





**AUTHORS:**

Phumudzo P. Tshikhudo¹ 
 Livhuwani R. Nnzeru² 
 Maanda Rambauli¹
 Rudzani A. Makhado³ 
 Fhatuwani N. Mudau⁴ 

AFFILIATIONS:

¹Directorate: Plant Health, Department of Agriculture, Land Reform and Rural Development, Pretoria, South Africa

²Directorate: Biosecurity, Department of Forestry, Fisheries and the Environment, Cape Town, South Africa

³Department of Biodiversity, University of Limpopo, Polokwane, South Africa

⁴School of Agricultural, Earth and Environmental Sciences, University of KwaZulu-Natal, Pietermaritzburg, South Africa

CORRESPONDENCE TO:

Phumudzo Tshikhudo

EMAIL:

tshikhudopp@gmail.com

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 Salmima Mokgehele 

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Phytosanitary risk associated with illegal importation of pest-infested commodities to the South African agricultural sector

We evaluated the phytosanitary risk associated with illegal importation of pest-infested plant commodities into South Africa. Samples were collected from different South African ports of entry over 8 years (2011 to 2019) and data were analysed descriptively using Statistical Software Package. Pests were frequently detected on commodity species such as *Citrus* (18.31%), *Zea mays* (13.22%), *Phaseolus vulgaris* (12.88%), *Musa* spp. (9.15%) and *Fragaria ananassa* (5.08%). The highest number of pests intercepted occurred on fresh fruits (44.06%), followed by grains (26.44%) and vegetables (14.23%). The most intercepted organisms were *Callosobruchus rhodesianus* (7.79%), *Dysmicoccus brevipes* (7.11%), *Callosobruchus maculatus* (6.10%) and *Phyllosticta citricarpa* (4.74%). The majority of intercepted organisms were non-quarantine organisms (70.50%), followed by pests of unknown status (17.28%), quarantine pests (10.84%) and potential quarantine pests (1.35%). *Phyllosticta citricarpa*, *Bactrocera dorsalis*, *Spodoptera frugiperda* and *Prostephanus truncatus* were the only quarantine pests intercepted in terms of South African regulatory status. The interception was mainly from southern African countries, particularly Mozambique, Zimbabwe and Eswatini. The findings present the level of phytosanitary risk associated with illegal importation and/or non-compliance in regard to plants and plant commodities from different countries through South African ports of entry. Crop production, biodiversity, food security, existing export markets, and access to new export markets could be threatened as importing countries may impose stringent phytosanitary measures to limit the chances of introduction and establishment of quarantine pests into their territories.

Significance

- Illegal importation of plant commodities may lead to the introduction, establishment and spread of pests that are of quarantine significance to South Africa.
- Introduction of pest species such as *Phyllosticta citricarpa*, *Bactrocera dorsalis*, *Spodoptera frugiperda* and *Prostephanus truncatus* into South Africa could result in undesirable impacts on the ecosystem, agriculture, biodiversity and economy of the country.
- Access to new export markets of plant commodities could be threatened as importing countries may impose stringent phytosanitary measures to limit the chances of introduction and establishment of these quarantine pests into their territories.

Introduction

Introduction of alien and invasive species into regions outside of their native ranges can have undesirable effects on both ecosystem and agriculture.¹ Most countries, including South Africa, are currently facing threats from the introduction, spread and establishment of alien and invasive species. Various countries are struggling to prevent the influx of further alien and invasive species as the global economy expands and the movement of goods, services and people continues to grow.² A primary means by which alien and invasive species become established is through unintentional introductions associated with international trade.³ These invasive alien species can have an exceedingly broad range of economic, environmental and social impacts.^{4,5} International trade of plants and plant products is one of the major pathways for the introduction and spread of exotic pests. Some of these pests may affect agricultural production and/or limit access to international export markets. Phytosanitary inspections of plants and plant products at border ports are an important phytosanitary practice to determine the levels of compliance with phytosanitary requirements. To reduce phytosanitary risk, trading partners adhere to rigorous measures for import or export to avoid the introduction of alien and invasive species to new regions. Alien and invasive species are common stowaways on shipments of imported plants, plant products and other regulated articles.^{6,7} Alien and invasive species may arrive on imports encompassing a variety of commodities, including agricultural produce, greenhouse and ornamental plants, nursery stock, cut flowers, wood products, stored products and packing materials.^{8,9}

Global air transportation and road transportation greatly facilitate the unintended spread of pests, including invasive species, because of the large volumes of goods and people transported internationally¹⁰ which also are gradually increasing every year¹¹. Given the tremendous increases in global passenger travel, there is a need to better characterise the extent to which passenger baggage serves as an invasion pathway for alien and invasive species.¹²

In South Africa, the potential introduction of pests and diseases is administered through the *Agricultural Pests Act No. 36 of 1983* and its associated regulations¹³, *National Environmental Management: Biodiversity Act No. 10 of 2004*¹⁴, and Alien and Invasive Species Regulation (2014) as amended¹⁴. The Acts deal with prevention and control of the introduction and spread of pests. The *Agricultural Pests Act* compels imported controlled goods

to be declared and presented at ports of entry to the executive officer and/or authorised inspector who then inspects or samples the controlled goods as necessary. The inspection and sampling are done to determine the presence of regulated pests in a commodity. Regulated pests include both quarantine and non-quarantine pests.¹⁵ The Directorate: Inspection Services and Directorate: Plant Health within the South African Department of Agriculture, Land Reform and Rural Development (DALRRD) are responsible for inspections, policy development and implementation. The inspectors from DALRRD ensure that imported controlled goods are free from non-indigenous organisms, including phytophagous insects, mites, molluscs, nematodes, plant pathogens and invasive weed species. The Directorate: Inspection Services conducts inspections of baggage carried by international travellers or passengers that arrives at South African ports and borders, primarily focusing on plant commodities which could likely harbour live plant pests. These inspections were conducted for 8 years (2011–2019). The Directorate: Plant Health publishes and maintains the database of intercepted pests.

The purpose of this study was to determine the trend associated with the interception of pests in passengers' baggage at South African borders and airports. We examined the origins of imported commodities, pests intercepted, status of intercepted organisms in South Africa and the likelihood of establishing in South Africa, as a critical effort to prevent negative impacts on the economy, ecosystems and agriculture through the possible introduction and spread of quarantine species.

Materials and methods

Sample collection and preparation

Plant commodities intended for import into South Africa and illegally moved were confiscated by the DALRRD. Samples ($n=341$) from various specimens were collected over a period of 8 years (2011–2019) from O.R. Tambo International Airport (Johannesburg) and nine border posts (Vioolsdrift, Nakop, Grobler's Bridge, Skilpad's Gate, Ramatlabama, Beit Bridge, Lebombo, Oshoek and Golela). The samples were then sent to the DALRRD Diagnostic Laboratories in Pretoria (Gauteng Province) and Stellenbosch (Western Cape Province) for pest identification. In cases in which identification could not be made with certainty, the specimens were sent to the Biosystematics Division of the Agricultural Research Council (Pretoria) for further identification to species level. Immature and damaged specimens were identified to only genus or family level.

Data analysis

Data and information regarding commodity species name, commodity type, pests detected, pests' quarantine status and country of origin were analysed descriptively using Statistical Software Package Version 2010 (Statsoft Inc., Tulsa, OK, USA).

Results

Pests were frequently detected on commodity species such as *Citrus* spp. (oranges, lemons and grapefruit; 18.31%), *Zea mays* L. (maize; 13.22%), *Phaseolus vulgaris* (common beans; 12.88%), *Musa* spp. (bananas and plantains; 9.15%) and *Fragaria ananassa* Duchesne (strawberries; 5.08%). The pests detected at less than 5% were on plant commodity species as listed in Table 1.

Illegally imported plant commodities included fresh fruits, grains, vegetables, cobs, tubers, bran, nuts, seeds, cut flowers, cuttings and oil cakes (Table 2).

Irrespective of the quarantine and regulatory status for South Africa, the most intercepted organisms were *Callosobruchus rhodesianus* (Pic) (cowpea weevil; 7.79%) from grains, *Dysmicoccus brevipennis* (Cockerell, 1893) (pineapple mealybug; 7.11%) from pineapples, *Callosobruchus maculatus* (F.) (cowpea weevil; 6.10%) from grains and *Phyllosticta citricarpa* (McAlpine) Aa (citrus black spot; 4.74%) from *Citrus* spp. (Table 3). The highest number of pests intercepted occurred on fresh fruits, followed by grains and vegetables. Interception of pests was less frequent on maize cobs, tubers, bran, seeds, nuts, cut flowers, bulbs, cuttings, oil cakes and meal.

Based on the risk, intercepted pests were divided into quarantine, potential quarantine, non-quarantine and unclassified (N/A) pests. In terms of pest status in South Africa, most of the intercepted organisms were non-quarantine species (70.50%), pests of unknown status (17.28%), quarantine pests (10.84%) and potential quarantine pests (1.35%) (Figure 1). *Prostephanus truncatus* Horn (larger grain borer), *P. citricarpa*, *B. dorsalis* and *S. frugiperda* were the only quarantine pests intercepted from imported grains and fresh fruits (Table 2), but these pests have a high disaster risk to the South African agricultural sector as well as the economy. Pests of unknown status have a high potential to negatively affect agricultural production.

The highest frequency of pest interceptions occurred on commodities imported mainly from Mozambique (47%), followed by Zimbabwe (15%) and Eswatini (12%). The frequency of interceptions from Spain, France, Ukraine, Malawi, Ethiopia, Nigeria, Ghana, Mauritius, Zambia, USA and Israel was between 1% and 5%, while countries such as New Zealand, Angola, Kenya, DRC, Jordan, India, Russia and Namibia accounted for less than 1% (Table 3).

Discussion

The majority of pests intercepted were non-quarantine pests (Figure 1); however, these pests may also pose a risk in the agricultural sector by threatening food security and production. In terms of international and national prescripts, only regulated pests and/or quarantine pests are subject to phytosanitary measures.¹⁶ This is because the introduction and spread of quarantine pests may destroy the agricultural and horticultural sectors. The introduction and spread of quarantine pests and pests of unknown status may ultimately affect the environment, economy, food security as well as export markets.¹⁷ It could lead to agricultural production losses of 20–40%¹⁸ and further increase the cost of operations and disease control.

In most cases, the entry and introduction of plant pests of economic importance from other countries into South Africa is through the movement of plants and plant products during international trade and/or movement of people with commodities. Most alien and invasive species are introduced and/or intercepted during international trade worldwide.¹⁹

It is thus important that plant pest interception is appropriately dealt with in accordance with phytosanitary measures and actions. In South Africa, according to the *Agricultural Pests Act*, ports of entry are prescribed under Regulations R.111 of 27 January 1984 and Government Notice R.1013 of 26 May 1989 as amended, wherein plant commodities are permitted to be imported.¹³ This legislation requires all importers of plant products to comply with South Africa's import requirements and plant products are subject to inspection at the prescribed ports of entry.

In other countries, such as those in the European Union, alert lists on fruits have been established to manage the risk.²⁰ In South Africa, the majority of intercepted pests is found to be non-quarantine pests (Figure 1), and thus they are not subjected to phytosanitary measures. However, the majority of pests that have entered and been introduced into South Africa are pests of economic importance. This implies that the import procedures as well as the regulatory systems of South Africa need to be improved and strengthened.²¹

Although there are regulatory frameworks to regulate the importation of plant products in the Republic of South Africa, passengers still disregard the rules and manage to bypass the system with unauthorised commodities or by importing commodities that do not comply with South African import requirements. This study revealed that these activities normally happen at land borders (as opposed to the airport) where South Africa shares the borders with neighbouring countries such as Eswatini, Zimbabwe and Mozambique. The DALRRD should take decisive action in terms of plant health awareness as well as in enforcing the law at the ports of entry to ensure that a high level of compliance is realised. The *Agricultural Pests Act* requires that illegally imported plant products should be subject to confiscation and destruction, and offenders should be subject to Section 13 of the Act, which deals with 'offences and penalties'.

**Table 1:** Plant commodities imported into South Africa, 2011–2019 ($n=341$)

Commodity	Common name	Commodity type	Frequency of confiscated commodities (%)
<i>Citrus</i> spp.	Lemon/orange/lime/grapefruit	Fresh fruit	18.31
<i>Zea mays</i> L.	Maize	Grain/seed/corn	13.22
<i>Phaseolus vulgaris</i> L.	Bean	Grain/seed	12.88
<i>Musa</i> spp.	Banana/plantain	Fresh fruit	9.15
<i>Fragaria ananassa</i> Duch.	Strawberry	Fresh fruit	5.08
<i>Ananas comosus</i> L. Merr	Pineapple	Fresh fruit	4.41
<i>Mangifera indica</i> L.	Mango	Fresh fruit	4.41
<i>Brassica oleracea</i> L.	Cabbage	Vegetable	3.73
<i>Lactuca sativa</i> L.	Lettuce	Vegetable	3.73
<i>Spinacia oleracea</i> L.	Spinach	Vegetable	3.73
<i>Manihot esculenta</i> Crantz	Cassava	Tuber	2.37
<i>Gossypium</i> sp.	Cotton	Grain/seed	1.69
<i>Ipomoea batatas</i> (L.)	Sweet potato	Tuber	1.36
<i>Oryza sativa</i> L.	Rice	Grain/seed	1.36
<i>Pisum sativum</i> L.	Pea	Grain/seed	1.36
<i>Sorghum bicolor</i> L. Moench	Sorghum	Grain/seed	1.36
<i>Vigna mungo</i> L. Hepper	Blackgram	Grain/seed	1.36
<i>Vitellaria paradoxa</i> Gaertn.	Sheanut	Seed	1.36
<i>Cucurbita</i> sp.	Pumpkin/butternut	Vegetable	1.02
<i>Prunus persica</i> (L.) Batsch	Peach	Fruit	1.36
<i>Rosa hybrida</i> L.	Rose	Cutting	1.02
<i>Abelmoschus esculentus</i> (L.) Moench	Okra	Vegetable	0.68
<i>Anacardium occidentale</i> L.	Cashew nut	Seed	0.68
<i>Annona senegalensis</i> Pers.	Custard apple	Fruit	0.68
<i>Dioscorea alata</i> L.	Yam	Tuber	0.68
<i>Vitis vinifera</i> L.	Table grape	Fruit	0.68
<i>Arachis hypogaea</i> L.	Peanut	Grain/seed	0.34
<i>Corchorus olitorius</i> L.	Jute	Vegetable	0.34
<i>Glycine max</i> (L.) Merr	Soybean	Grain/seed	0.34
<i>Nicotiana tabaccum</i> L.	Tobacco	Leaf	0.34
<i>Psidium guajava</i> L.	Guava	Fruit	0.34
<i>Saccharum officinarum</i> L.	Sugarcane	Stem	0.34
<i>Triticum aestivum</i> L.	Wheat	Grain/seed	0.34



Table 2: Identity and quarantine status of intercepted organisms into South Africa, 2011–2019 ($n=341$)

Scientific name of pest	Order/sub-order: family	Common name	Quarantine status in South Africa	Interception (%)
<i>Callosobruchus rhodesianus</i> Pic.	Coleoptera: Bruchidae	Cowpea weevil	Non-quarantine pest	7.79
<i>Dysmicoccus brevipes</i> (Cockerell)	Hemiptera: Pseudococcidae	Pineapple mealybug	Non-quarantine pest	7.11
<i>Callosobruchus maculatus</i> Fab.	Coleoptera: Bruchidae	Cowpea weevil	Non-quarantine pest	6.10
<i>Phyllosticta citricarpa</i> (McAlpine) Aa	Botryosphaerales: Botryosphaeriaceae	Citrus black spot	Quarantine pest	4.74
<i>Chrysomphalus aonidum</i> (Linnaeus, 1758)	Hemiptera: Diaspididae	Circular scale	Non-quarantine pest	3.05
<i>Tribolium castaneum</i> (Fabricius)	Coleoptera: Bostrichidae	Lesser grain borer	Non-quarantine pest	3.05
<i>Helicoverpa armigera</i> (Hübner, 1809)	Lepidoptera: Noctuidae	Cotton bollworm	Non-quarantine pest	2.71
<i>Sitophilus oryzae</i> (Linnaeus)	Coleoptera: Dryophthoridae	Greater grain weevil	Non-quarantine pest	2.71
<i>Bactrocera dorsalis</i> (Hendel, 1912)	Diptera: Tephritidae	Oriental fruit fly	Quarantine pest	2.37
<i>Lagri</i> sp.	Coleoptera: Tenebrionidae	Beetle	N/A	2.37
<i>Sitotroga cerealella</i> (Olivier)	Lepidoptera: Gelechiidae	Grain moth	Non-quarantine pest	2.37
<i>Rhyzopertha dominica</i> (Fabricius)	Coleoptera: Bostrichidae	Lesser grain borer	Non-quarantine pest	2.03
<i>Plutella xylostella</i> (Linnaeus)	Lepidoptera: Plutellidae	Diamondback moth	Non-quarantine pest	1.69
<i>Ceratitis cosyra</i> (Walker)	Diptera: Tephritidae	Mango fruit fly	Non-quarantine pest	1.35
<i>Prostephanus truncatus</i> (Horn)	Coleoptera: Bostrichidae	Larger grain borer	Quarantine pest	1.35
<i>Parlatoria pergandii</i> (Comstock, 1881)	Hemiptera: Diaspididae	Dictyospermum scale	Non-quarantine pest	1.35
<i>Carpophilus dimidiatus</i> (Fabricius, 1792)	Coleoptera: Nitidulidae	Cornsap beetle	Non-quarantine pest	1.01
<i>Ceratitis capitata</i> (Wiedemann)	Diptera: Tephritidae	Medfly	Non-quarantine pest	1.01
<i>Frankliniella occidentalis</i> (Pergande)	Thysanoptera: Thripidae	Western flower thrips	Non-quarantine pest	1.01
N/A	Hemiptera: Diaspididae	Scale insect	N/A	1.01
N/A	Lepidoptera: Arctiidae	Moth	N/A	1.01
N/A	Sarcoptiformes: Acaridae	Predatory/fungi-feeding mite	Non-quarantine pest	1.01
<i>Phenacoccus solenopsis</i> (Tinsley)	Hemiptera: Pseudococcidae	Cotton mealybug	Non-quarantine pest	1.01
<i>Piezotrachelus</i> sp.	Coleoptera: Apioninae	Weevil	Non-quarantine pest	1.01
<i>Planococcus citri</i> (Risso, 1813)	Hemiptera: Pseudococcidae	Citrus mealybug	Non-quarantine pest	1.01
<i>Sitophilus zeamais</i> (Motschulsky)	Coleoptera: Dryophthoridae	Greater grain weevil	Non-quarantine pest	1.01
<i>Spodoptera frugiperda</i> (J.E. Smith)	Lepidoptera: Noctuidae	Fall armyworm	Quarantine pest	1.01
N/A	Hemiptera: Anthoridae	Pirate bug	N/A	0.67
<i>Aonidiella aurantii</i> (Maskell)	Hemiptera: Diaspididae	Red scale	Non-quarantine pest	0.67
N/A	Hemiptera: Aphididae	Aphid	N/A	0.67
<i>Brevipalpus californicus</i> (Banks)	Prostigmata: Tenuipalpidae	False spider mite	Non-quarantine pest	0.67
<i>Brevipalpus yothersi</i> (Baker, 1949)	Prostigmata: Tenuipalpidae	False spider mite	Non-quarantine pest	0.67
<i>Callosobruchus chinensis</i> (Linnaeus, 1758)	Coleoptera: Bruchidae	Chinese bruchid	Non-quarantine pest	0.67
<i>Chilo partellus</i> (Swinhoe, 1885)	Lepidoptera: Crambidae	Spotted stem borer	Non-quarantine pest	0.67
<i>Cryptolestes ferrugineus</i> (Stephens)	Coleoptera: Cucujidae	Rusty grain beetle	Non-quarantine pest	0.67
<i>Cryptolestes pusillus</i> (Schönherr, 1817)	Coleoptera: Cucujidae	Flat grain beetle	Non-quarantine pest	0.67
<i>Cylas</i> sp.	Coleoptera: Apionidae	Sweet potato weevil	N/A	0.67
<i>Ebertia</i> sp.	Sarcoptiformes: Acaridae	Mite	N/A	0.67
<i>Frankliniella schultzei</i> (Trybom)	Thysanoptera: Thripidae	Common blossom thrips	Non-quarantine pest	0.67
<i>Haplothrips gowdeyi</i> (Franklin)	Thysanoptera: Phlaeothripidae	Black flower thrips	Non-quarantine pest	0.67
<i>Hellula undalis</i> (Hulst)	Lepidoptera: Crambidae	Cabbage webworm	Non-quarantine pest	0.67
N/A	Lepidoptera: Noctuidae	N/A	N/A	0.67
N/A	Diptera: Lonchaeidae	Lance fly	N/A	0.67
<i>Neohydatothrips lepidus</i> (Faure)	Thysanoptera: Thripidae	Thrips	Non-quarantine pest	0.67
Noctuid larva	Lepidoptera: Noctuidae	N/A	N/A	0.67
<i>Oryzaephilus mercator</i> (Fauvel, 1889)	Coleoptera: Silvanidae	Grain beetle	Non-quarantine pest	0.67
<i>Sancassania oudemansi</i> (Zachvatkin, 1937)	Sarcoptiformes: Acaridae	Mite	Non-quarantine pest	0.67
N/A	Diptera: Tephritidae	Fruit fly (tephritid larvae)	N/A	0.67
<i>Thrips gowdeyi</i>	Thysanoptera: Thripidae	Thrips	Non-quarantine pest	0.67
<i>Thrips</i> sp.	Thysanoptera: Thripidae	Thrips	N/A	0.67
<i>Tuckerella</i> cf. <i>murrensis</i>	Prostigmata: Tuckerellidae	Mite	Non-quarantine pest	0.67
<i>Tuckerella ornata</i> (Tucker)	Prostigmata: Tuckerellidae	Mite	Non-quarantine pest	0.67
<i>Tyrophagus putrescentiae</i> (Schrank)	Acari: Acaridae	Mite	Non-quarantine pest	0.67
N/A	Coleoptera: Curculionidae	Weevil	N/A	0.67



Table 2 continued

Scientific name of pest	Order/sub-order: family	Common name	Quarantine status in South Africa	Interception (%)
<i>Aonidomytilus albus</i> (Cockerell, 1893)	Hemiptera: Diaspididae	Tapioca scale	Non-quarantine pest	0.33
<i>Aphis gossypii</i> (Glover, 1877)	Hemiptera: Aphididae	Cotton aphid	Non-quarantine pest	0.33
<i>Aphis</i> sp.	Hemiptera: Aphididae	Aphid	N/A	0.33
<i>Argopistoides octomaculata</i> (Jacoby, 1892)	Coleoptera: Chrysomelidae	Beetle	Non-quarantine pest	0.33
<i>Bagrada hilaris</i> (Burmeister)	Hemiptera: Pentatomidae	Invasive stink bug	Non-quarantine pest	0.33
N/A	Prostigmata: Bdellidae	Predatory mite	N/A	0.33
N/A	NA	Beetle	N/A	0.33
<i>Brevicoryne brassicae</i> L.	Brassicales: Brassicaceae	Cabbage aphid	Non-quarantine pest	0.33
<i>Brevipalpus</i> sp.	Prostigmata: Tenuipalpidae	False spider mite	N/A	0.33
<i>Bruchidius atrolineatus</i> Pic.	Coleoptera: Bruchidae	African cowpea bruchid	Non-quarantine pest	0.33
<i>Callosobruchus</i> sp.	Coleoptera: Bruchidae	Weevil	N/A	0.33
<i>Cenopalpus</i> sp.	Prostigmata: Tenuipalpidae	Tenuipalpid mites	N/A	0.33
<i>Ceratitidis rosa</i> (Karsch)	Diptera: Tephritidae	Natal fruit fly	Non-quarantine pest	0.33
N/A	Coleoptera: Bostrychidae	NA	N/A	0.33
N/A	Diptera: Tephritidae	Fruit fly	N/A	0.33
N/A	Diptera: Drosophilidae	Vinegar fly	N/A	0.33
<i>Ferrisia virgata</i> (Cockerell, 1893)	Hemiptera: Pseudococcidae	Striped mealybug	Non-quarantine pest	0.33
<i>Hadromerus</i> sp.	Coleoptera: Curculionidae	Bug	N/A	0.33
<i>Lampides boeticus</i> (Linnaeus)	Lepidoptera: Lycaenidae	Pea blue butterfly	Non-quarantine pest	0.33
<i>Lasioderma serricornis</i> (Fabricius, 1792)	Coleoptera: Anobiidae	Cigarette beetle	Non-quarantine pest	0.33
<i>Lepidosaphes beekii</i> (Newman, 1869)	Hemiptera: Diaspididae	Purple scale	Non-quarantine pest	0.33
<i>Leucinodes orbonalis</i> (Guenee)	Lepidoptera: Crambidae	Eggfruit and shoot borer	Non-quarantine pest	0.33
<i>Lipaphis erysimi</i> (Kaltenbach)	Hemiptera: Aphididae	Mustard aphid	Non-quarantine pest	0.33
<i>Lipaphis pseudobrassicae</i> (Davis, 1914)	Hemiptera: Aphididae	Turnip aphid	Non-quarantine pest	0.66
<i>Myzus persicae</i> (Sulzer)	Hemiptera: Aphididae	Green peach aphid	Non-quarantine pest	0.33
<i>Nephus</i> sp.	Coleoptera: Coccinellidae	Lady bird beetle	N/A	0.33
Nitidulid larva	Coleoptera: Nitidulidae	Sap beetle	N/A	0.33
Non-tephritid fly	N/A	N/A	N/A	0.33
<i>Odonaspis saccharicaulis</i> (Zehntner, 1897)	Hemiptera: Diaspididae	Paragrass scale	Non-quarantine pest	0.33
<i>Penthimiola bella</i> (Stål)	Hemiptera: Cicadellidae	Citrus leafhopper	Non-quarantine pest	0.33
<i>Peregrinus maidis</i> (Ashmead)	Hemiptera: Delphacidae	Corn planthopper	Non-quarantine pest	0.33
<i>Phenacoccus madeirensis</i> (Green)	Hemiptera: Pseudococcidae	Madeira mealybug	Non-quarantine pest	0.33
<i>Phenacoccus</i> sp.	Hemiptera: Pseudococcidae	Mealybug	N/A	0.33
<i>Phytonemus pallidus</i> (Banks)	Acari: Tarsonemidae	Cyclamen mite	Non-quarantine pest	0.33
NA	Acari: Phytoseiidae	N/A	Non-quarantine pest	0.33
<i>Pseudococcus longispinus</i> (Targioni Tozzetti)	Hemiptera: Pseudococcidae	Long-tailed mealybug	Non-quarantine pest	0.33
<i>Saissetia</i> sp.	Hemiptera: Coccidae	Scale insect	N/A	0.33
N/A	Sarcoptiformes: Acaridae	Mite	Non-quarantine pest	0.33
N/A	Hemiptera: Diaspididae	Scale insect	N/A	0.66
<i>Scirtothrips aurantii</i>	Thysanoptera: Thripidae	South African citrus thrips	Non-quarantine pest	0.33
<i>Spoladea recurvalis</i> (Fabricius, 1775)	Lepidoptera: Crambidae	Beet webworm moth	Non-quarantine pest	0.33
<i>Stigmatonotum capucinum</i> (Stål)	Heteroptera: Lygeidae	N/A	Non-quarantine pest	0.33
Tachinidae	Diptera: Tachinidae	N/A	N/A	0.33
<i>Tarsonemus confusus</i> (Ewing)	Prostigmata: Tarsonemidae	Tarsonemid mite	Non-quarantine pest	0.33
<i>Tetranychus</i> sp.	Prostigmata: Tenuipalpidae	Spider mite	N/A	0.33
<i>Thaumatotibia leucotreta</i> (Meyrick)	Lepidoptera: Tortricidae	False codling moth	Non-quarantine pest	0.33
N/A	Thysanoptera: Tubilifera	NA	N/A	0.33
N/A	Trombidiformes: Tydeidae	Mite (scavenger)	Non-quarantine pest	0.66
<i>Tyrophagous</i> sp.	Astigmata: Acaridae	Straw mite	Non-quarantine pest	0.33
<i>Udea ferrugalis</i> (Hübner)	Lepidoptera: Pyralidae	Rusty dot pearl	Non-quarantine pest	0.33
<i>Ulotrichopus primulinus</i> (Hampson, 1902)	Lepidoptera: Erebidae	Moth	Non-quarantine pest	0.33

N/A, not applicable (identified up to genus or family level to determine quarantine status in South Africa)

Table 3: Recorded pest interceptions into South Africa by country, 2011–2019 ($n=341$)

Country	Interception (%)
Mozambique	47.00
Zimbabwe	15.00
Eswatini	12.00
Spain	4.00
France	3.00
Ukraine	3.00
Malawi	2.37
Mauritius	1.99
Ethiopia	1.69
Nigeria	1.69
Ghana	1.35
Zambia	1.01
USA	1.00
Israel	1.00
New Zealand	0.90
Angola	0.67
Kenya	0.67
DRC	0.33
Jordan	0.33
India	0.33
Russia	0.33
Namibia	0.33

Currently, the DALRRD is undergoing a review of the *Agricultural Pests Act* in relation to phytosanitary measures so that there is better alignment with internationally prescribed export and import provisions. The approval of the proposed bill (Plant Health (Phytosanitary) Bill) could limit the introduction of exotic pests. The provisions of the proposed bill also provide for on-the-spot fines for non-compliance.²² This approach is not new; the Australian government has imposed on-the-spot fines and/or penalties for non-compliance since 2009 under the *Plant Health Act, 2009* and this mechanism is working effectively to reduce smuggling and/or illegal imports of plant commodities.²³

South African borders still lack relevant equipment such as scanners to detect undeclared plant products during movement of people crossing South African borders. Therefore, the majority of passengers with unauthorised plant products and/or fruits pass through undetected, as indicated by the high number of interceptions in this study. Currently, South Africa employs sniffer dogs in other ports of entry to detect plant commodities in passengers' luggage. However, these remain limited and need to be increased across all ports of entry in order to reduce the introduction of pests through undeclared and/or non-compliant plant commodities. The system may be further intensified at ports of entry with the establishment of the new South African Border Management Authority under the *Border Management Act, 2020 (Act No. 2 of 2020)*.

Based on our results, adequate measures are required at South Africa's land borders, particularly for imported fruits. The majority of illegal imports and pest interceptions occurred from Mozambique, Zimbabwe and Eswatini (Table 3), which thus require the most stringent measures to be put in place to prevent the introduction of pests. The challenge is not only in South Africa – all African borders are under enormous pressure due to the movement of people and goods across borders.²⁴ In contrast, in the USA, the highest number of pest interceptions was recorded at the airports, followed by the land border between the USA and Mexico.²⁵

The results from this study suggest that imported fruits followed by grains are the commodities with the highest levels of interception of quarantine pests into South Africa from neighbouring countries. Fruits are also the major pathway of pests and disease worldwide.²⁶ The majority of countries, including South Africa, import fruits in large volumes. Insects and/or pests hide, grow and reproduce in those imported fruits, which are later intercepted by the receiving country.⁶ This implies that fresh produce (fruits and vegetables) is the major pathway for actionable pests in the USA²⁷ as well as in South Africa.

We have demonstrated a high phytosanitary risk associated with the illegal importation of plant commodities. Amongst the intercepted organisms, the quarantine pests were *B. dorsalis*, *S. frugiperda*, *P. citricarpa* and *P. truncatus*, which occur in South Africa but are currently under official control in terms of the *Agricultural Pests Act*. According to the International Plant Protection Convention, a quarantine pest is 'a pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled'.

The discovery of *B. dorsalis* on the African continent during 2003 raised biosecurity concerns in South Africa where agriculture is of major socio-economic importance.²⁸ This is a pest species that has recently been introduced into eastern Africa and has subsequently made a rapid expansion across tropical Africa.²⁹ *B. dorsalis* is highly polyphagous^{30,31}, it has more than 40 known cultivated and wild hosts in Benin³², and is expected to have a broad host range as exhibited by some other members in the *B. dorsalis* complex. Female individuals can lay an average of 1300 eggs during their lifetimes, depending on the host and climatic conditions. The species is multivoltine with an average life span of about 3 months.³³ Given the apparently rapid spread of *B. dorsalis* across Africa, and its impacts on local horticulture, the possibility of this species being introduced to, and establishing in and invading other regions of the world, should be prevented.³⁴ *B. dorsalis* is currently considered one of the major pests in Africa^{28,35}, displacing indigenous fruit flies³⁶. This invasive species has major economic impacts, ranking among the most devastating pests of local agricultural products, particularly mango.³⁴

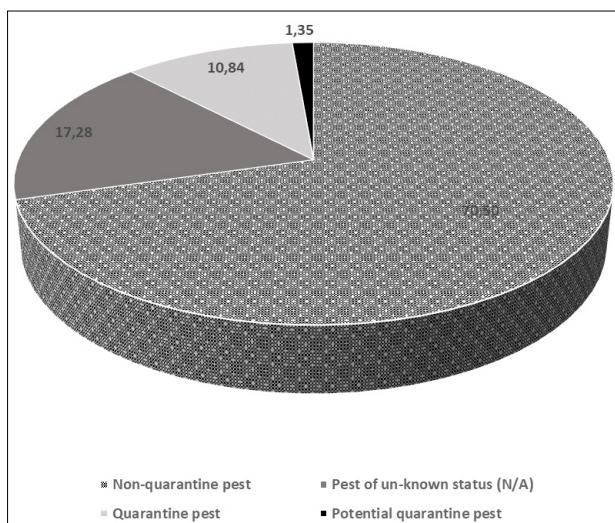


Figure 1: Categories of intercepted organisms ($n=341$) in South Africa, 2011–2019.

Research in West and East Africa has demonstrated that it can become dominant in mango monocultures.³³

Spodoptera frugiperda was also intercepted in this study. In Africa, the first detection of fall armyworm *S. frugiperda* was recorded in Nigeria at the beginning of 2016, from where it later moved to several western and central parts of the continent by April 2016.³⁷ *S. frugiperda* is widely distributed in North America, where it causes the most serious damage to about 80 different commercial crops, including maize, rice, sorghum, sugarcane, cabbage, beet, groundnut, soybean, alfalfa, onion, pasture grasses, millet, tomato, potato and cotton.³⁸ In Ethiopia, maize infestation of this insect pest was estimated to range from 24% to 39%, while in Kenya, the infestation was about 3854%.³⁹ Fall armyworm caused reductions in maize yields of 934 kg/ha and 1381 kg/ha in Ethiopia and Kenya, respectively.³⁹ Farmers in Ethiopia and Kenya observed a more than 82% increase in the spread of fall armyworm on their farms. The Ethiopian and Kenyan farmers reported fall armyworm as a serious insect pest, which caused a higher level of damage than the maize stalk borer.³⁹

Another intercepted pest found in the current study was the citrus black spot pathogen, *P. citricarpa*, which is a fungal pathogen of citrus plants, specifically orange and lemon varieties.⁴⁰ In South Africa, citrus fruit exports to European and US markets are subjected to strict phytosanitary measures.⁴¹ Internationally, *P. citricarpa* is considered a quarantine pathogen.⁴² Citrus black spot occurs in citrus-growing regions with warm summer rainfall climates.⁴³

The larger grain borer, *P. truncatus*, was also detected in the current study and is regarded as an economically important pest of stored commodities such as maize and dried cassava.⁴⁴ This pest is endemic to Mexico and Central America, although it has recently been introduced and become established on the African continent, where it has caused severe damage to stored maize. The first outbreaks were reported in the Eastern part of Africa.⁴⁵ *P. truncatus* became established in Togo in 1984, and gradually spread to Benin, Burkina Faso, Niger, Nigeria, Guinea Conakry and Guinea Bissau.⁴⁶ The economic impact of insect pest attacks on stored grain is associated with the amount of grain damaged or the percentage weight loss.⁴⁷ In Zimbabwe, it was first reported in Mashonaland West and Mashonaland Central Provinces, with potential distribution from the northern part of the country moving further inland towards the central and eastern parts, and neighbouring countries such as South Africa, Zambia and Mozambique.^{48,49}

Conclusion

The risks posed by the illegal introduction of pests through a particular plant commodity should also be considered in a pest risk analysis, because even though the commodity itself may not pose a pest risk, it may harbour organisms that have pests. Therefore, illegal importation of plant and plant products into South Africa should undergo a high phytosanitary risk assessment. The introductions of alien and invasive pests into South Africa can have undesirable effects on the ecosystem, agriculture, biodiversity as well as the economy. The highest number of pest interceptions occurred on fresh fruits, grains and vegetables mainly from southern African countries, particularly Mozambique, Zimbabwe and Eswatini. Although the majority of intercepted pests were non-quarantine species, the consequences due to repeated interceptions of quarantine pests should be taken into consideration. The agricultural sector, particularly citrus, maize, fruit and vegetable industries in South Africa, could be under severe threat from the establishment and spread of quarantine pests such as *P. citricarpa*, *B. dorsalis*, *S. frugiperda* and *P. truncatus* to areas where these do not occur. In addition, consignments presented for import into South Africa must be subject to pre-import phytosanitary inspection. As an economic consequence, fresh produce farmers in areas free from these pests stand to spend more money in eradicating these pests if they are introduced and/or established. Many people stand to lose jobs as farmers will be reducing their workforce because of reduced profits. Crop production, biodiversity, food security, existing export markets, and access to new export markets could also be threatened as importing countries may impose stringent phytosanitary measures to limit the chances of introduction and establishment of these quarantine pests into their territories.

South Africa is a signatory member of the World Trade Organisation Agreement on the Application of Sanitary and Phytosanitary Measures and the International Plant Protection Convention. These international organisations acknowledge the sovereign right of Members to protect the life and health of plants within their territories by means of phytosanitary regulatory controls. The spread of quarantine pests to new areas where they have not previously occurred can lead to severe crop production losses and food insecurity.

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Competing interests

We have no competing interests to declare.

Authors' contribution

P.P.T.: Conceptualisation and development of the initial draft of the manuscript. L.R.N.: Conceptualisation and write-up. M.R.: Write-up of the article. R.A.M.: Data analysis and write-up. F.N.M.: Critique and validation of the article.

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