Oriental Fruit fly distribution within Kandara sub county, Murang'a, Kenya

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Abstract: The Oriental fruit fly *(Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae), previously recognized as *Bactrocera invadens,* presence in Kenya dates since 2003, the first record of this pest in Africa. Its phytosanitary importance resulted to avocado export ban to South Africa in 2008 and later to Seychelles, to prevent possible entry of this pest into these markets through fruit trade. To regain these markets and avoid more external market loss, this study was carried out to facilitate creation of a pest free area for fruit flies as required by the International Standards for Phytosanitary Measures (ISPM) number 26. Detection survey for the pest was conducted using 110 methyl eugenol lure-based traps laced with malathion insecticide, placed throughout Kandara Sub-County, at a density of 5 traps/km^2 in June 2013. The sub county has the highest concentration of small-scale farmers of avocados for export markets in Kenya. The traps were examined after 2 weeks of placement. Data on host plants was also collected. The results showed that traps captured the pest in all agroecological zones (Lower highland (LH)1, Upper midland (UM) 1, Upper midland (UM) 2 and Upper midland (UM) 3). Possible host plants observed in the farms included avocado, mango, pawpaw, guava, coffee, passion fruit, loquats, banana, citrus, and tree tomato. The pest density was highest in UM 3, which has the lowest elevation and the highest concentration of mango orchards. High trap catches recorded in market centres was associated with poor disposal of fruits. The lowest pest density was recorded at LH 1, which has the highest elevation in the sub-county. Therefore, creation of a pest free area in the Sub County will rely on effective mass trapping exercise for more than six months in order to remove all the flies, followed by protection of the area from emerging flies using strategically placed traps and various cultural practices, accompanied by strong farmer participation and stakeholder partnership to ensure integrity of exported fruit sources.

Keywords: Asian invasive fruit fly, pest free area, fence traps, Agro ecological zones

Introduction

Avocado (*Persea Americana* Mill*,* Family Lauraceae) in Kenya is grown in several agro-ecological zones mainly by small-scale growers (85%) for subsistence, local and export markets (Cooper *et al.*, 2003). The fruits are important sources of vitamins and proteins, and are popular globally, making export markets lucrative for smallholder Kenyan farmers. In addition, some varieties have excellent oil qualities, supporting

manufacture of avocado oil, a high-end consumer product globally. The crop therefore contributes to grower livelihood and economic stability across the commodity value chain. The main production areas in Kenya are Murang'a, Kiambu, Embu, Meru, Taita and Trans Nzoia Counties (Wasilwa *et al.,* 2005). About 40,000 tons of avocado fruits produced in Kenya is wasted due to poor pre- and postharvest handling practices; limited access to superior varieties and planting materials, poor tree crop management practices; poor infrastructure, poor market information, pests and diseases and limited utilization (Wasilwa *et al.,* 2005).

The Asian invasive fruit fly *Bactrocera invadens* is now recognized as the Oriental fruit fly (*Bactrocera dorsalis* (Hendel) (Schutze *et al.*, 2015). The pest has become a major hindrance to avocado trade particularly due to its presence in the country since 2003 (Lux *et al.,* 2003, Drew *et al.,* 2005) and studies that have shown avocado as a possible host of this pest (Mwatawala *et al.,* 2009). The pest is of quarantine importance in many countries where it does not occur (Clarke *et al.,* 2005), reducing market opportunities for avocado fruits to export destinations. Kenya lost the South African market for avocado in 2008 due to the presence of the pest in the country. However, since then, the pest has invaded various parts of that country even with intensive management to prevent its spread (Manrakhan *et al.*, 2015). Even so, without phytosanitary control measures, it is not possible to access that market.

Currently there are no known effective methods for controlling *B. dorsalis* at farm level that can ensure no introductions to export destination through the exported commodity. Pesticide use in avocado is limited at fruiting stage due to the need to maintain residues below maximum residue levels, which is a major food safety concern. This is the period that *B. dorsalis* infestation commences, therefore making its control more challenging. In the past few years, the International Center for Insect Physiology and Ecology (*Icipe*) has released some natural enemies for purposes of long-term sustainable reduction of the pest population but these cannot assure total absence of the pest on exported fruit (*Icipe*, 2014). The pest has high host range, short life cycle and no known local natural enemies, which gives it an upper hand in competing with the introduced natural enemies. Although Hamacek *et al*. (2005) suggested that avocados are poor hosts for fruit flies in Australia and control treatments are seldom required if fruits are harvested at a hard stage, countries such as the RSA where the pest has been identified as a major threat to their citrus industry (Grové *et al*., 2009) has had to ban imports from Kenya and other African countries, until appropriate risk management measures are in place. Therefore, it became necessary for the Government of Kenya to take steps towards installation of integrated measures in a systems approach, as an option for pest risk mitigation designed to meet phytosanitary requirements for avocados. Diverse avocado varieties are grown in Kenya but currently the most commonly exported variety is Hass. Fuerte was the most popularly grown cultivar particularly for South Africa market but since the export ban farmers have reduced its acreage significantly (MOA, 2013).

Bactrocera dorsalis has wide plant host range, with more than 40 plant families (Ekesi *et al.*, 2006; Mwatawala *et al.*, 2009; Goergen *et al.*, 2011). Avocado is one of the least preferred hosts (Mwatawala *et al.*, 2009) with the pest preferring mango, guava, and citrus (Mwatawala *et al.*, 2009). Thus these hosts can form a major source of infestation in nearby avocado orchards. In Kenya, almost all small-scale avocado growers have in addition to avocado other

fruit crops that probably will be better hosts of the *B. dorsalis* compared to avocado.

To regain the lost avocado export market Kenya decided to create pest (*B. dorsalis*) free area where export fruits can be grown, following the ISPMs of the International Plant Protection Convention (IPPC). This study was done as the first step to document presence and distribution of the pest at Kandara Sub-County, Murang'a County. This information would assist in identifying the best approach towards eradicating *B. dorsalis* from Kandara Sub-County.

Materials and Methods

Study site

The study was undertaken in Kandara Sub-county, which is situated between 36.85^{o} and 37.13^{o} East and between 0.79^{o} and 0.97^{o} South within Murang'a County. The sub county has four main agro-ecological zones (Jaetzold and Schmidt, 1983); i.e. lower highland zone with annual temperature between 15^{o} – 18^{o}C (Hl1), usually suitable for growth of tea the upper midland zone 1 (UM1) with annual mean temperature between 18^{o} – 21^{o}C, is suitable for growth of both tea and coffee while in upper midland zone 2 (UM2), coffee is mainly grown Avocados are grown across the sub-county with the highest concentration of trees in Ng'araria location, in the UM2. The soils are developed on tertiary basic igneous rocks (olivine basalts, nephelinephonolites; older basic tuffs included). They are well-drained, extremely deep, dark reddish brown, friable and slightly smeary clay, with acid humic topsoil. PH ranges between 4.5 and 5.6, exchangeable minerals: mg 0.6–1.7, Na 0.1–0.2, and K 0.1–1.0. These climatic and soil conditions make the area conducive for intensive agricultural activities.

Trap placement and data collection

Traps were sourced from Farmtrack Consulting Ltd and were placed to cover all the four agro-ecological zones of Kandara sub-County at a density of 5 traps/km^2 on 21st June 2013. The traps had Methyl eugenol lure (which attracts male *B. dorsalis*) laced with Malathion (which kills the trapped flies). In total, 110 traps were laid across the sub county and their geographical positioning recorded using GPS. Two weeks after placement, traps catches were collected and counted. Confirmatory identification was done at KALRO Kabete Entomology Laboratory.

Fruit incubation for in the laboratory

A total of 353 Avocado fruits, 176 (variety Hass) and 177 (variety Fuerte), of export market age, were harvested on 5th September 2013 from farmer orchards, representing all the agroecological zones and taken to PTC laboratory for incubation. They were monitored for pest emergence on weekly basis until 26th October 2013 when the trial was terminated.

Data analysis and presentation

Data of trap content included the number of individuals caught based on species. For pest emergence, record included the time (days) taken to emerge and the number of emerged individuals based on species. Data was cleaned before analysis. Total count for each trap was compared using standard deviation and significance determined at 95% level of confidence limit. Arch GIS software was used to map the trap position across the sub county and also compare trap *B. dorsalis* density based on the count.

Results and Discussion

Results show that at the time of trap placement, *B. dorsalis* were present in all the four agro-ecological zones (Figure 1). The population was higher towards the easterlies (UM2 and UM3) compared to the westerlies (LHI and UM 2) zones in the sub

county. The eastern end lies at lower elevation and has higher temperature compared to the western ends. High temperature (ranging 25-30**°**C) favour pest development, reducing full cycle to less than 20 days while low temperatures (of 15**°**C) result into prolonged cycle, up to 75 days (Rwomushana *et al.*, 2008). The Eastern part of the county seems to have favourable temperatures for development of *B. dorsalis* compared to the eastern side. This area also happens to be the highest producer of avocado, the target crop where measures to eradicate the pest are supposed to be implemented.

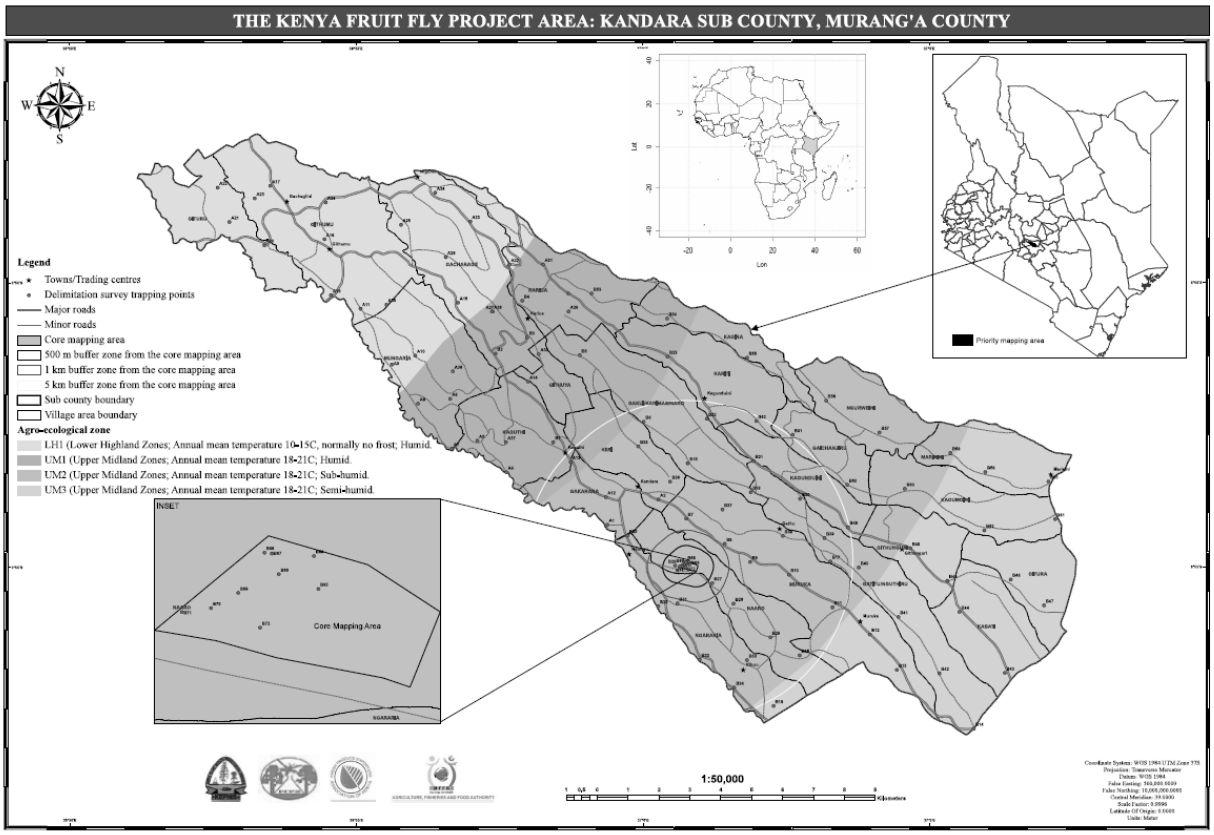

Figure 1: Distribution and density of *B. dorsalis* across Kandara sub county, July-August, 2013.

Key: Colour (shades of black) bands represent the different agro ecological zones (from left): Lower highland (LH)1, Upper midland (UM) 1, Upper midland (UM) 2, Upper midland (UM) 3(Ref: Jaetzold, 1983).

The presence of *B. dorsalis* in the area confirms the importance of initiating best control option to ensure exported fruits do not become a pathway of pest dissemination to the importing country (EPPO, 2014). However, trap catch itself does not definitely indicate that *B. dorsalis* are hosted by Avocado since it has wide host range (Mwatawala *et al.*, 2009) and the trap attracts the male flies from a distance, implying they may not be coming from same orchard/fruit host. In all the traps located in different agro ecological zones, *B. dorsalis* count was more than 90% of the total trap catch (Figure 2), confirming the specificity of Methyleugenol pheromone in trapping male *B. dorsalis* (Mwatawala *et al.*, 2006). The lowest count of *B. dorsalis* was observed in LH1 and the highest at UM3. The total trap catch was

highest at UM 2, which also had the highest trap density (52) compared to LH 1 (19), UM 1 (23) and UM 3 (16). The results confirm that the pest establishment is highly influenced by weather conditions, preferring more warm areas and spreading to cool areas when host is not in season (Mwatawala *et al.*, 2006). Other insects observed on the traps included fruit flies (*Ceratitis cosyra, C. capitata, C. rosa*, and *Perilampsis pulchella*), non-fruit fly flies (beetles, thrips, coccinelids, wasps and spiders). However, their numbers were low and seem not to affect efficiency of traps in capturing male *B. dorsalis*.

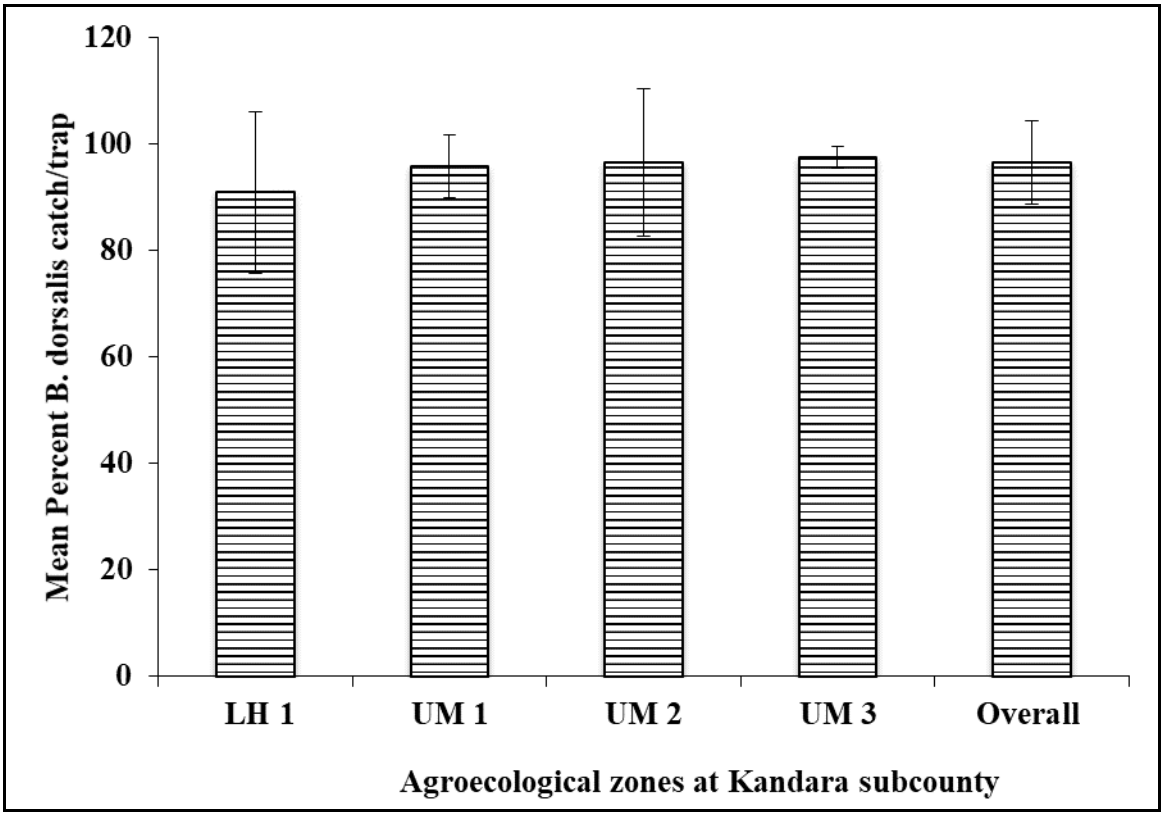

Figure 2: Percent male *B. dorsalis* caught per trap at Kandara Sub-County in July-August, 2013.

LH (Lower highland), UM (Upper midland)

Lower highland 1 and UM 1 agroecological zones had significantly lower *B. dorsalis* trap catch compared with the trap catch in UM 2 & 3 (Figure 2). This could be explained by the cool weather conditions prevailing in these zones, which is not conducive for the survival and population build-up of the pest. The LH 1 had the lowest catch of 28 individuals in the 2-weeks exposure period compared to 178 individuals in UM 1, showing the drastic effects of weather changes on the pest. Upper midland 2 and 3 recorded the highest trap counts with the UM 3 having the highest (478 and 573 individuals, respectively). This shows that any effort to create a pest free area should consider preventing infestation of orchards from the direction of UM3.

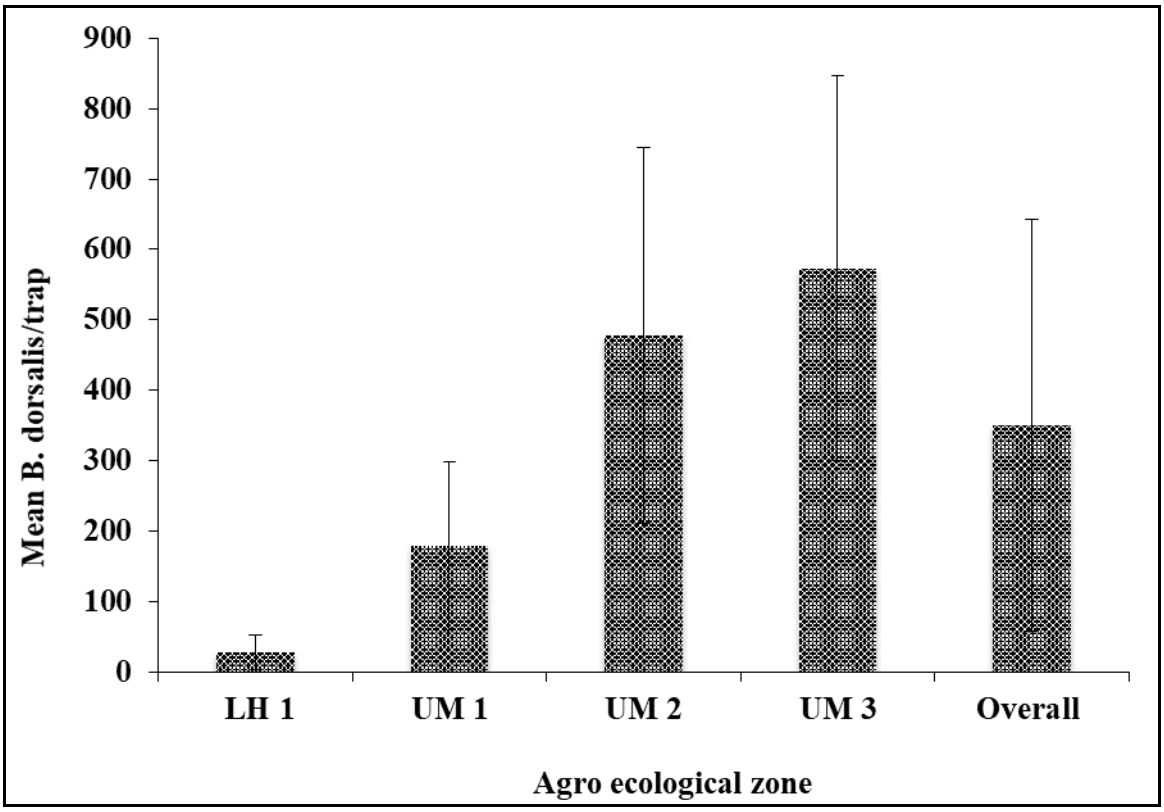

Figure 3: Mean (±SD) number of *B. dorsalis* on traps based on the agro-ecological zones of Kandara Sub-County, Murang'a County. LH (Lower highland), UM (Upper midland)

The highest density of *B. dorsalis* across the agroecologies was confirmed by the high fly trap catches per day, FTD (Figure 4). The UM 3 recorded trap catch of 2.4 FTD, which is usually a very high value based on the international standards (IAEA, 2003). Such a value is an indication that the pest was under no control strategy in the area, which would be responsible for reduced pest pressure. The *B. dorsalis* infestation in UM 1&2, with FTD of 0.5 indicates that it is possible to suppress the pest population in these two zones, with high possibility of creating an area of low pest prevalence. However, the LH 1 had the lowest FTD values of 0.09, showing that it is possible to eradicate the pest in this area. Therefore, for purposes of creating a pest free area or area of low pest prevalence, the project should concentrate on building on the LHI, UM 1 and UM 2 but creating a strong buffer and barrier in UM3, where there should also be more activities to reduce the pest presence.

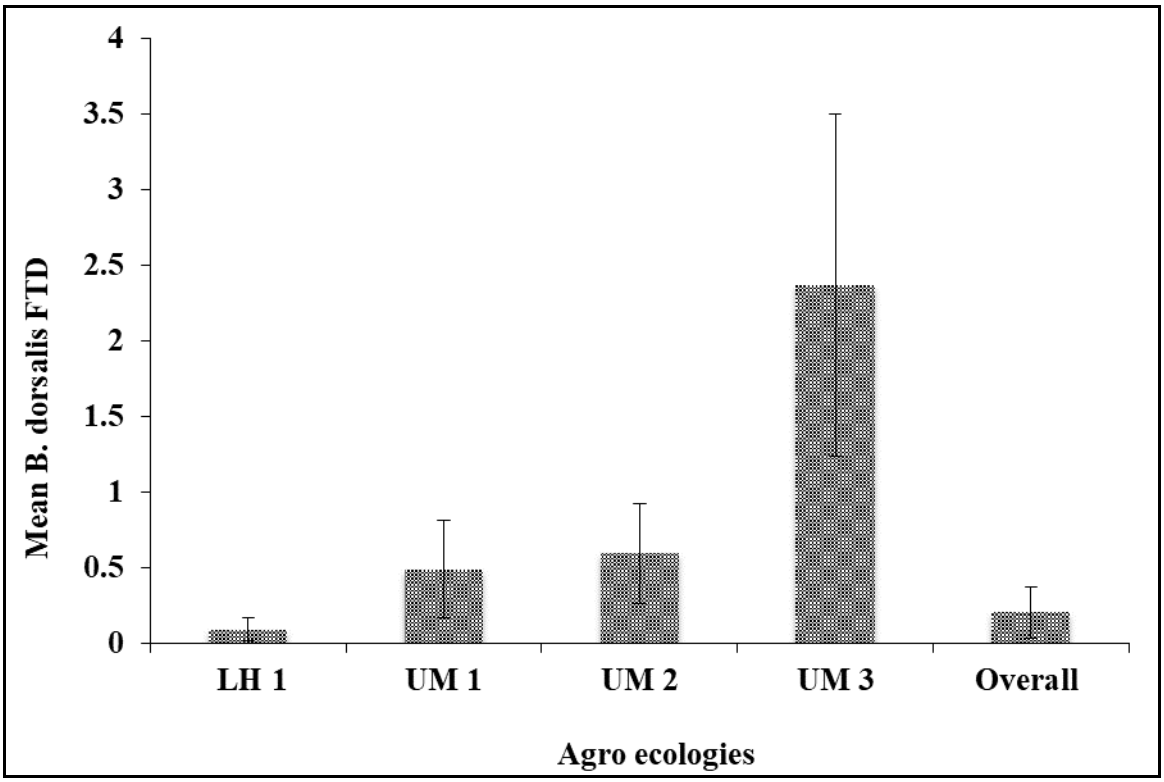

Figure 4: The number of flies per trap per day (FTD) recorded at Kandara sub county in July and August 2013. LH (Lower highland), UM (Upper midland)

Avocado was the dominant fruit tree in the area, with 49% presence in the farmland of the total tree count in the area sampled (Figure 5). Other tree plants recorded included coffee (32%), banana (10%), mango (5%) and pawpaw (1%). The rest of the fruit trees had a count of less than 1%. These were recorded in 1,640 farms, representing almost all households in the sub county. Amongst the dominant fruit trees, mango is the most preferred host of *B. dorsalis* (Mwatawala *et al.*, 2006, 2009). With presence of many possible host plants for *B. dorsalis*, it is not possible to pinpoint avocado as the preferred host of *B. dorsalis* at Kandara Sub-County even though there are records that have shown that the pest can complete its lifecycle on the crop (Akol *et al.*, 2013) and has been recorded emerging on avocado fruit (Muchemi *et al.*, 2012). In addition, Kenyan farmers are known to grow more than one fruit tree and crops in the farmland, hence making it difficult to link trap catches to avocado without having lab data on fruit pest emergence.

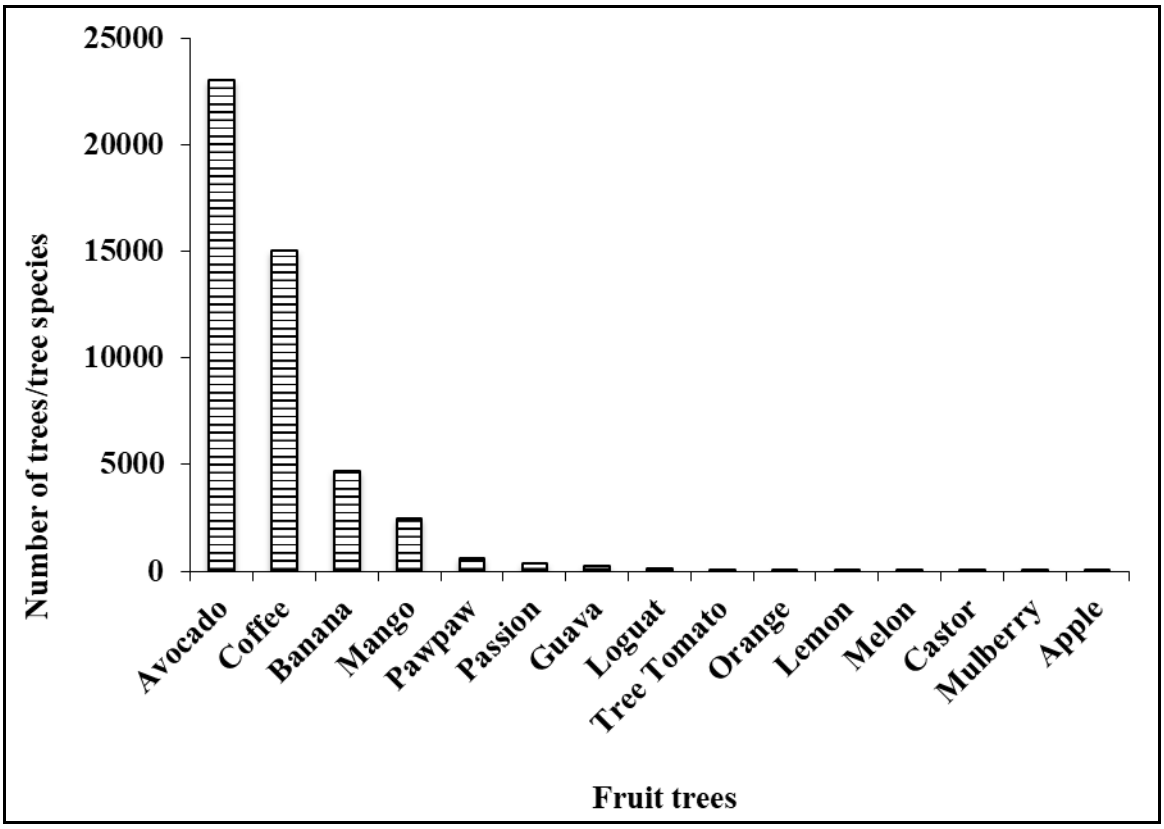

Figure 5: Number of different fruit crops grown in Kandara Sub County, Kenya in July-August, 2013.

From the 353 incubated avocado fruits there was no emergence of *B. dorsalis* or any other pest, showing that the pest was multiplying and infesting other host plants in the Sub-County. It also confirms earlier reports from surveys on non-emergence from avocados. For example, Muchemi *et al.* (2012) only reported a single fruit emergence of *B. dorsalis* amongst fruits collected in all parts of Kenya. This shows that the farming system in the sub county, of mixed fruit trees could be resulting to possible prevention of avocados from infestation by the pest since there are better preferred hosts. Long-term incubation studies for avocado of various ages will be preferable to develop database of the pest-fruit relation in the area, which may be used to negotiate trade deals with importing countries.

Conclusion

In this study, the presence and distribution of *B. dorsalis* was confirmed in Kandara Sub-County. The pest population is high in the eastern side, which is a low elevation zone compared to the rest of the sub county. It is possible that the pest migrated from the Eastern part of the country to the sub-county. The ME traps used were efficient as they attracted more than 90% of the trapped insects as *B. dorsalis*. The wide range of host plants in the area provides both positive and negative challenges towards pacifying the area of *B. dorsalis*. Since avocado is not the preferred host, the preferred hosts could still sustain the pest population in the area and hence pose a challenge in creating an area free of the pest. However, the wide host range could also provide evidence that the

avocado fruits are not hosting the pest, which was confirmed by the laboratory fruit incubation studies, which provides evidence that the avocado fruits from Kandara Sub-County do not post risk of disseminating the pest in trade. It is suggested that any effort to create pest free area in the sub county should consider effective reduction and prevention of *B. dorsalis* in the area from the eastern borders.

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