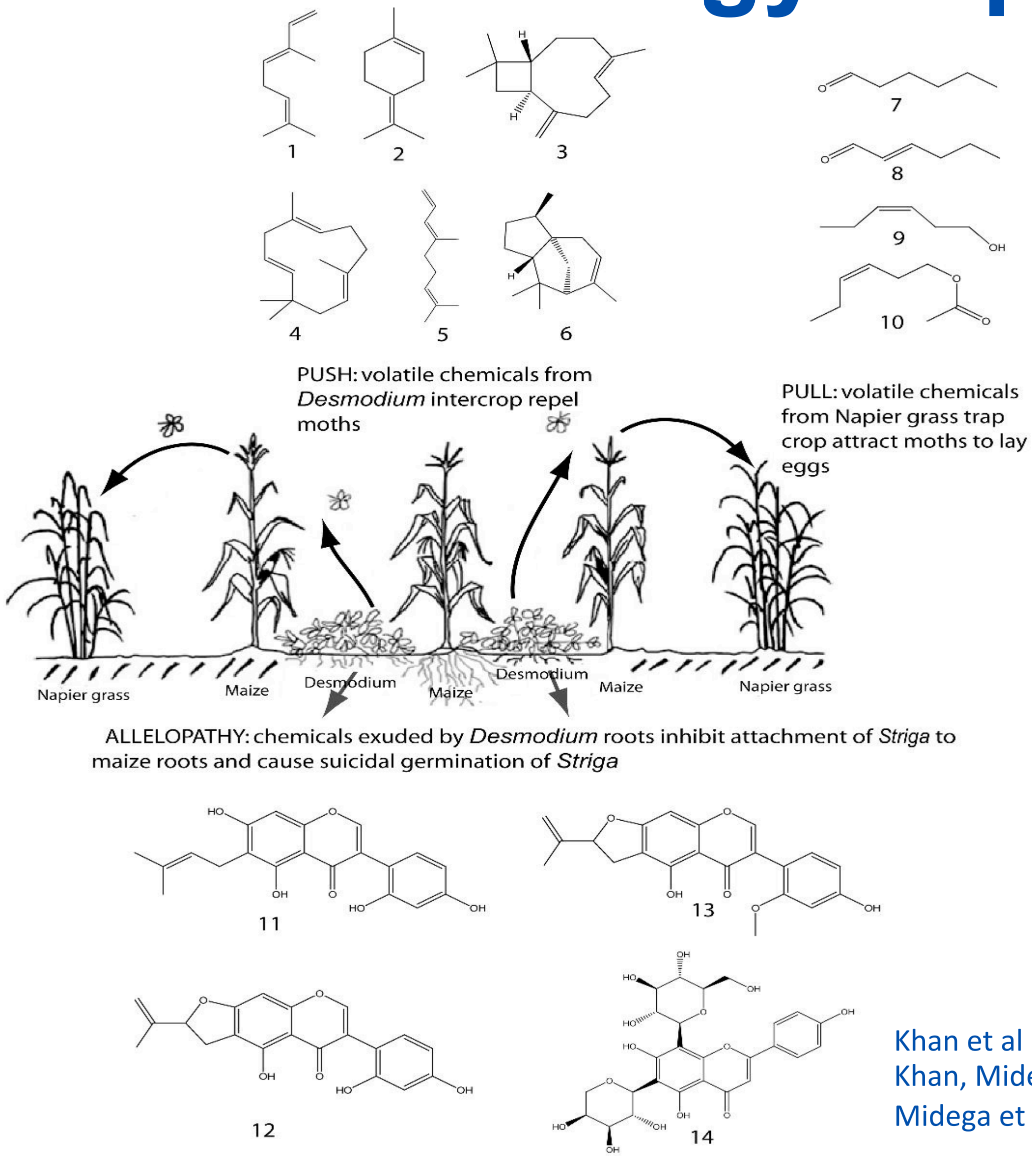
Push-pull encompasses intercropping maize with the legume desmodium and a border row of Napier grass around the plot; both desmodium and Napier grass are perennial fodder plants

Chemical ecology of push-pull

1= (*E*)-ß-ocimene;
2= α-terpinolene;
3= β-caryophyllene;
4= humulene;
5= (*E*)-4,8-dimethyl-1,3,7-nonatriene;
6= α-cedrene;

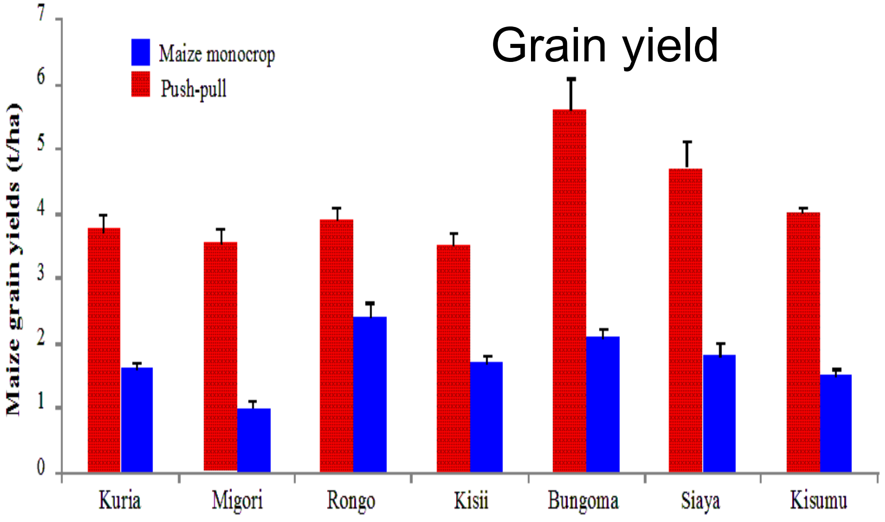
7= hexanal;
8= (E)-2-hexenal;
9= (Z)-3-hexen-1-ol;
10= (Z)-3-hexen-1-yl acetate ;

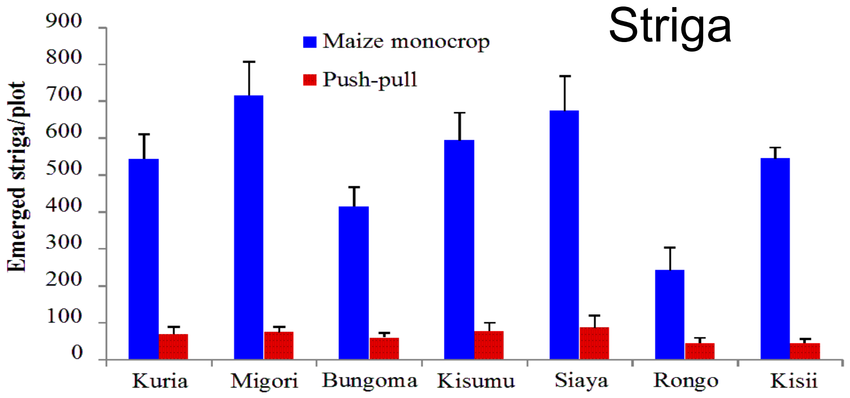
11= 5,7,2′,4′-tetrahydroxy-6-(3-methylbut-2-enyl)isoflavanone (uncinanone A);
12= 4″,5″-dihydro-5,2′,4′-trihydroxy-5″-isopropenylfurano-(2″, 3″;7,6)-isoflavanone (uncinanone B); 13= 4″,5″-dihydro-2′-methoxy-5,4′-dihydroxy-5″-isopropenylfurano-(2″,3″;7,6)-isoflavanone (uncinanone C), 14= di-*C*-glycosylflavone 6-*C*-α-L-arabinopyranosyl-8-*C*-β-Dglucopyranosylapigenin

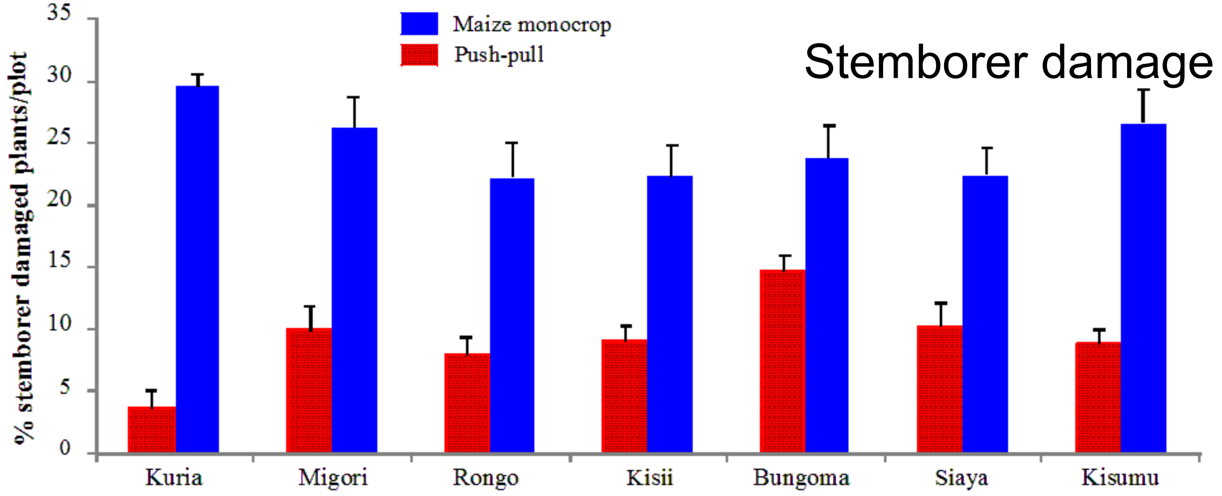


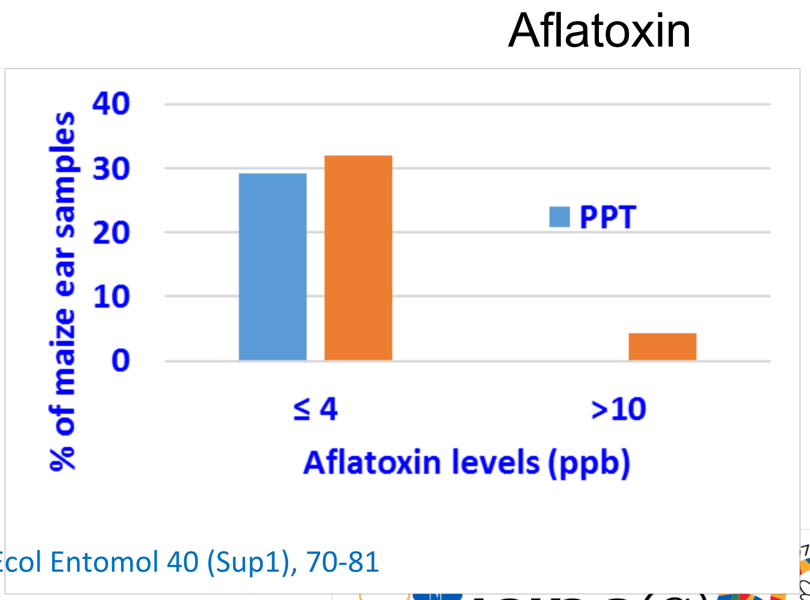
Khan et al (1997) Nature Nature 388: 631-632
Khan, Midega et al., 2010, J. Exp Bot 61, 4185–4196
Midega et al., 2015. Ecol Entomol 40(Sup1), 70-81

The push-pull technology



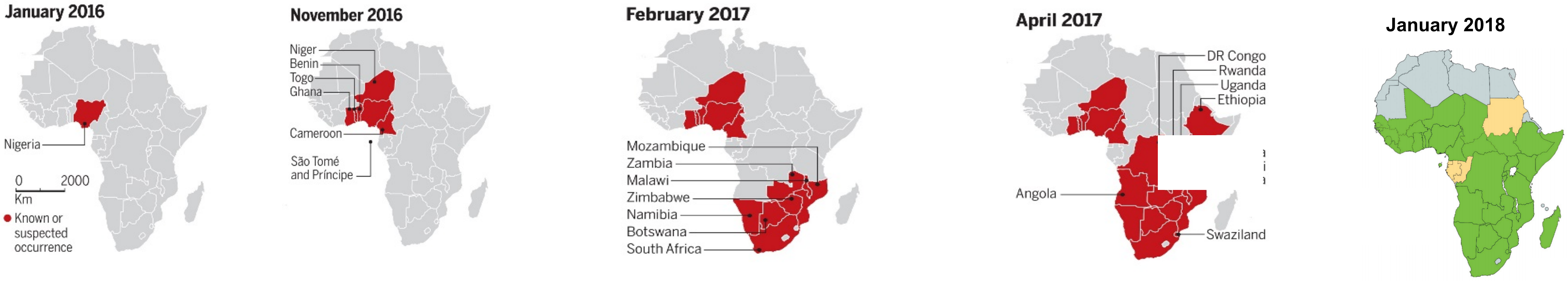






Midega et al., 2015. Ecol Entomol 40 (Sup1), 70-81

Fall armyworm invasion of Africa



Economic Impact on maize: US$6.2 billion annually (CABI, 2017)

Source: Eric StokStad (2017), *Science* **356** (6337), 473-474

Emergency response!!!

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Posts Tagged: Army worm

1 May

Ugandan govt considers aerial spray against Fall Armyworm

Author: guide - Category: News - No Comments

The EastAfrican NEWS BUSINESS OPED SCIENCE & HEALTH MAGAZINE RWANDA TO

Rwanda faces hunger over fall armyworm invasion

SATURDAY APRIL 22 2017

icipe@50 1970 – 2020 Insects for Life

Push-pull effectively controls FAW

Crop Protection 105 (2018) 10–15

Contents lists available at ScienceDirect

Crop Protection

journal homepage: www.elsevier.com/locate/cropro

A climate-adapted push-pull system effectively controls fall armyworm, *Spodoptera frugiperda* (J E Smith), in maize in East Africa

Charles A.O. Midega[a,*], Jimmy O. Pittchar[a], John A. Pickett[b], Girma W. Hailu[a], Zeyaur R. Khan[a]

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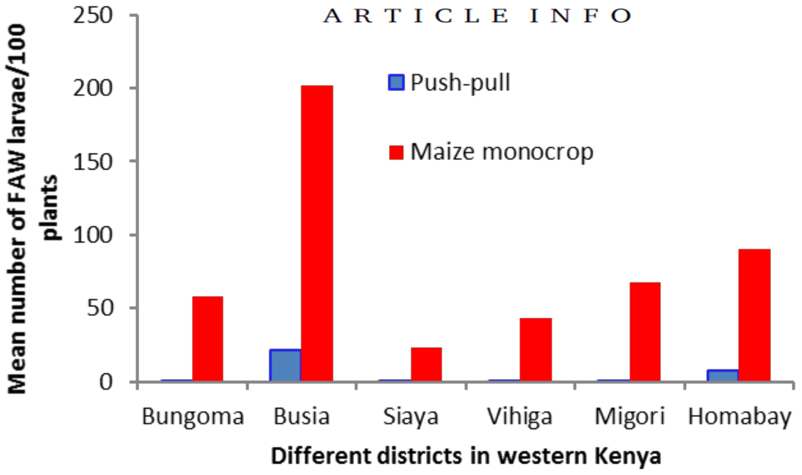
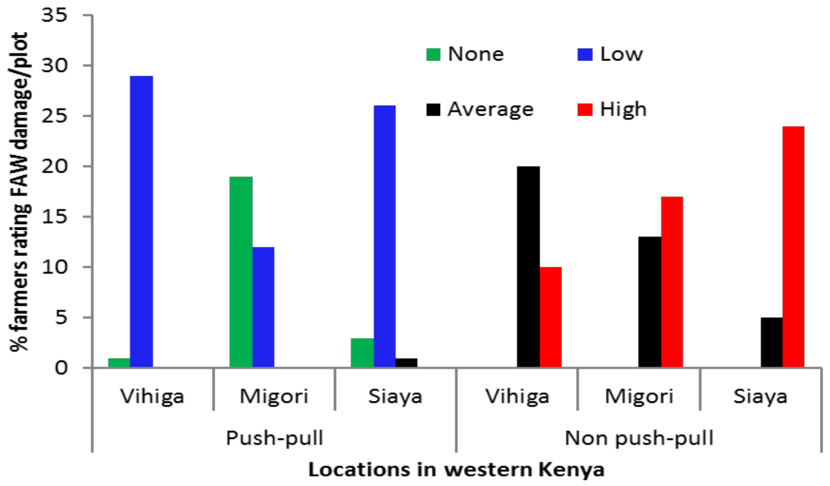
[b] *Department of Biological Chemistry and Crop Protection, Rothamsted Research, Harpenden, UK*

ARTICLE INFO

ABSTRACT





The push-pull technology – Natural enemy diversity in push pull field

Native parasitoid for FAW management

Chelonus curvimaculatus

5%
parasitism

Cotesia icipe

5 – 45%
parasitism

Charops ater

7 – 12%
parasitism

Coccygidium luteum

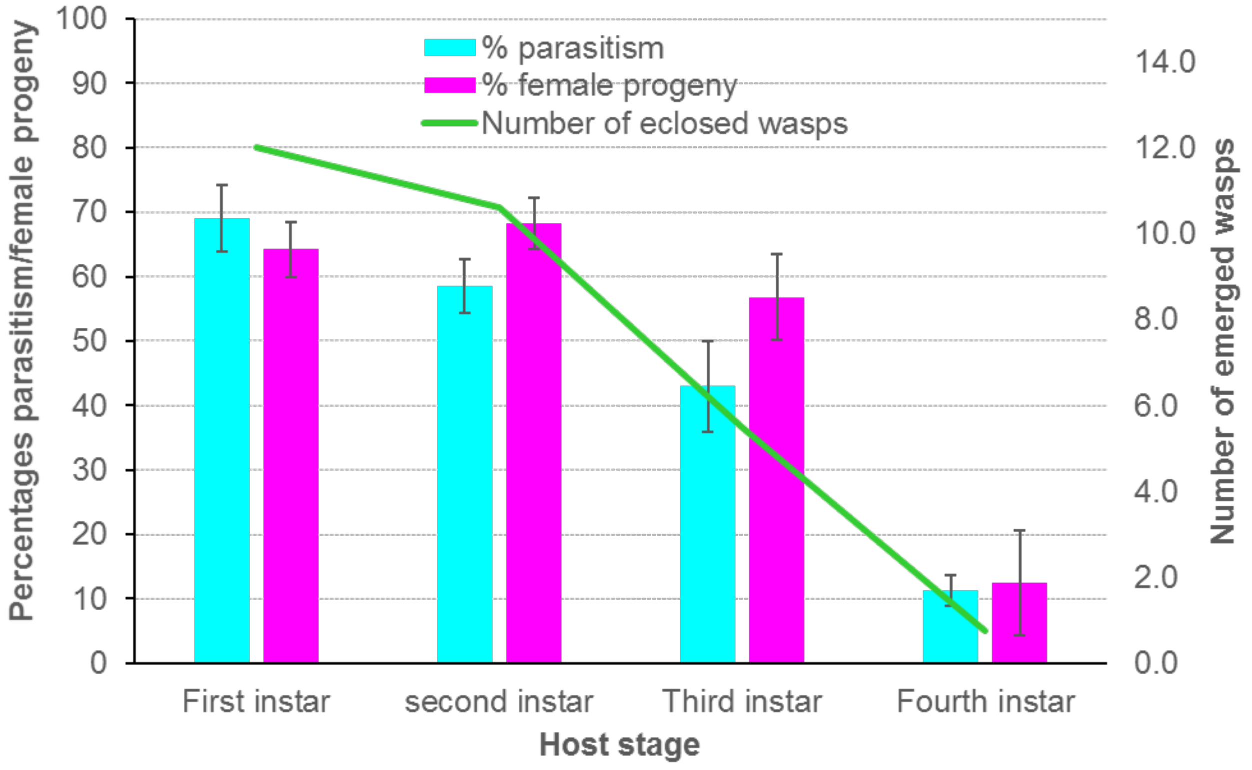
5 – 8%
parasitism

Palexorista zonata

5 – 13%
parasitism

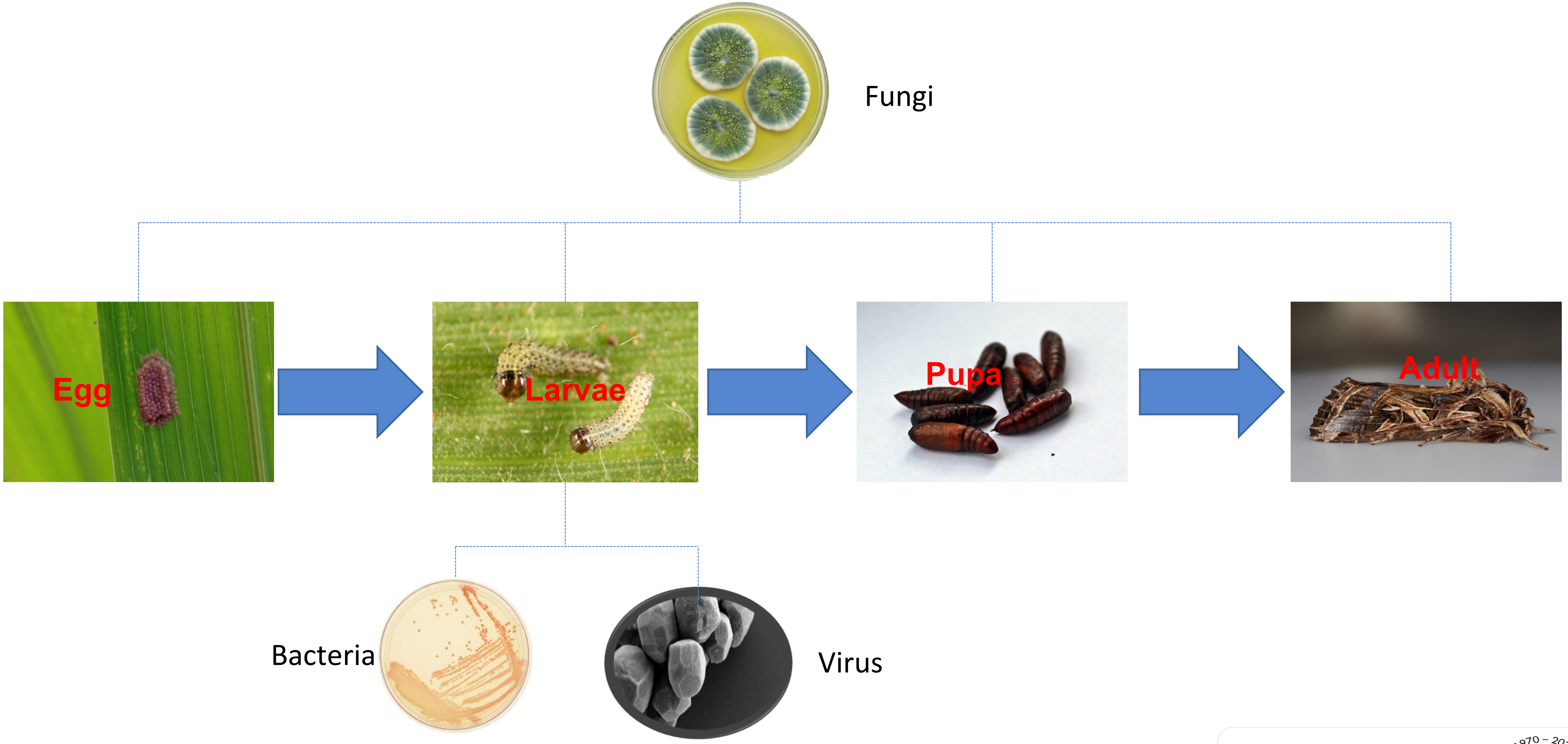
Sisay et al. 2018. J. Appl. Entomol.

Performance of *Cotesia icipe* on various larval instar of FAW

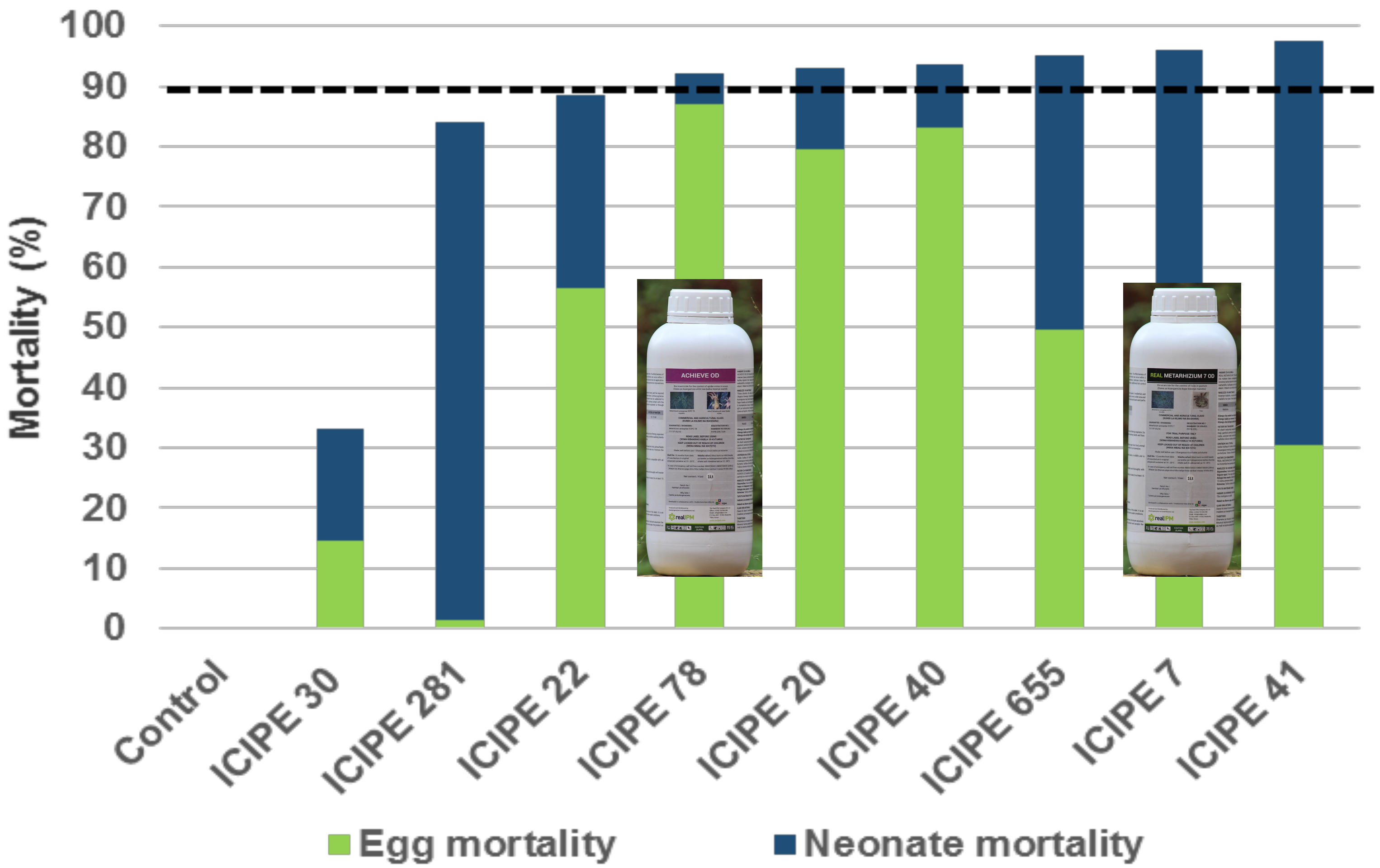


Agbodzavu, Ekesi et al. 2018. J. Appl. Entomol.

Biopesticide products for all stages for FAW

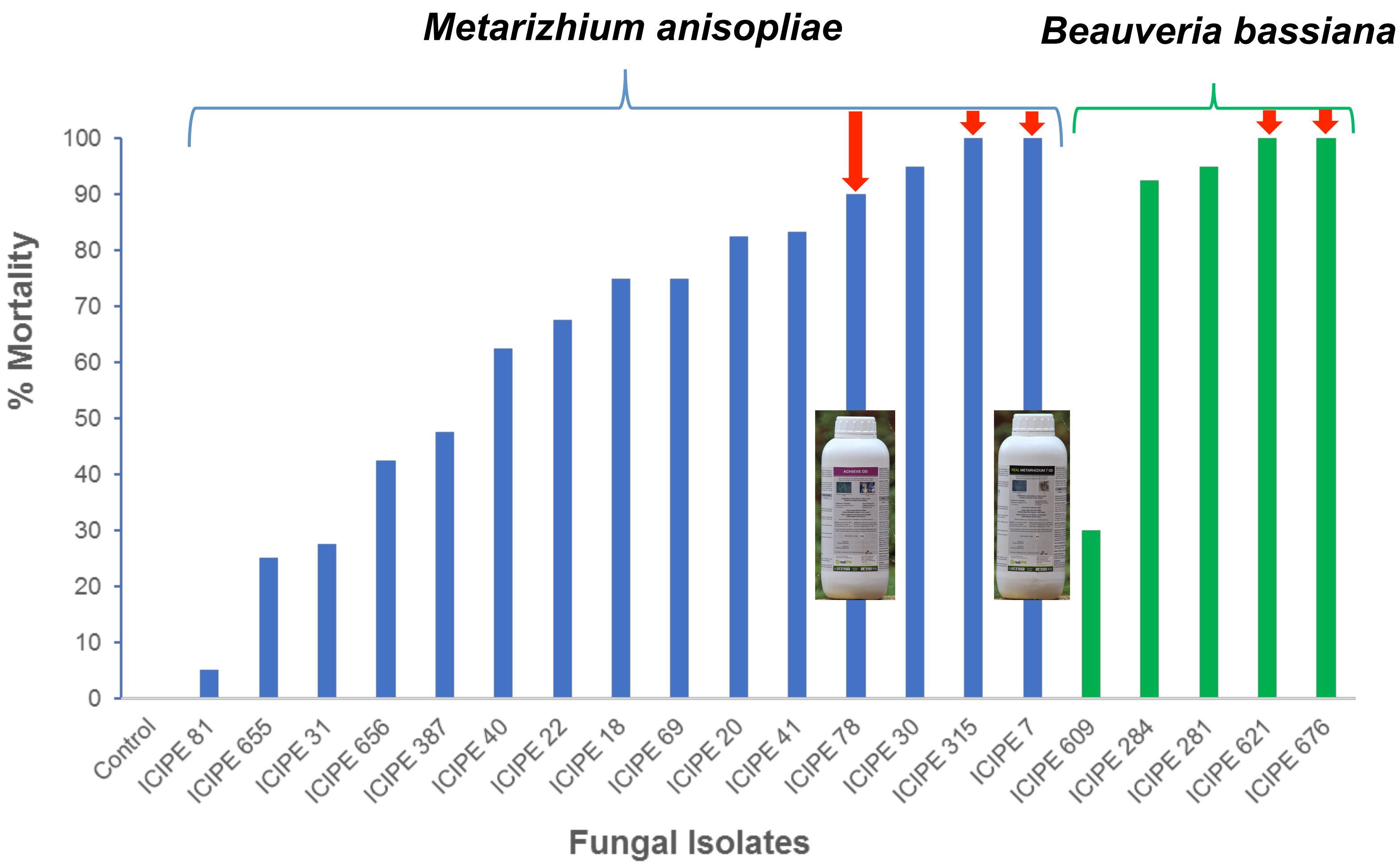


Efficacy of fungal biopesticide on FAW egg and larvae



Akutse, Ekesi et al. 2019. J. Appl. Entomol.

Efficacy of fungal biopesticides on FAW adults



- ***M. anisopliae*** – ICIPE 315 & ICIPE 7 and ***B. bassiana*** – ICIPE 621 & ICIPE 676 caused 100% mortality

Fruit fly IPM

Fruit flies as major constraint

- **In Africa:** fruit flies cause annual loss of fruits and vegetables worth US$ 2.0 billion
- **Direct damage:** 30-100% of fruits destroyed by maggots feeding on pulp
- **Indirect damage:** quarantine restrictions on trade & lost of export opportunities

Ekesi et al. 2016. *Ann. Rev. Entomol*. 61
Ekesi et al. 2014. *J. Econ. Ent.* 107(1): 299-309
Ekesi et al. 2011. *Acta Hort.* 911: 165-184

Fruit flies – implications on trade

- **US Federal order:** has place total band on several horticultural produce from countries in Africa where *Bactrocera dorsalis* have been report
- **EU**: Maximum Residue Levels are being implemented
- **Implications**: Lost of export markets, income, jobs, poor nutrition

Examples of fruit fly complex

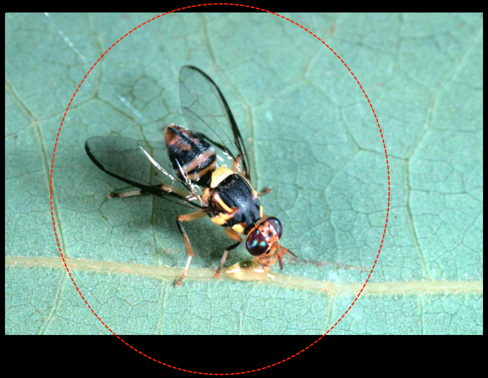
Ceratitis cosyra

Ceratitis capitata

Ceratitis anonae

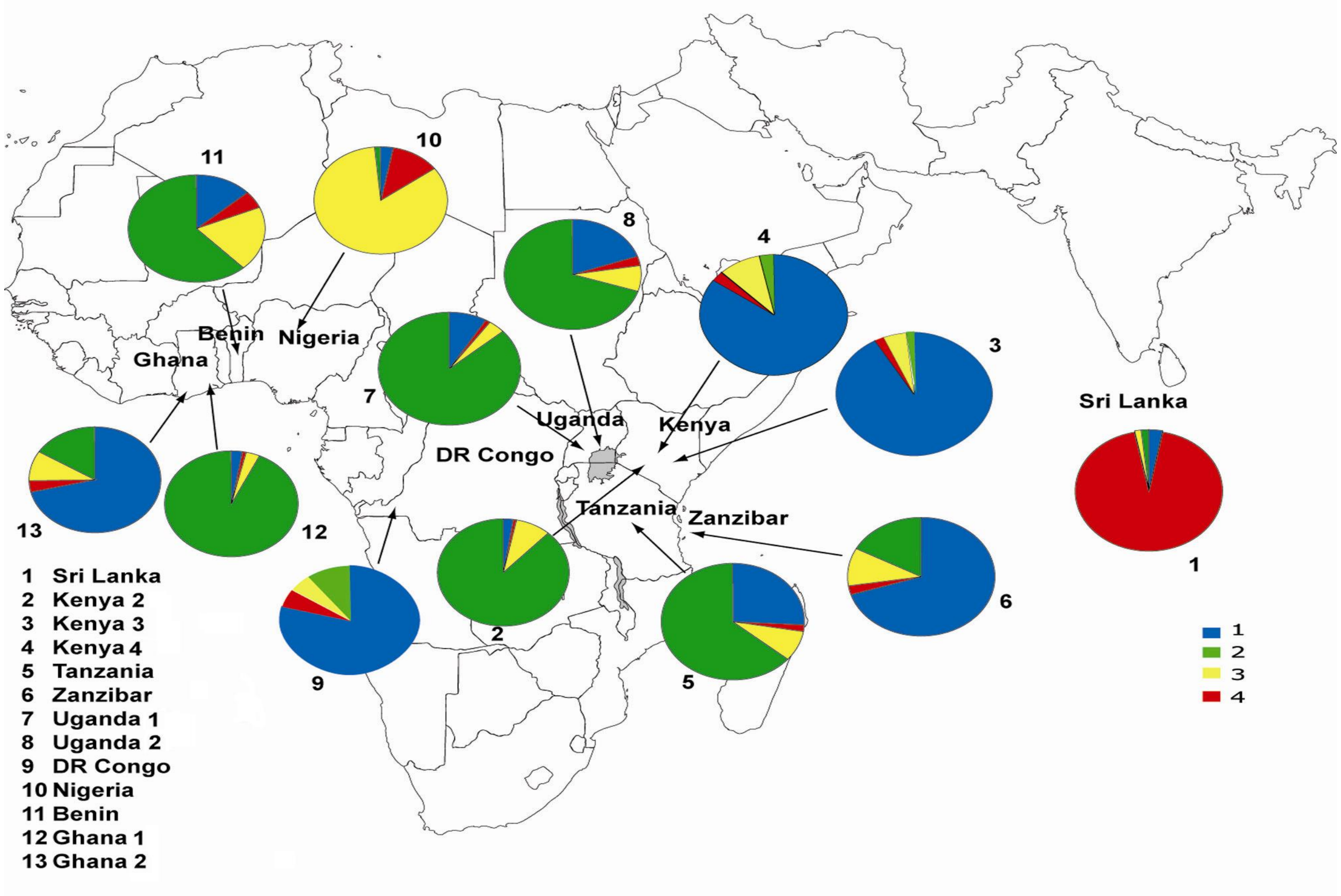
Ceratitis fasciventris

Ceratitis rosa



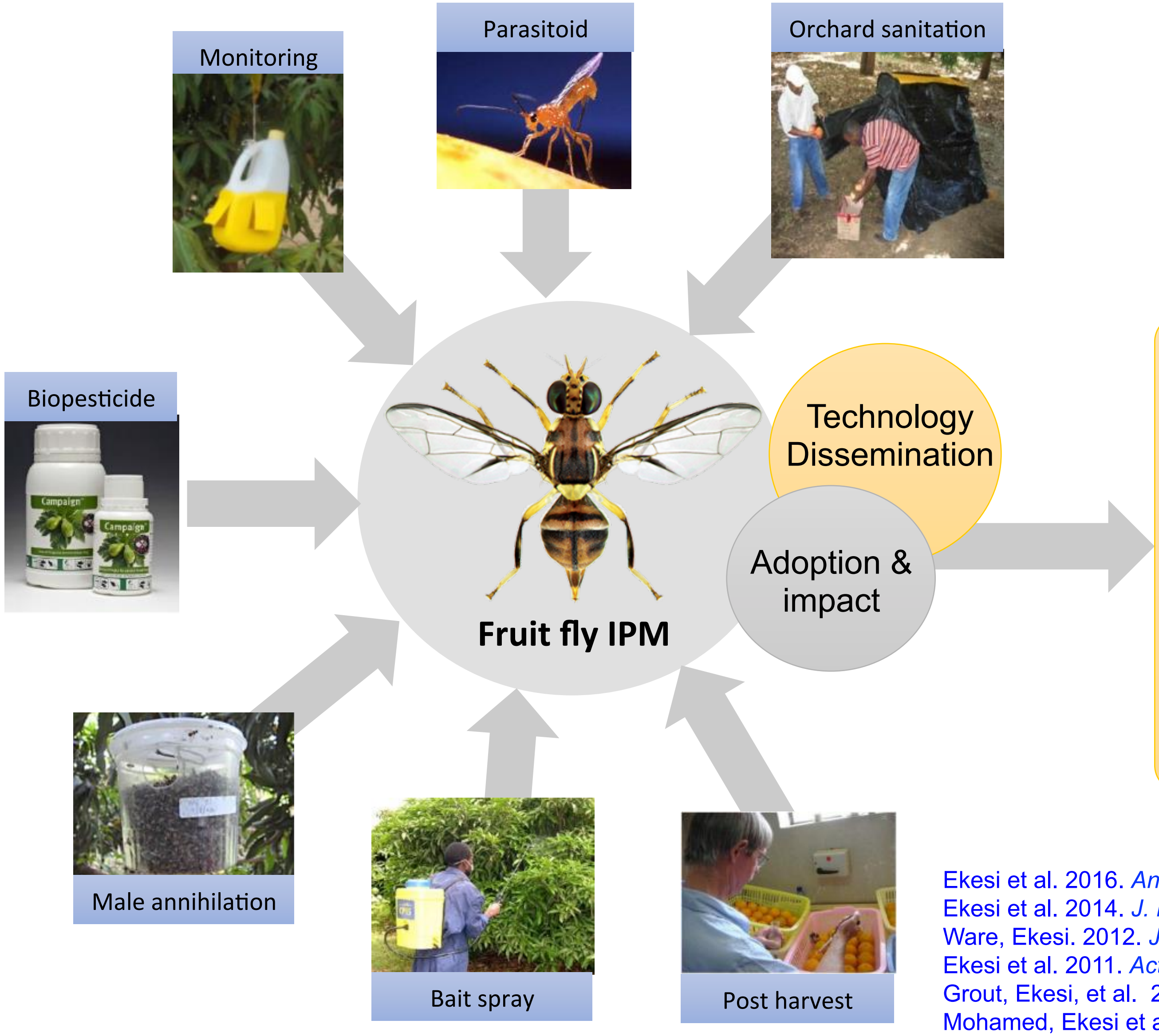
Bactrocera dorsalis

B. dorsalis populations



Khamis, **Ekesi** et al. (2009) *Mol. Ecol.* 18: 4798-4810

Fruit fly Management options



- Improved yields
- Income
- Employment
- Improved health
- Low production costs
- Access to inputs

Ekesi et al. 2016. *Ann. Rev. Entomol*. 61
Ekesi et al. 2014. *J. Econ. Ent.* 107(1): 299-309
Ware, Ekesi. 2012. *J. Econ. Entomol*. 105: 1963-1970
Ekesi et al. 2011. *Acta Hort.* 911: 165-184
Grout, Ekesi, et al. 2011 . *J. Econ. Entomol*. 104: 1180-1188
Mohamed, Ekesi et al. 2010. Bio. Sci. Tech. 20: 183196

icipe/Kenya Biologics Partnership - Fruitflymania™

KENYA BIOLOGICS
Green, safe, and cost-effective crop protection

Biopesticide + bait spray

Biopesticide

+

Bait

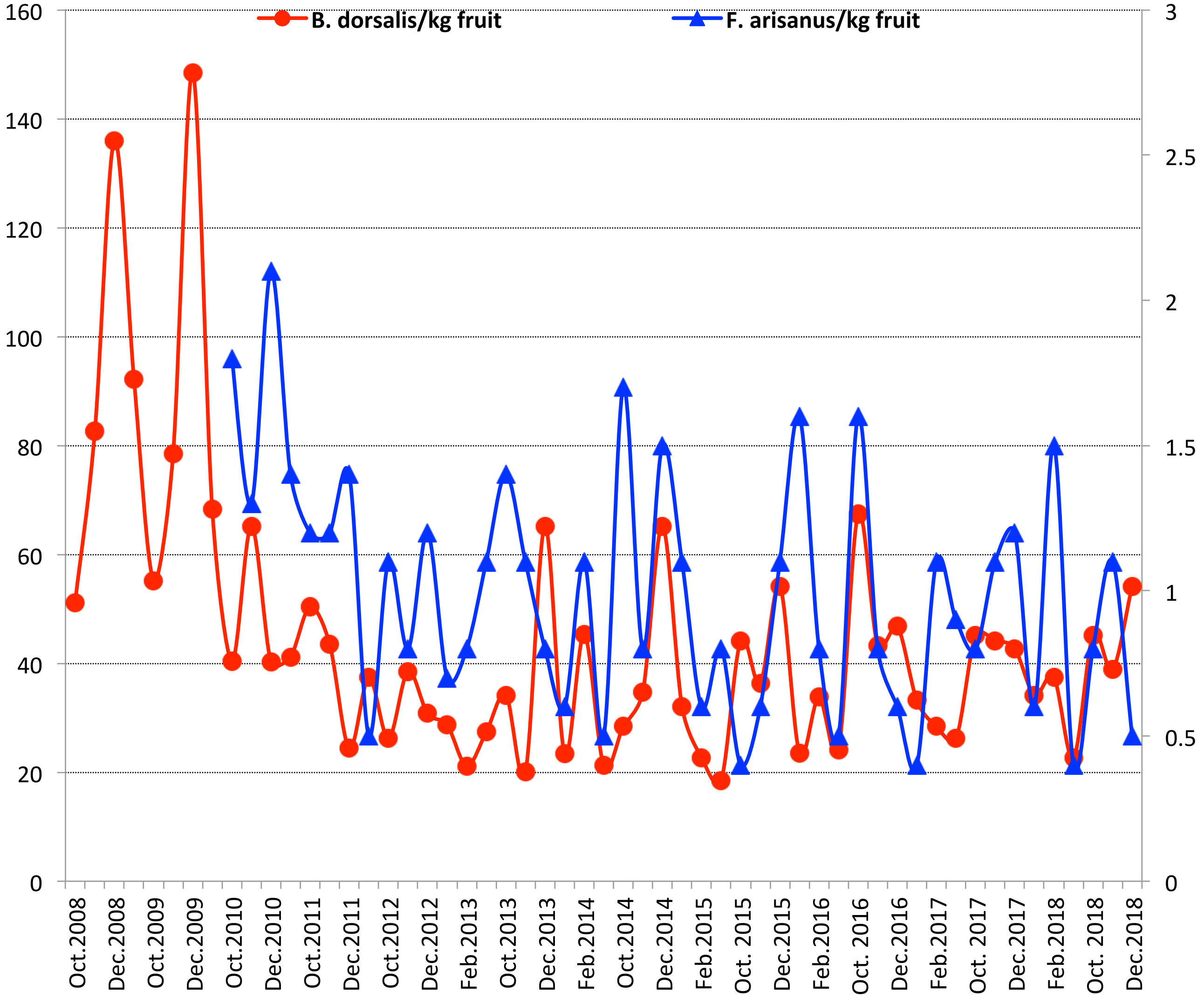
Treatments	Yield (kg/ha)	% Yield gain	Monetary gain (US$/ha)
Protein bait+Biop	17,765	82	3514
Protein bait	12,876	75	2341
Biopesticide	10,114	69	1678
Control	3121		

Ekesi et al (2011) Biocontr. Sci. Tech. 21 (3) 299 – 316

Parasitoid introduction from Hawaii – releases & establishment

Fopius arisanus

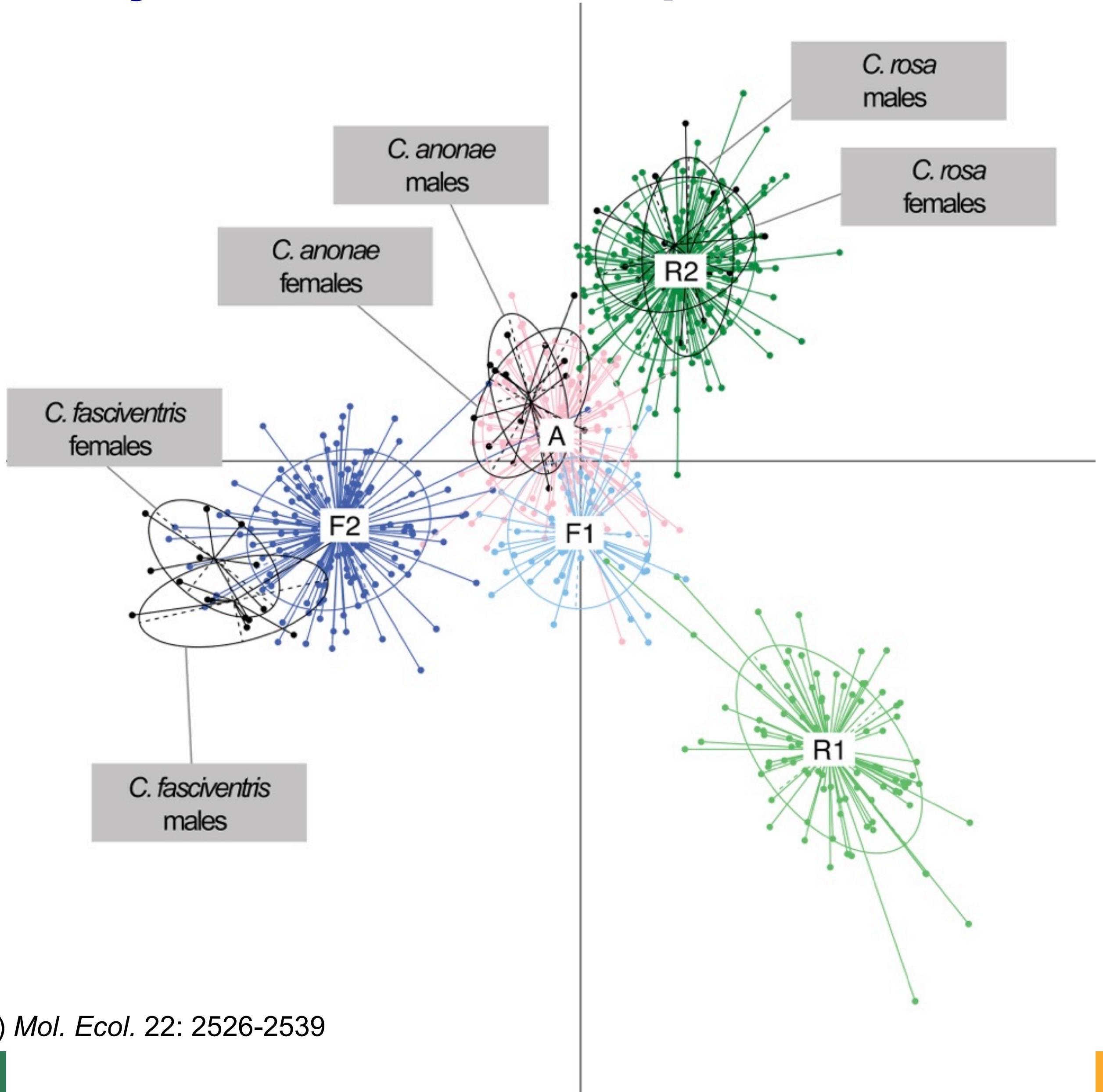
Diachasmimorpha longicaudata



USDA

Parasitoid releases and establishment > 12 African countries

Taxonomic variability in the FAR complex

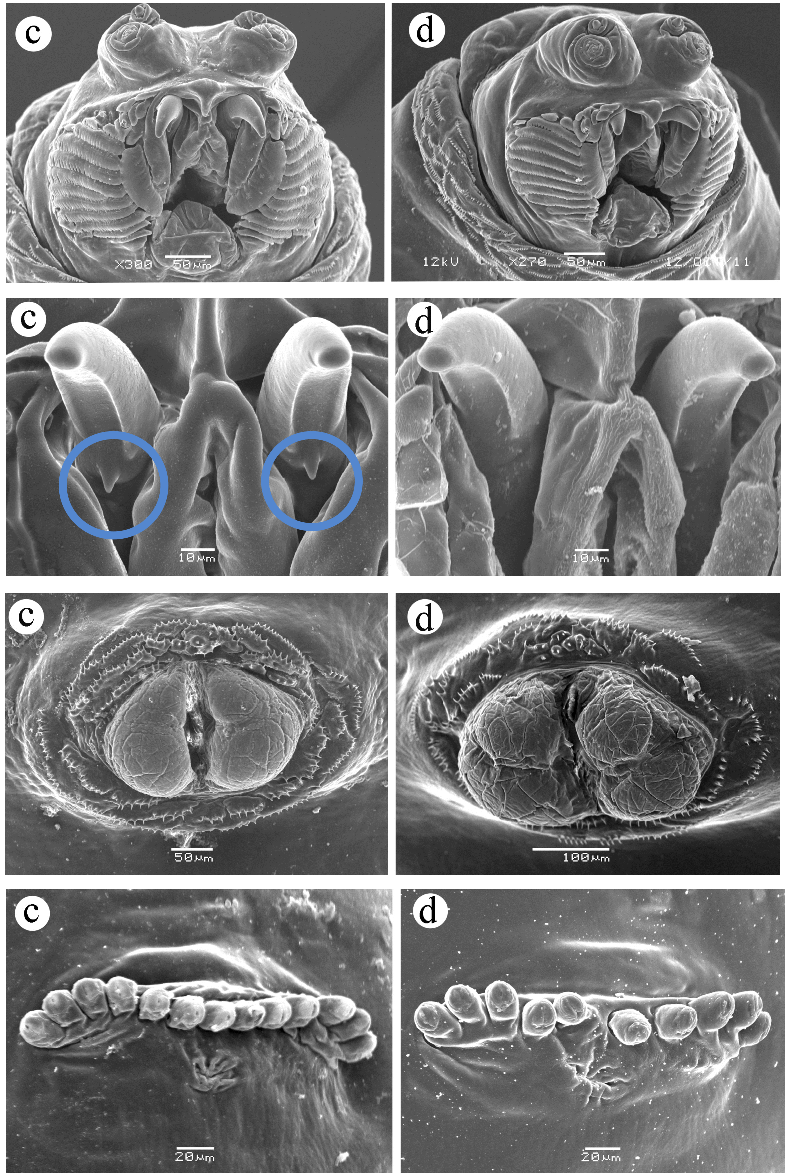


 Virgilio et al (2013) *Mol. Ecol.* 22: 2526-2539

Head – *Ceratitis rosa*

Steck & **Ekesi** (2015) *Zookeys.* doi: 10.3897/zookeys.540.10061

R1 - Lowland | R2 - Highland



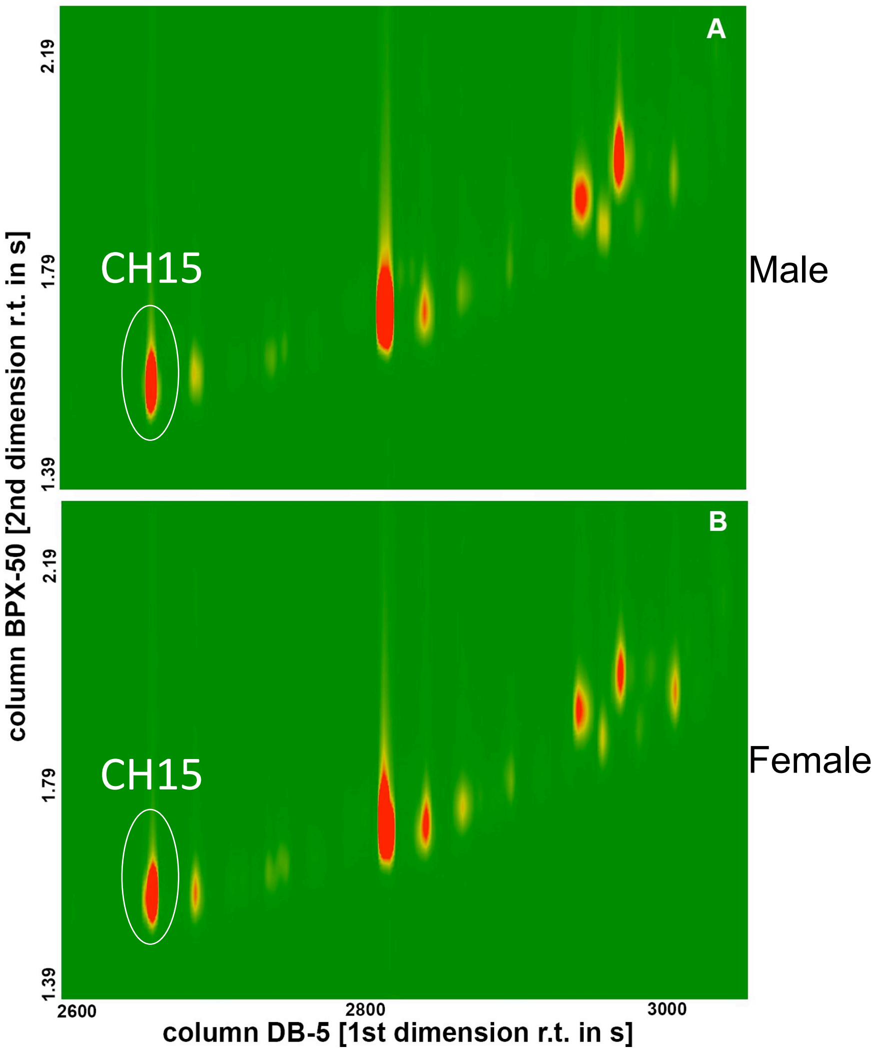
Head

Mouth hooks

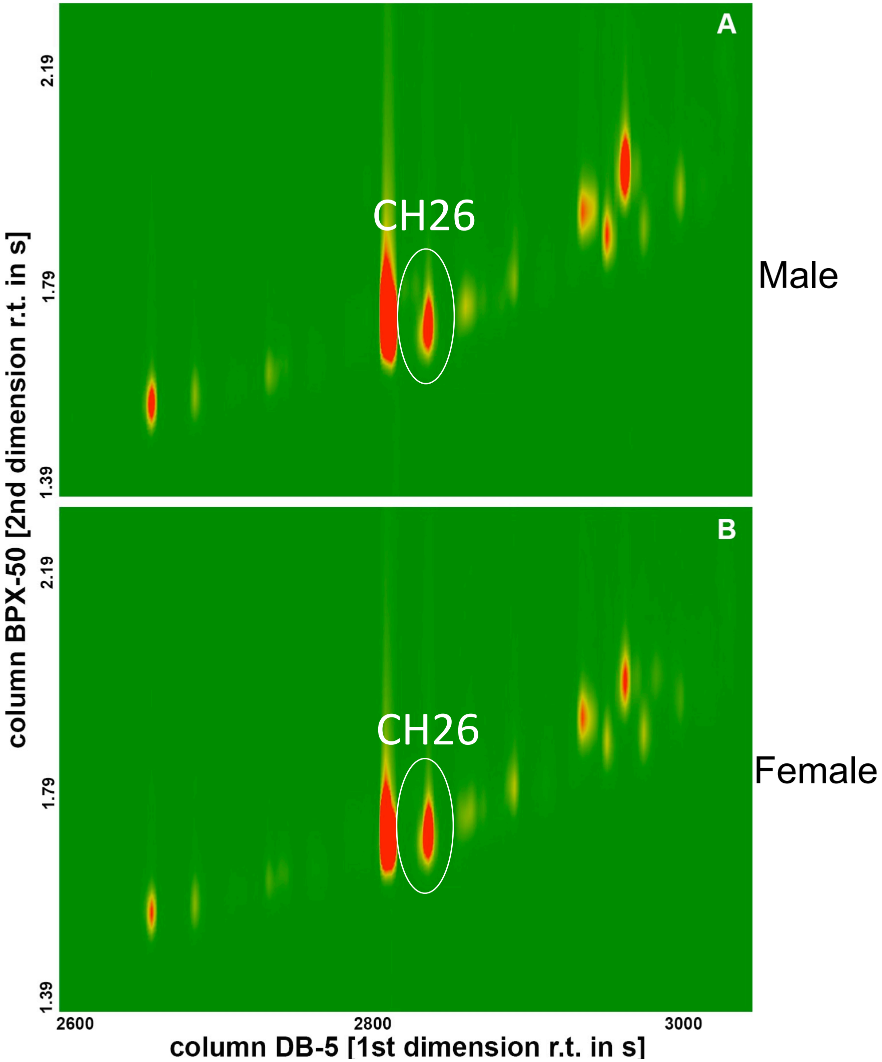
Anal lobe

Anterior spiracles

Chemotaxonomic makers



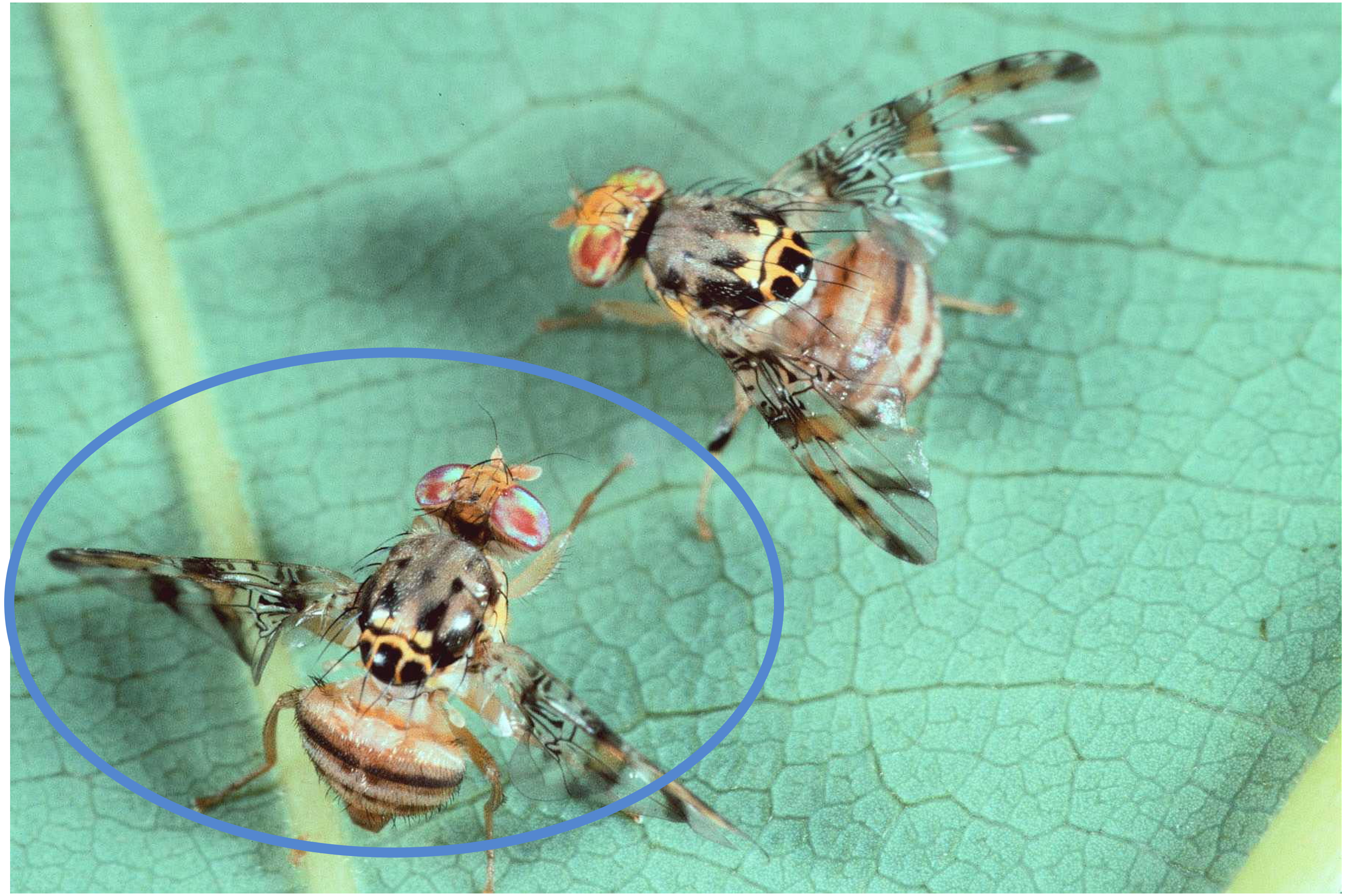
Highland (R2): 2-methyloctacosan
(2-Me$C_{28,}$ *RI 2865*, CH15)



Lowland (R1): X,Y-dimethyloctacosane
(X,Y-diMeC_{28} , *RI 3105*, CH26)

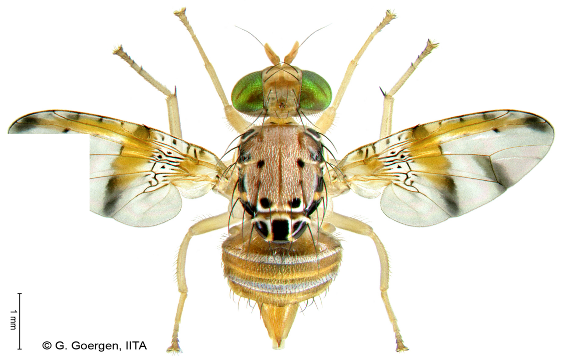
Vanickova, **Ekesi** et al. (2015) *Zookeys.* doi: 10.3897/zookeys.540.9619

New kid on the block: *Ceratitis quilicii*



De Meyer, **Ekesi** et al. (2016) *Zookeys*. doi: 10.3897/zookeys.540.10046

Fruit fly novel attractant identified

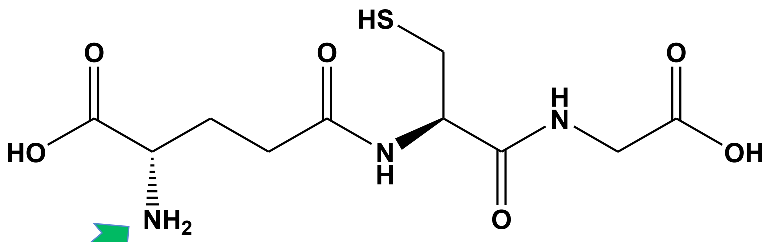


C. cosyra

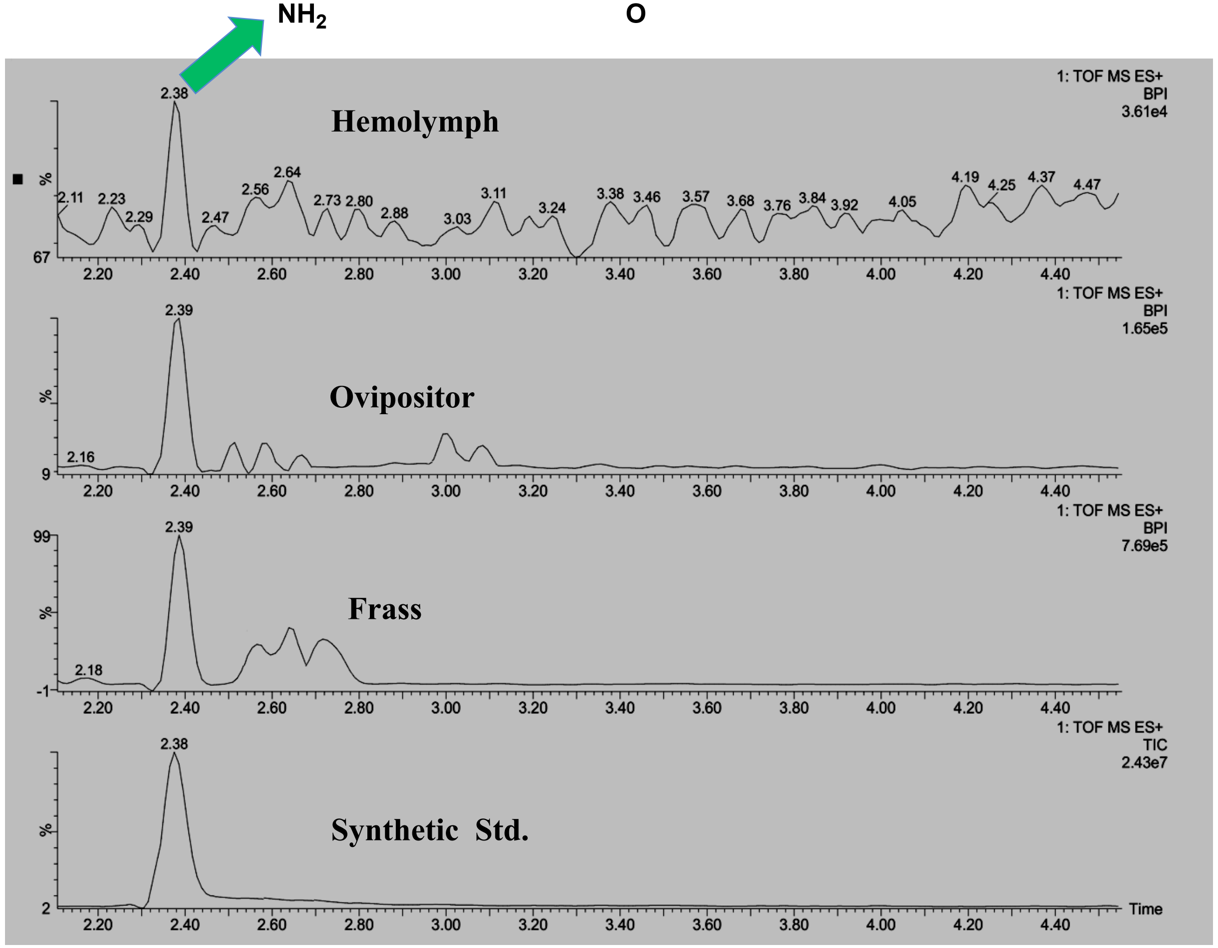
JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY
Article
pubs.acs.org/JAFC

Identification of the Ubiquitous Antioxidant Tripeptide Glutathione as a Fruit Fly Semiochemical

Xavier Cheseto,[†,‡] Donald L. Kachigamba,[§] Sunday Ekesi,[†] Mary Ndung'u,[‡] Peter E. A. Teal,[⊥,¶] John J. Beck,[⊥] and Baldwyn Torto*[,†]

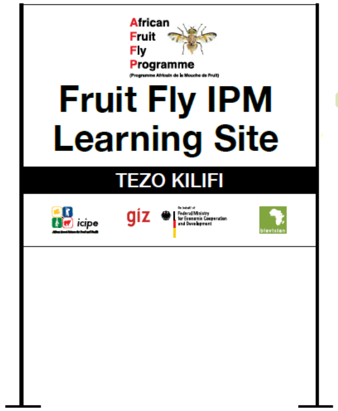


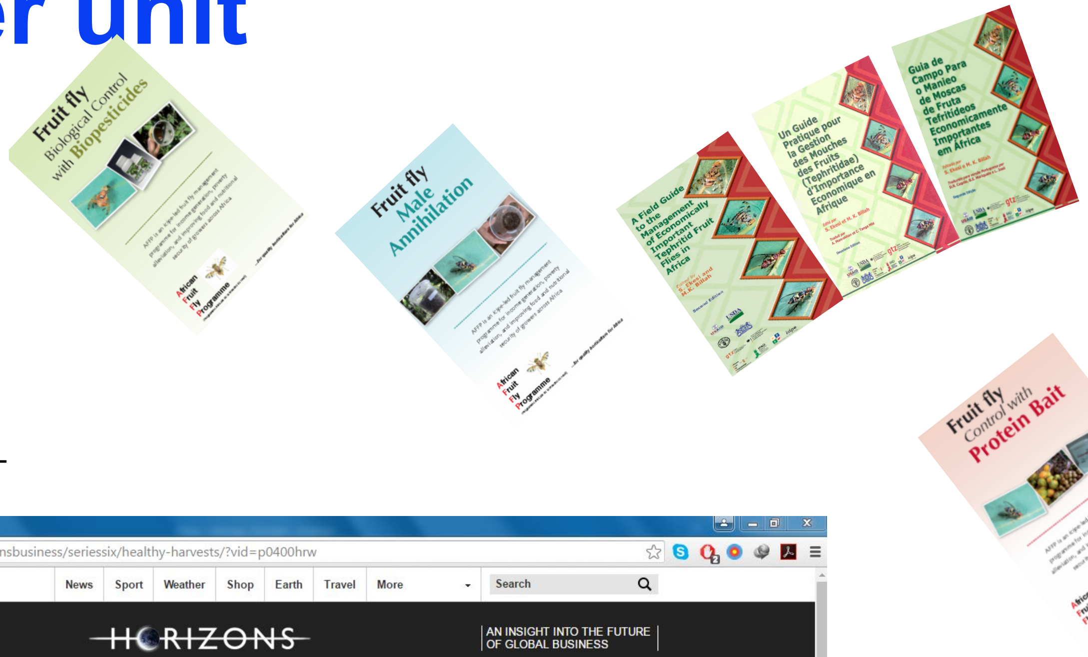
Glutathione

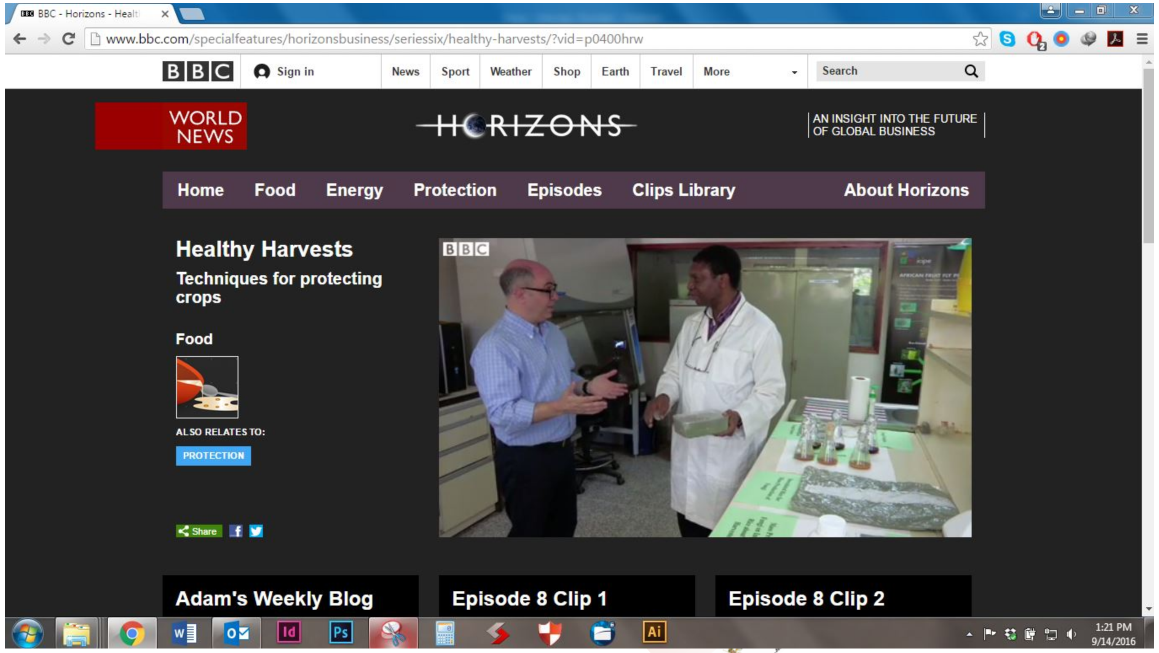


C. cosyra host marking pheromone

Outreach materials and actions with the Tech transfer unit

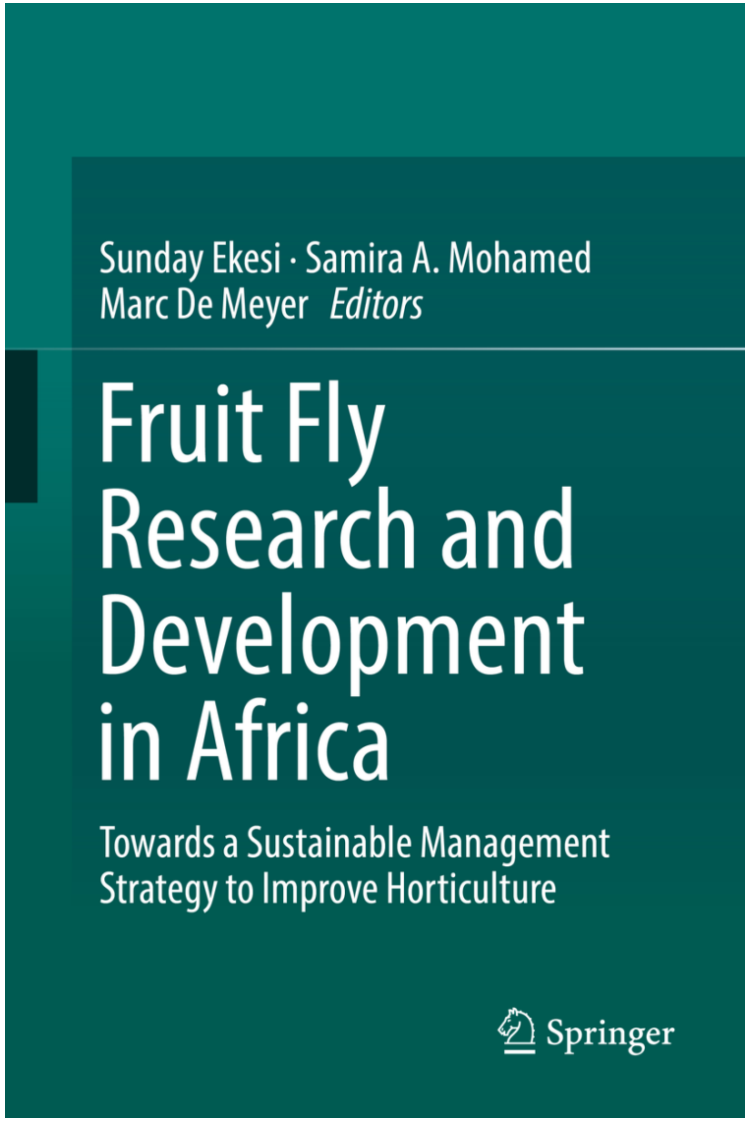






www.icipe.org

Title



Fruit fly IPM OUTCOMES

- Mango rejection reduced by 54.5%
- Income increase among smallholders: 22.4-48%
- Household expenditure on synthetic pesticide reduced by 46.3%
- Net economic benefits in Kenya alone: US$56.7 million in terms of NPV – This is more than the US$5.2 million invested in the program
- Reduction in number of rural poor in Kenya alone: 635,000
- For every US$ 1 invested, US$20 was generated

Tuta absoluta IPM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Nigeria's Kaduna state declares 'tomato emergency'

24 May 2016

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The richest man in Africa has stopped making tomato paste

A state of emergency has been declared in the tomato sector in Kaduna state,

Parasitoids of *Tuta absoluta*

Bethylidae, *Goniozus* sp.

Braconidae, *Bracon* sp.

Diglyphus isaea

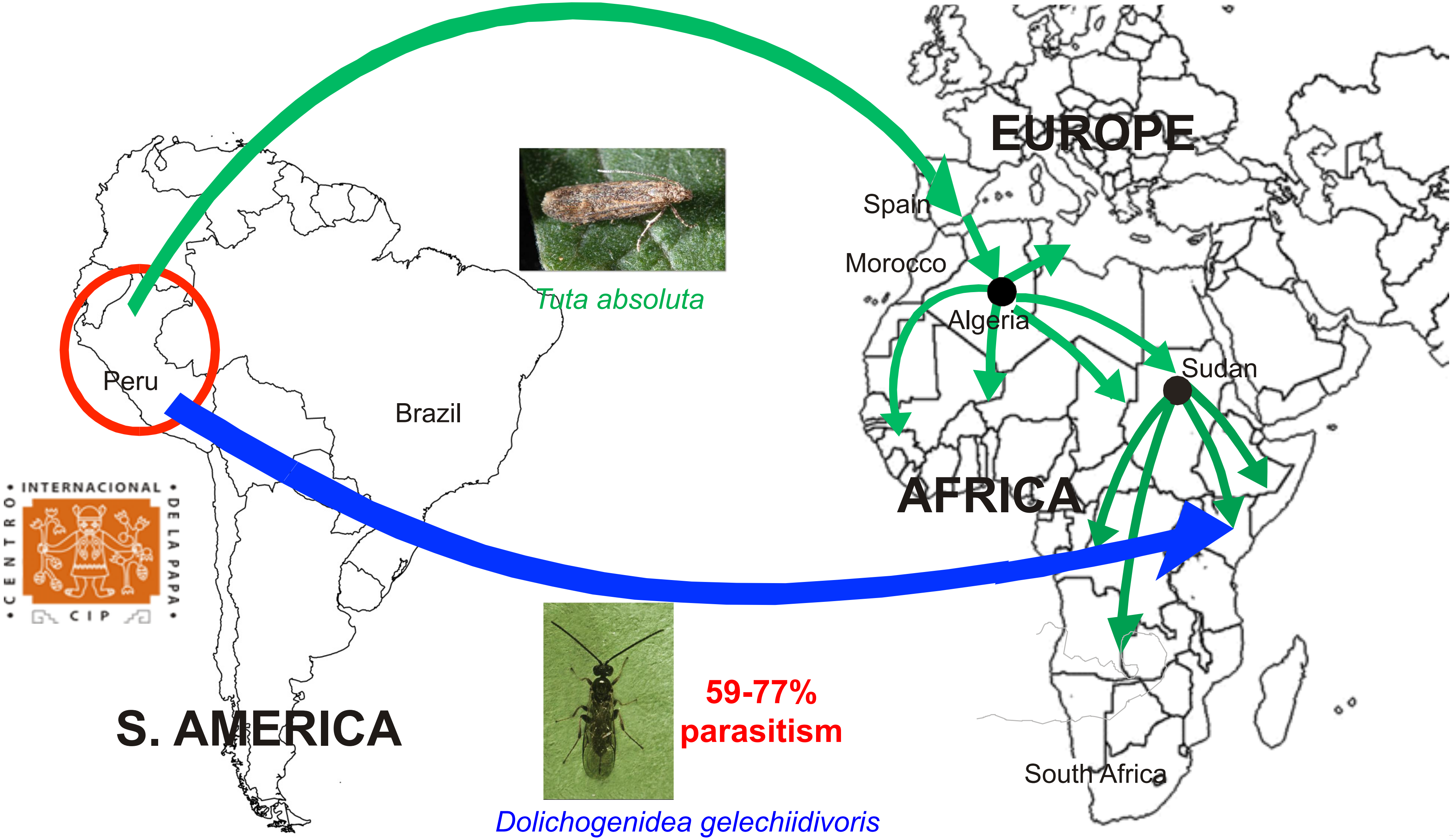
Chalcididae, Chalcidini
Brachymeria sp.

Eulophidae, *Necremnus* sp.

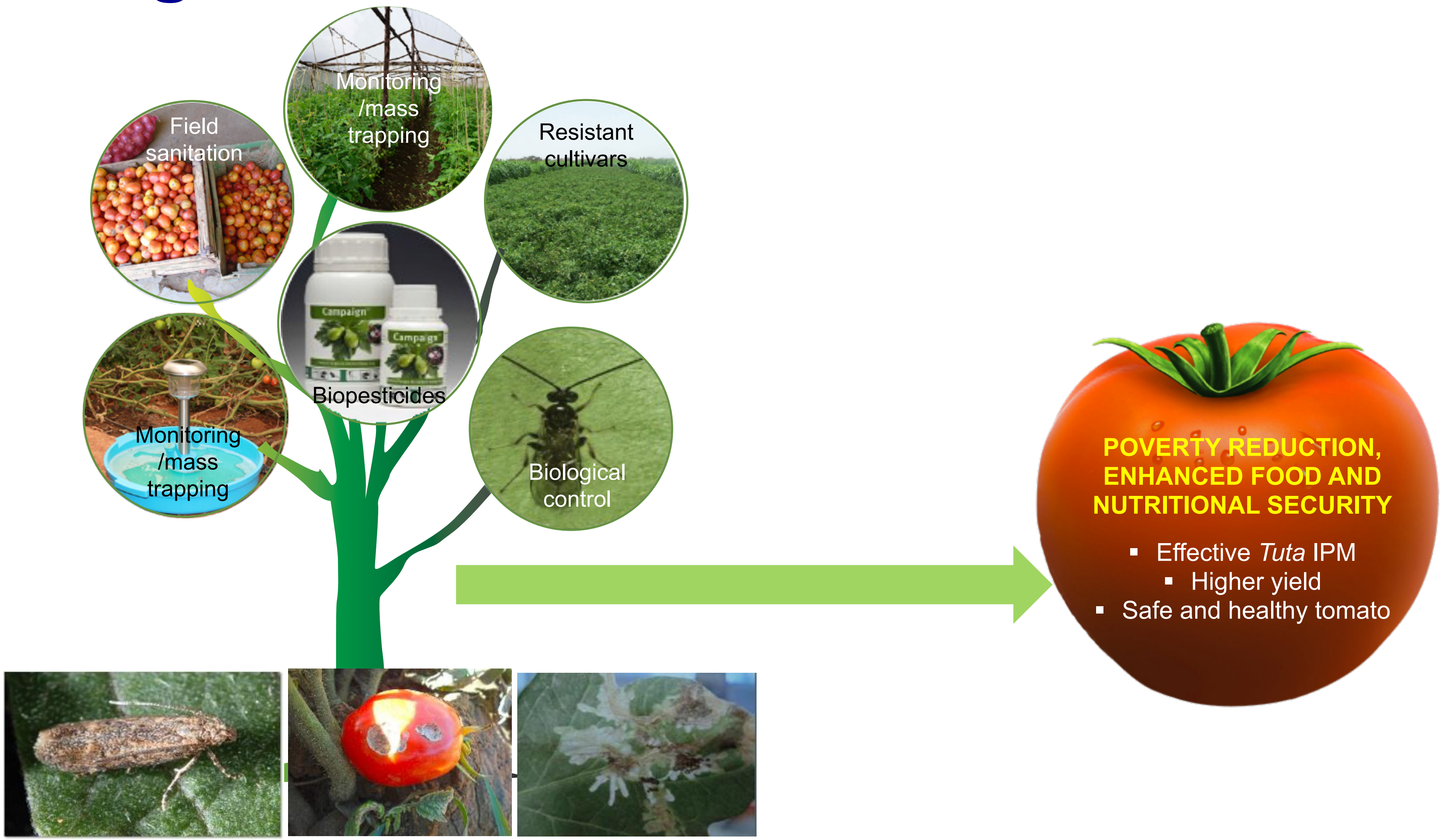
Percent parasitism is typically very low

Photos © Dr. Copeland

Introduction of parasitoid



Tuta management toolbox



Summary

- Push pull combats stemborer, FAW, striga in addition to providing multiple benefits related to soil fertility improvement and fodder availability
- Climate smart push pull now utilizes drought tolerant Bracharia for maize, sorghum and rice
- Engage private sector partners for desmodium seed production
- Fruit fly pre- and post harvest management technologies is permitting access to quarantine markets
- The discovery of less known fruit fly species that are increasingly becoming economically important warrants the need to explore for additional arsenals for control
- Engage a diversity of partners (NARES, NGOs, CBOs, private sector etc) to promote technology

Acknowledgement

Donors directly providing financial support to *icipe*

The Rockefeller Foundation
Ministry of Foreign Affairs of Denmark DANIDA International Development Cooperation

BMZ Federal Ministry for Economic Cooperation and Development
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
Department for International Development
Government of Kenya
Swiss Agency for Development and Cooperation SDC
Sida
African Union
ASI Make It Happen
AWARD African Women in Agricultural Research and Development
Australian Government Australian Centre for International Agricultural Research

BBSRC bioscience for the future
Bayer
British Council Institutional Links
Newton Fund
BioInnovate Africa
biovision
Biovision Africa Trust
CIM Centre for International Migration and Development
cirad Agricultural Research for Development
Conservation International
CNHR Consortium for National Health Research

DAAD Deutscher Akademischer Austausch Dienst German Academic Exchange Service
DFG Deutsche Forschungsgemeinschaft
Embrapa
FAO Fiat Panis
Federal Democratic Republic of Ethiopia
FiBL
Ford Foundation
FNSNF
Google.org
Grand Challenges Canada Grands Défis Canada
IAEA

IDRC CRDI
IFAD Investing in rural people
IFS International Foundation for Science
iie
IRD Institut de Recherche pour le Développement France
IVCC Combating Insect Borne Disease
JRS Biodiversity Foundation
Government of South Korea
wellcome
JIRCAS Japan
mastercard foundation
Max Planck Institute for Chemical Ecology

The McKnight Foundation
Ministry for Foreign Affairs of Finland
National Academy of Sciences
National Geographic Society
NIH National Institutes of Health
NRF Kenya National Research Fund
NSF
Netherlands Directorate-General for International Cooperation
NWO
R.Geigy-Stiftung
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Vetenskapsrådet
World Federation of Scientists
World Health Organization
World Trade Organization
WSD

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Thank you

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