

Threat and responses to *Bactrocera invadens* in Southern and East African countries exporting to South Africa

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Abstract

The increasing threats posed by phytophagous flies, notably *Bactrocera invadens* (Diptera: Tephritidae), in the southern third of Africa during the first decade of the third millennium has been generally met with a sporadic and uncoordinated response by the region. Indeed some countries have yet to initiate proper surveillance for *B. invadens* as of 2010. The result is that trade in fruit within the region has been severely affected and fruit exports, particularly from South Africa which currently remains free of *B. invadens* are under threat should this pest arrive in the country. The response by South Africa, notably the partnership formed by the National Plant Protection Organization and the Southern African Citrus Growers Association to pro-actively meet the threat provides a good model for other countries in the region to develop structures to meet the trade threats posed by this destructive pest.

Keywords; *Bactrocera invadens*, trade, fruit, Africa

Introduction

Fruit flies are one of the world's more devastating crop pests and cause millions of US\$ in lost production each year. In Africa there are several species that attack fruits, vegetables and wild plant species. *Bactrocera invadens* (Diptera: Tephritidae), a fruit fly species native to Asia, was recorded for the first time on the African mainland in 2003 (Lux et al., 2003) and has already become a pest species of major concern to fruit growers in the continent.¹ The species attacks a wide variety of crops including mango, guava, pumpkin, melon, tomato, citrus and cashew nuts. Since its first detection in Kenya in 2003, *B. invadens* has spread to at least 27 countries in Africa and is known to attack at least 46 host plants, including many commercially grown crops and species indigenous to Africa.² The level of diversity and common ancestry among several African populations collected across the invaded areas confirm the Asian origin of this pest. Although Sri Lanka belongs to the native range only a small percentage of genotypes from this country can be found in Africa. African populations display features indicative of rapid population growth and expansion with possible multiple introductions. The results of the analyses support that invasion started in East Africa, where *B. invadens* was initially isolated (Khamis et al 2009)³

Using modeling algorithms De Meyer et al (2010) have determined that the areas considered most suitable the establishment of *B. invadens* are the Equatorial climate categories (minimum temperatures $\geq 18^{\circ}\text{C}$), especially Af (Equatorial rainforest, fully humid) and Am (Equatorial monsoon) based on the updated Köppen-Geiger climate classification (Kottek et al., 2006) (Figures 1 (a) and 1 (b)). These climates correspond to the blue regions in Figure 1 (c).⁴ In addition the model also assigns high suitability to a large part of the Aw (Equatorial savannah with dry winter) climate class suggesting that *B. invadens* prefers hot and humid environments with high annual precipitation. Continuous presence of *B. invadens* in Af and Am climates is not as yet supported by field data for lack of field studies, but some presence in Aw and more recently in Csa climates [the latter corresponding to the pale green in Figure 1 (c) where winter are dry and minimum temperatures during that season are below 18°C] is now amply demonstrated. (Mwatawala et al 2006).⁵

B. invadens is a devastating pest that can severely impact on sustainable agriculture and rural livelihoods, as well as export markets and poses a threat to agriculture in other countries, particularly USA, should it be introduced through transport or trade. The detection of *B. invadens* in Mozambique, northern Namibia and Zambia led to



the temporary curtailment of fruit exports to South Africa and, most recently all exports into Zimbabwe from Mozambique and from Zimbabwe into South Africa have been stopped. The border closure again highlights the urgent necessity to establish the extent and status of invasive flies in Southern Africa, the implementation of surveys and monitoring for establishment of Pest Free Areas (PFAs) and Areas of Low Pest Prevalence (ALPPs) and research into the biology, ecology and appropriate post harvest treatments to mitigate the effects of this pest.

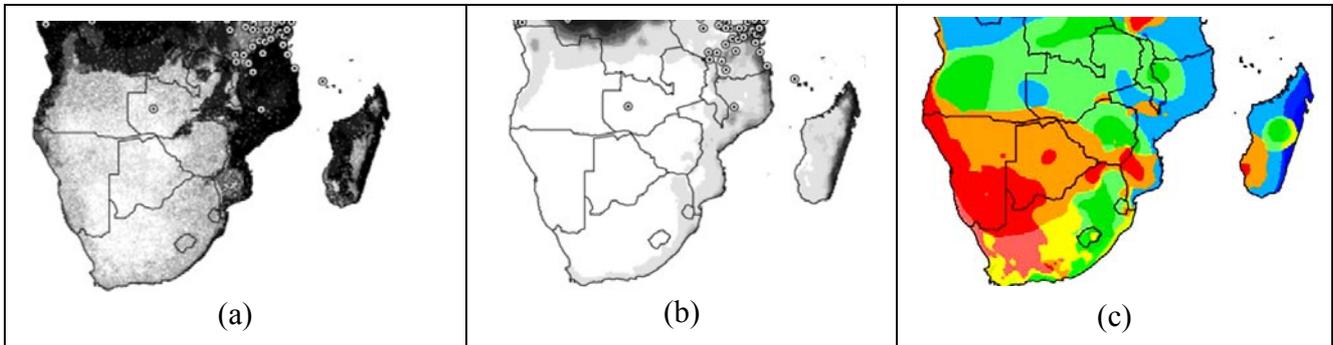


Figure 1(a) and 1(b) Predicted distribution of *Bactrocera invadens* in southern Africa and Madagascar, using genetic algorithm for rule-set prediction (GARP) and maximum entropy method (Maxent). White, predicted absence, as indicated by the LTPT thresholding; shades of grey indicate higher levels of prediction (chosen arbitrarily); with black the highest strength for predicted presence.⁶ Figure 1 (c) Koppen map (from Kottek et al 2006).

Responses of South Africa’s trading partners; Southern Africa

Angola, Lesotho and Malawi,

There are no credible reports of the presence of *B. invadens* in Angola, Lesotho or Malawi nor of any domestic fruit fly surveillance programs although Angola is deemed by the United States to be a country where the pest is present (APHIS 2009).⁷ It is very important that both Angola and Malawi start surveillance for this pest soon as both countries are effectively surrounded by countries where *B. invadens* has been recorded. The possibility of *B. invadens* establishing itself in Lesotho is unlikely from both a climatic and host plant perspective. Furthermore, since Lesotho has only one neighboring country i.e. South Africa, the chance of the pest establishing itself in the country without it first being detected in South Africa is improbable.

Botswana

The declaration by the National Plant Protection Organization (NPPO) of Botswana to the NPPO of the Republic of South Africa (RSA) that the fruit fly *Bactrocera cucumis*, a pest of quarantine importance to South Africa, was present in Botswana resulted in slowing/stopping the imports of possible hosts of *B. cucumis* such as butternuts and melons into South Africa. In fact the pest does not occur in Botswana, or, for that matter, even Africa. When the South African NPPO requested confirmation, the NPPO of Botswana replied that the fruit fly was actually *B. cucurbitae* and not *B. cucumis*, an even more serious quarantine pest and an Asian species which in Africa is almost certainly a very long established introduction dating from at least the early 1930’s (White, 2006).⁸ There also have been incorrect assertions in some non peer reviewed articles that *B. invadens* is, in fact, present in Botswana (CIRAD, 2008).⁹

Subsequently, in October 2009, the Botswana NPPO notified the South African NPPO of the results of a fruit fly trapping program initiated in August of that year. McPhail traps with methyl eugenol were specifically included in the program to determine the true status of *Bactrocera* spp, including *B. invadens*, in the country. No *Bactrocera* spp were identified from the trapping program. In February 2009 the United States Department of Agriculture Animal and Plant Health Inspection Service (USDA-APHIS) visited Botswana and reviewed the trapping program in the south-eastern parts of Botswana. A second visit occurred later in 2009 by a USAID funded Sanitary and Phytosanitary (SPS) specialist from South Africa to the northern parts of the country including a mango growing area near the Zambezi River. Additionally USDA-APHIS had been involved since

August 2008 in the identification of fruit flies from the initial trapping program. The South African NPPO has since accepted that the initial declarations by the Botswana NPPO in respect of *B. cucurbitae* and *B. cucumis* were in error.

Namibia

Initial surveys and trapping for the presence of *B. invadens* were started in Namibia by the NPPO with assistance from USDA-APHIS at Etunda in the northern part of the country in September 2007 as well as in the southernmost grape-growing areas of Aussenkehr and Komsberg (on the Orange River), and Mariental (between Windhoek and the Orange River). The discovery of *B. invadens* at Etunda in northern Namibia allowed the South African NPPO to be selective from the start in applying restrictions on fruit exports from Namibia. Upon discovery of the fly, South Africa closed its borders to certain agricultural products, including watermelons, butternuts, mangoes and tomatoes, and then only from the north of the country. The Etunda Irrigation Scheme, a 600-hectare producer at Ruacana in the Omusati Region, was severely affected by the closure of the South African borders in November 2008 with reported immediate losses to the scheme in excess of US\$ 500,000 in the weeks following the closure.¹⁰ The existence of over a year of data from extensive trapping that met the prescribed standards for surveillance enabled the Namibian NPPO to immediately declare the southern part of the country as remaining free of *B. invadens*.

Follow-up work included measures to prevent the potential movement of *B. invadens* into the southern parts of Namibia. Such a southward movement would be of concern to the grape and citrus growing area along the South African side of the Orange River, which though some distance to the east of Aussenkehr and Komsberg, is considered at risk. Also of concern is the securing of logistical routes for grape exporters from Namibia whose growers export all their grapes through Cape Town, an option that would possibly be closed if *B. invadens* became established in southern Namibia. Longer term plans include the starting of a MAT (male annihilation technique) program in the northern Etunda and southern grape area to eradicate *B. invadens* from the former and, should it be introduced, eradicate it quickly from the southern area given that these areas are climatically marginal for establishment of the fly. It is possible to control *B. invadens* by increased surveillance trapping and this has commenced at Tsumeb with no further *B. invadens* being trapped. Namibia still has a great chance to eradicate or keep *B. invadens* at bay and, in fact, would be a wonderful country study to see how this can be achieved in practice.

Mozambique

As can be seen from Figure 1 Mozambique, because of its climate and geographical position, represents the most southerly area in Africa that present good opportunities for the southward movement of invasive tropical fruit flies. Furthermore, because it shares a land border with South Africa the movement of fruit both between Mozambique and South Africa and within Mozambique are of interest to the South African NPPO and, by extension, due to South African citrus exports to North America, the US government.¹¹ *B. invadens* was recorded in Mozambique for first time in 2007 in Cuamba district in the Northern Province of Niassa (Correia *et al.*, 2008).¹² The two main fruit exports from Mozambique to South Africa are bananas and mangoes. Both of these are of interest in the spread of the pest because of the status of bananas¹ as a host and the fact that mango appears to be a preferred host of *B. invadens*.¹³

Subsequent to the discovery in Niassa a few isolated fruit flies were found at the Vanduzi farm in northern Manica Province in July 2008. At the time this discovery did not lead to breeding populations (Vanduzi is represented by the green dots just to the north of the Machipanda-Inchope road in Figure 2). The checkpoints and surveillance plan summarized in Figure 2 has led to the recognition that areas to the south of the Zambezi river can potentially be considered for fruit exports to South Africa.¹⁴ A follow up visit by the South African NPPO in December 2009 to inspect the on-the-ground activities by the Mozambique government has reaffirmed the arrangements as outlined in Figure 2 though the South African NPPO has yet to communicate officially on

¹ The status of banana as a host of *B. invadens* has been effectively been established in a paper published in a peer reviewed journal (Ekesi *et al* 2006). The exact nature of this host status needs to be established by further research – see main text.

the outcome of the inspection visit. Meanwhile banana exports from Maputo province have continued, though all mango exports to South Africa from Manica province were suspended in 2008 and 2009 leading to severe difficulties for growers. The newly in-production banana project headed by Chiquita in Nampula province continues to be excluded from South African markets. Bananas from Nampula were discovered in Harare early in 2010. The presence of these bananas directly led to the closure of the Zimbabwe-Mozambique border on the 5 Feb 2010 (source; The Herald, Harare, Zimbabwe) and has led to some question marks as to the effectiveness of the Mozambican controls on the internal movement of fruit in that country. Joint trapping by the University of Eduardo Mondlane and USDA-APHIS carried out in Quelimane and parts of Zambezia between 24 - 31 March 2010 has established that *B. invadens* continues to move south and has essentially reached the coastal parts of the northern bank of the Zambezi River though populations are low and occurrence is sporadic.

A particular problem in Mozambique is the status of the large scale banana production project underway in Nampula province. The project is severely constrained from moving fruit southward by the confirmed presence of *B. invadens* in the provinces of Nampula, Zambezia, Niassa and Cabo Delgado. There remains the, by no means certain, possibility that South Africa will recognize a restricted area (i.e.; Chiquita's production area in Matanuska) provided there are sufficient trapping data and a surveillance/monitoring system is in place. However, a potentially more practical approach would be similar to that of Hawaiian bananas destined for the continental USA whereby USDA post harvest packing and shipping protocols are used to exclude fruit suitable as a host for fruit flies (Armstrong 2001).¹⁵ One point raised earlier is the exact nature of the current proof that *B. invadens* is a pest of banana. The only published piece of literature on for this is the paper by Ekesi et al (2006) which in turn cites unpublished data. If this is all the evidence to hand then the true status of banana as a host merits further investigation although it is currently beyond the means of the Mozambique government to do so.

Other research activities planned are the importation of natural enemies (*Fopius arisanus* and *Diachasmimorpha longicaudata*) originally imported from Hawaii. Mozambique is one of three countries in Africa and the only one in southern Africa selected for experimental releases of these parasitoids (Ekesi, undated;¹⁶ AACP 2009,¹⁷ MAFSC 2009¹⁸). The development of public private partnerships in Mozambique is at an early stage and several attempts have been made to develop a national partnership of fruit exporters so far without success. The various attempts are discussed in the section 'The role of the private sector and the formation of PPPs'.

Swaziland

The citrus industry and other fruit exports are under threat from the potential movement of *B. invadens* spreading from northern Mozambique given that Swaziland shares a border with Maputo Province. Swaziland temporarily closed its border to fruit and vegetable imports from Mozambique late in 2008 because of concerns that further unmonitored southward movement within that country would potentially result in the introduction of this pest into Swaziland. In this regard the South African plant health regulatory authorities and Citrus Research International (CRI) had expressed concern about Swaziland being a potential pathway for introduction of *B. invadens*. As a consequence the national fruit fly survey program by the Swaziland NPPO and private sector assisted by USDA-Foreign Agriculture Service (FAS) and USDA-APHIS in March 2009 initiated the current program for early detection and monitoring of the movement of invasive fruit flies in the country.¹⁹

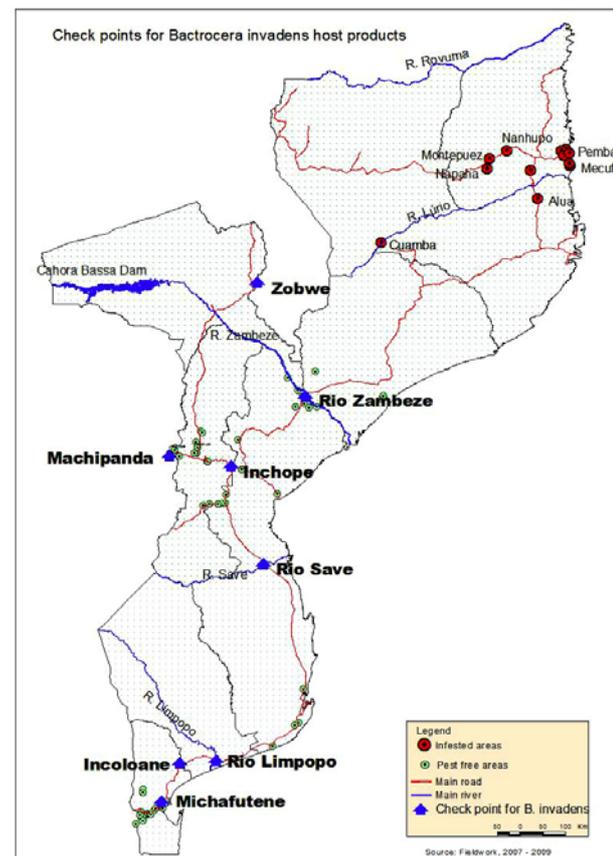


Figure 2; Occurrence of *B. invadens* in Mozambique and internal controls on the movement of fruit (as of June 2009)

In terms of the ongoing institutional arrangements Swaziland has the active involvement of CRI which has led directly to a coordinated response between the citrus industry and the public sector. In particular the close link between the private sector and NPPO, involving growers (represented through a strong association), research bodies (e.g. CRI, Universities) means that although the NPPO of Swaziland lacks resources this does not necessarily represent a major constraint. In addition, legal updates via the new Plant Health Protection Bill of the SPS system are fully justified (Kleih et al 2010).²⁰

Zambia

On 20 March 2008 the Zambian NPPO reported the presence of *B. invadens* to the World Trade Organization (WTO, 2008).²¹ The report was as a result of a fruit fly surveillance program which commenced earlier in 2007 with the assistance of the USDA-APHIS. The presence of *B. invadens* has been confirmed as far south and west as Kaoma in the Western Province of Zambia (corresponding to the single point in west central Zambia – Figures 1a and 1b). A by product of this surveillance program was the first undisputed record of *Ceratitidis capitata* in Zambia. Previously this had been an issue between South Africa and Zambia as the latter had been insisting on cold sterilization of deciduous fruit to eliminate this pest (Jaffee et al 2006).²²

Zimbabwe

Currently there is no formal surveillance for fruit flies in Zimbabwe by the NPPO though some is carried out in the Burma Valley (on the border of Mozambique south of Machipanda) under the auspices of the University of Pretoria and by some citrus growers north of the Limpopo River. In part this is a consequence of the severe budgetary constraints under which the Zimbabwe NPPO operates but is also a function of the virtual disappearance of significant fruit exports from the country in recent years. The discovery of bananas from Nampula in Mozambique at Harare's Mbare market in January and February 2010 led directly to the border closure by Zimbabwe to all fruit imports from Mozambique (Global trade Alert, 2010).²³ Because of the limited fruit fly surveillance in Zimbabwe the NPPO is not clear as to the status of various invasive fruit flies in the country (especially *Bactrocera* spp). It was confirmed with the NPPO that the known economically important fruit fly species in Zimbabwe are primarily *Ceratitidis* spp and that invasive *Bactrocera* spp have not been confirmed as either present or absent in the country. The NPPO is therefore keen to develop a surveillance partnership for fruit flies with the private sector including citrus industry and other fruit growers and exporters based on International Standard for Phytosanitary Measure (ISPM) 26 and Annex 1 to this ISPM. The first trapping for *B. invadens* under this partnership started about 70 km southeast of Harare in April 2010 (Williams, personal communication).

East Africa

Review of invasive fruit flies in Ethiopia

The Mediterranean fruit fly (*C. capitata*) has historically been a major pest of citrus in Ethiopia causing heavy fruit losses. However detailed studies on the species composition fruit flies attacking various fruits in the country are lacking. A survey was conducted in 2007 by the Hawassa University and Melkassa Research Centre (MARC) to record the species of fruit flies on different fruit crops, primarily citrus, guava and mango, in selected fruit production areas including the Central Rift Valley, North Shoa, South Wollo, eastern Ethiopia, Southern Ethiopia and Gambella regions. *C. capitata* was present in all of the areas while in the eastern Ethiopia and the central Rift Valley regions both *C. capitata* and *C. fasciventris* are the co-dominant species. *C. fasciventris* was earlier identified on mangoes at Upper Awash Agro-Industry Enterprise (UAAIE) (Birtukan, 2006). *C. fasciventris* has been reared from fruits of citrus, guava and mango collected from farms in Metehara, UAAIE, Welkitie, Jimma/ Sokoru. *B. invadens* has become a very important pest of mango and guava and recorded mainly from southern and western Ethiopia including Arbaminch, Asossa, Arjo, Bako, Gambella, Gibe, Ghimbi, and Welkitie on guava and mango (Ferdu Azerefege and Difabachew Belay, unpublished data).

Burundi, Rwanda and Uganda

B. invadens was first recorded in Uganda in July 2004 (EPP0 2010)²⁴. There is little further information on the status of this pest other than that it appears well established in the country and appears to have affected exports of bananas (Reuters Alertnet, 2008).²⁵

In November 2008 single specimen hand captured in Bujumbura turned out to be *B. invadens*²⁶. Presence of the pest in Burundi was formally declared in February 2009. *The Institut des sciences agronomiques du Burundi* (ISABU) is coordinating further work on the pest including the possibility that there are Braconid parasitoids already established in Burundi that attack *B. invadens*. However there has been no further information on subsequent events in Burundi since that date. On May 8 2009 Burundi was added by USDA-APHIS to the list of countries subject to a Federal Order because of the presence of *B. invadens*.²⁷

Fruit fly surveillance was initiated in Rwanda in early May 2009 by USDA-APHIS personnel at the request of the Rwandan Dept. of Agriculture. The main objectives were to survey for the presence of the invasive fruit fly species, *B. invadens* and *B. cucurbitae*, and to start a fruit fly pest list for Rwanda. *B. invadens* was found to be well established at lower altitudes in the country. Five other species, all indigenous, were also recorded. Prior to this no fruit fly surveys had ever been undertaken in Rwanda and it was not known whether *B. invadens* occurred in that country, nor were there any inventories of Tephritidae available for Rwanda. An important objective was to determine the effect of the mountainous topography of Rwanda on the distribution of *B. invadens* within the country, i.e. whether altitude has an effect upon its distribution. The visit determined that *B. invadens* is well established at lower altitudes in Rwanda. There were, however, indications that *B. invadens* does not thrive at higher altitudes as all stations above about 1600 metres in altitude failed to yield *B. invadens*, whereas at Bugarara, the lowest altitude (1067m) flies arrived immediately the traps were placed. Therefore there are indications that Rwanda has potential for establishment of pest free areas because of the mountainous topography. The recommendations of the USDA-APHIS team were that the survey programme should be continued to determine which areas of Rwanda could be determined as being pest free for *B. invadens*.

Tanzania

After the first discovery of *B. invadens* in Kenya in 2003 (Lux *et al.*, 2003) it was discovered shortly thereafter from Tanzania (Mwatawala *et al.*, 2004). Close on this discovery, work on the host range was started by Mwatawala in three agro-ecological areas of Morogoro region of central Tanzania, during 2004–2005. This early work established the climatic and host plant preferences of *B. invadens*. At higher altitudes (1650m) its incidence was determined to be temporal, possibly the result of human dispersal from lower altitudes. Most importantly grapefruit (*Citrus×paradisi*) was determined to be a favored commercial host fruit and that the fly was also capable of using avocado (*Persea americana*) as a host (Mwatawala *et al.* 2006).²⁸ The main fruit fly pest of mango in Tanzania is now determined as *B. invadens*. A multi pronged proposal to the Food and Agriculture Organization (FAO) by the Ministry of Agriculture Food Security (MAFSC) of the Republic of Tanzania proposes several parallel activities to mitigate the effect of *B. invadens* including research into post harvest protocols, trapping to prevent the introduction of other Asian fruit flies, and the introduction of parasitic wasps for bio control (MAFSC 2009). This is a very worthy program as it brings together many of the principle institutions involved in *B. invadens* work in Eastern and Southern Africa but also involves a pro-active strategy rather than the reactive work that has been mainly the case so far and is a pre-requisite for any sustained export led horticultural development involving fruit crops in the region and not just Tanzania.

Kenya

Kenya is the country where *Bactrocera* was first discovered though there is no evidence that it was first introduced there 2003 (Lux *et al.*, 2003). Co-incidentally Kenya is the base of the International Centre of Insect Physiology and Ecology (ICIPE – sometimes written *icipe*) and has an active and effective NPPO (Kenya Plant Health Inspection Service, KEPHIS). The Kenya horticultural industry is very dynamic and is the fastest growing agricultural sub-sector playing a major role in the economy of the country. Kenya horticulture earned US\$1 billion in 2008 overtaking tourism as the main source of foreign exchange with mango exports

valued at US\$ 42 million annually. *B. invadens* has rapidly displaced the native *Ceratitis* species in much of Kenya and has significantly affected fruit growing and exports, in particular those to South Africa, which does not accept any Kenyan fruit. Despite the presence of the African Fruit Fly Initiative (AFFI²) from 1999 there still remains a huge gap in local expertise and affordable technologies for management of African fruit flies (Ekesi undated)²⁹

Donor funded programs

Food and Agriculture Organization (FAO)

A significant level of support is given to Africa through the International Plant Protection Convention (IPPC) which is administered by FAO. Support is usually broad based and consists of legal framework reviews, support for participation by S, general capacity building, and needed infrastructure to support national plant protection obligations entered into under the IPPC. There is limited direct intervention in fruit flies in southern Africa although there is an FAO led program underway in Mozambique for the introduction of the natural enemies, *Fopius arisanus* and *Diachasmimorpha longicaudata*. Training of Mozambican technicians in the care and rearing of these parasitoids is already in progress at Centre of Insect Physiology and Ecology (ICIPE).

The World Bank

The main support provided by the World Bank is in Zambia and Mozambique under bilateral assistance programs. In the case of Zambia support is under the umbrella of Agricultural Development Support Program (ADSP) whereby the Government of Zambia and World Bank agreed to include a funding line for SPS management within the Institutional Component of ADSP. In practice, however, most fruit fly related activities have been in conjunction with USDA-APHIS.

In the case of Mozambique there have been a wider range of activities undertaken by the World Bank as subcomponents of existing plans. While these have limited impact as yet the Coordination Unit, All ACP (African, Caribbean, Pacific) Agricultural Commodities Programme which has the university of Eduardo Mondlane as the implementing agency has already considerably strengthened surveillance activities in Mozambique, Action fiche (AACP, 2009)

The United States Department of Agriculture (USDA); Agriculture and Plant Health Inspection Service (APHIS) and Foreign Agriculture Service (FAS)

The USDA has an office in Pretoria, South Africa, operated by the Agriculture and Plant Health Inspection Service (APHIS). USDA-APHIS in Pretoria has significant technical expertise on fruit flies. The office provides technical support but no money and works with other agencies such as the NPPO's, and funding agencies to get the surveillance underway. Collected specimens are identified by APHIS in Pretoria and if any are quarantine pests, they are sent to the Royal Museum in Belgium for final confirmation. Advice is provided on mitigation or eradication measures for invasive flies. NPPOs are helped with the generation of a pest list of fruit flies of economic importance, knowledge of invasive species present can help in preparation of management plan; presence/absence information is vital to initiate and maintain trade relationships. Mozambique, Namibia, Zambia, Botswana, South Africa, Swaziland, Rwanda have all benefited from this program to date. The USDA-FAS operate a United States Agency for International Development (USAID) funded program in sub Saharan Africa for trade related technical support under the African Growth Opportunities Act (AGOA). Primarily this involves the use of diagnostic tools for helping prioritize government support for agricultural exports. Capacity building of NPPO's to certify exports in terms of the presence/absence of fruit flies forms an important part of this program and here FAS supports APHIS activities through its own funds.

² From 2005 this is now the African Fruit Fly Program (AFFP)

A regional training course on the identification and management of economically important fruit flies was held at the ICIPE in July 2009. The training was presented jointly by USDA-APHIS, USDA-FAS and the African Fruit Fly Program (AFFP), ICIPE as well as the (Belgian) Royal Museum of Central Africa, with a grant from USDA-FAS. A total of 12 participants represented their National Plant Protection Organizations (NPPO) from Botswana, Kenya, Mozambique, Rwanda, Swaziland and Zambia. USDA and USAID also support the development of regional information sharing and have been instrumental in the formation of the East African Phytosanitary Information Committee (EAPIC) of which some southern African countries, notably Zambia, are active participants (EAPIC 2009).³⁰

The role of the private sector and the formation of public-private partnerships (PPPs)

It is an established fact that regional NPPO's in Southern Africa are inadequate when compared with the nature of the regional threats to plant health. The institutional weaknesses of the NPPOS in less developed countries was been explicitly recognized in the response to the incorporation of the Sanitary and Phytosanitary (SPS) Agreement into the overall setting up of the World Trade Organization in 1994. Sixteen years later many of these weaknesses persist despite significant strides to address problems. A major weakness that is not directly recognized in the SPS agreement is the necessity for strong public private partnerships. The one exception in Southern Africa is the South African Department of Plant Health (DPH) which has established good communication with all stakeholders involved in the export of citrus products. Although there are a multitude of SPS related forums and working groups in South Africa these are deemed necessary for exporters and export certifiers to comply with the requirements of sensitive citrus markets, in order not to jeopardize exports of this important industry.

The Southern African Citrus Growers Association (CGA) and its research arm, CRI, is by far the most proactive regional growers organization addressing the problems posed by *B. invadens*. Included in the program is a large scale trapping exercise by grower members of the GGA using methyl eugenol based attractants the southern African region (including in Swaziland, Mozambique, Zimbabwe, Botswana and Namibia). Additionally there is a research program at ICIPE paid for by CRI on the suitability of the existing cold sterilization protocols for false codling moth, FCM, (*Cryptophlebia leucotreta*) in citrus exports to the United States for controlling *B. invadens*.³ CRI have also participated in trials in West Africa in the use of MAT for control of the pest and have taken the lead role in drawing up an emergency action plan should the pest be detected in South Africa – a plan that is also available to other SADC countries.³¹&³² Swaziland, Botswana, and Namibia's citrus exporters and NPPO are firmly linked with the South African system and any changes in the latter's SPS set-up and processes would equally affect them. Given that these countries NPPO's only have a relatively small number of staff, a recruitment drive appears justified.

In contrast the other fruit export associations in Southern Africa are weak or non-existent. The Horticulture Promotion Council (HPC) of Zimbabwe has taken no active part in supporting the remainder of its member's fruit exports and the Zambian Export Growers Association (ZEGA) has no effective technical arm. In Swaziland, Botswana and Namibia support has come mainly through regional grower support such as that through CGA and CRI. Attempts are underway to create an export growers association in Mozambique with the lead being taken by Mozambican government through the Center for the Promotion of Agriculture (CEPAGRI). In the interim a fruit fly working group has been formed in Mozambique to address immediate technical issues.

³ These cold sterilization procedures for control of FCM in citrus are unsuitable in terms of the post harvest physiology of tropical crops in terms of time (generally too long) and temperature (too cold)

The role of regional trade associations The East African Community (EAC), the Common Market for East and Southern Africa (COMESA), and the Southern African Development Community (SADC)

There are no known programs to deal with the threats of *B. invadens* that directly involve the EAC, COMESA or SADC. Within SADC the Food, Agriculture and Natural Resources Directorate (FANR) is one of four directorates at the SADC Secretariat in Gaborone, Botswana. FANR's main function is to harmonize agricultural policies and programs in the SADC countries, in line with priorities in the Regional Indicative Strategic Development Plan (RISDP). The main focus of FANR is in the realm of regional food security and there have been no programs that address regional SPS issues in more than a general way. In 2008 the United Kingdom (UK) ComMark Trust commissioned a study which came up with (among other recommendations) the following recommendation for action on fruit flies by SADC; i.e. a "regional survey for *Bactrocera invadens* and other fruit fly species (Lopian 2007)³³

This project has yet to get underway though it was understood at the time some funds had been allocated for the holding of a regional workshop under the now completed ComMark Trust program. To summarize the African regional trade groups are primarily focused on activities at a policy level and the harmonization of laws and regulations that influence trade. The issue of the threat posed by *B. invadens* has been dealt with in that framework and not by specifically directed actions.

The Role of ICIPE as a Regional Training and Research Institution

ICIPE has participated in and run several courses in fruit fly identification and taxonomy held in various parts of Africa. ICIPE's expertise, laboratory facilities and field sites are ideal for such training. The most effective training is aimed at taxonomists and para-taxonomists that are active in their country's fruit fly programs. In addition ICIPE has assisted with African PhD studies, the establishment of national fruit fly teams, the development of biological control with two parasitoids (*Fopius arisanus* and *Diachasmimorpha longicaudata*), the development of cost effective food baits, pioneering the use of entomopathogenic fungi *Metarhizium anisopliae* and *Metarhizium mazoferm*, (in baits and applied to the soil) and male annihilation technique (MAT) as part of the overall support to the program. With Citrus Research International (CRI) funding the potential for cold sterilization has been largely completed with the assessment of duration of exposure to achieve probit 9 level of mortality (99.9968) completed. Similar trials are being applied to avocado and heat treatment (hot bath) trials on mango are underway. These will lead to protocols being generated for citrus, avocado, mango for quarantine sensitive markets.

Conclusions

The most appropriate responses to the demands from South Africa for countries threatened by or infested with *B. invadens*, are an effective application of relevant ISPM's, particularly ISPM 26, and the development of effective mitigation protocols for the movement of uninfested fruit. However, with the exception of the ICIPE led African Fruit Fly Program (AFFP) and the work done by the Mozambican DSV the responses of the Eastern and Southern African countries exporting to RSA have been primarily that of passive monitoring rather than proactive management of *B. invadens*. A reason for this uneven approach is that there has been relatively little at stake in terms of fruit exports to South Africa with the exception of bananas from Maputo province in Mozambique. Even in the case of Kenya, with its large horticultural sector, the vast majority of exports to South Africa consist of non host vegetable crops.

The most successful public-private partnership has been that of the CRI and the DPH in South Africa. It is strongly suggested that this partnership forms the best practice model for other countries in s-SA. However a stronger regional focus is needed as the linkages between private sector organizations that represent fruit growers in s-SA are far weaker than the similar linkages between the various NPPO's in the region. While there has been much attention to the latter the former have received relatively little attention in terms of funding and

institutional support. Given the relatively small funding received by the CRI it has had an enormous impact, far out of proportion to the money spent, on the activities of the DPH as well as on national awareness and planning in respect of *B. invadens* within South Africa and at ICIPE. A strong regional private sector organization intent on protecting and promoting the production and trading of fruit within and from Africa will bring a sharp focus to fruit fly work in s-SA. A not inconsiderable advantage would be a nearly direct benefit on the food security of smallholders that cannot or do not participate in global trade. The regional trading associations of SADC, COMESA and the EAC, which have done little in the way of practical activities to meet the invasive fruit fly threat would benefit from this regional private sector focus. This focus needs to be on developing the tools, through a range of basic and practical research on the application of IPM, classical biological control, post-harvest treatments including fumigation, irradiation, non-host status and regulatory inspection protocols, and physical disinfestation treatments such as heat or cold treatment.

Other lessons include the need for understanding and synergy between different development partners, the development of a center of excellence, the development of management practices appropriate and cost effective for smallholders, a real commitment by regional bodies crucial to all efforts and a fuller linking up with research efforts and experiences in West Africa to more fully explore synergies and partnerships.

Acronyms

AACP	ACP Agricultural Commodities Programme
ADSP	Agricultural Development Support Program
AFFI	African Fruit Fly Initiative
AFFP	African Fruit Fly Program
AGOA	African Growth Opportunities Act
ALPP	Areas of Low Pest Prevalence
CEPAGRI	Center for the Promotion of Agriculture
CGA	Southern African Citrus Growers Association
COMESA	Common Market for East and Southern Africa
CRI	Citrus Research International
DPH	Department of Plant Health (South Africa)
EAC	East African Community
EAPIC	East African Phytosanitary Information Committee
FANR	Food, Agriculture and Natural Resources Directorate (SADC)
FAO	Food and Agriculture Organization
FCM	false codling moth
HPC	Horticulture Promotion Council
ICIPE	International Centre of Insect Physiology and Ecology
IPPC	International Plant Protection Convention
ISPM	International Standard for Phytosanitary Measures
MAFSC	Ministry of Agriculture Food Security
MAT	male annihilation technique
MARC	Melkassa Research Centre
NPPO	National Plant Protection Organization
PFA	Pest Free Areas
PPPs	public private partnerships
RISDP	Regional Indicative Strategic Development Plan
RSA	Republic of South Africa
SADC	Southern African Development Community
SPS	Sanitary and Phytosanitary
s-SA	Sub-Saharan Africa
UAAIE	Upper Awash Agro-Industry Enterprise
UK	United Kingdom
USA	United States of America
USAID	United States Agency for international Development
USDA-APHIS	United States Department of Agriculture - Animal and Plant Health Inspection Service
USDA-FAS	United States Department of Agriculture - Foreign Agriculture Service
WTO	World Trade Organization

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