Assessment of the host range of fall armyworm *Spodoptera frugiperda* Smith (Lepidoptera: Noctuidae) in Manica province, Mozambique.

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Abstract:

The alien invasive insect pest *Spodoptera frugiperda* Smith (Lepidoptera: Noctuidae), commonly referred to as Fall Armyworm (FAW), is a polyphagous insect feeding on more than 350 host plants in addition to maize in its native habitat. Due to the voracious nature of FAW, significant yield losses on maize production were reported across the African continent since its detection in 2016. Despite being a polyphagous insect, little is known about its alternative host plants in the new habitat including Mozambique. This study aimed to assess the host range of FAW in the central province of Manica, Mozambique. A field survey was conducted from May to August 2019 (dry season of 2018/2019 cropping season) and in December 2019 and January 2020 (rainy season of 2019/2020 cropping season) in maize fields and crops often mixed with maize or located in the vicinity of maize fields. A total of 1291 fields were surveyed. In each field, 20 plants were selected in a "W" pattern and checked for the presence of FAW egg masses and/or larvae. At the time of the sampling, no evidence was found suggesting that in Manica province FAW feeds in crops other than maize because out of 35 different crops surveyed, FAW was only recorded on maize. Results from this study suggest that the strain of FAW occurring in Manica province might be the one specialized in maize or the continuous availability of maize fields throughout the year is influencing the choices of the host plants of this invasive insect pest.

Keywords: invasive species; Noctuidae; host plants; polyphagous insects; host-strain; pest management

INTRODUCTION

The Fall Armyworm *Spodoptera frugiperda* Smith (Lepidoptera: Noctuidae) is an alien polyphagous insect pest originating from the Americas, where it has more than 350 different host plants including both crop and non-crop species (Montezano *et al.*, 2018). Despite its ability to survive in different host plants, fall armyworm (FAW) is known to have a high preference for maize (Molina-Ochoa *et al.*, 2001; Nagoshi *et al.*, 2018). In Africa, FAW was first reported in West and Central Africa in 2016 (Goergen *et al.*, 2016), and rapidly spread to the rest of the continent with devastating consequences on maize production (Feldmann, Rieckmann and Winter, 2019). Initially confused with stem borers by agricultural extension officers, the occurrence of FAW in Mozambique was confirmed in early 2017 (Cugala *et al.*, 2017). In 2018, FAW was also reported in Asia (Sharanabasappa *et al.*, 2018). The rapid spread of FAW is largely attributed to its migratory potential (Meagher *et al.*, 2004) and high dispersal capacity (Kumela *et al.*, 2018).

Alien invasive species are known to disrupt the natural balance in newly invaded ecosystems creating serious problems (Toepfer *et al.*, 2019). The introduction of FAW in Sub-Saharan Africa is a serious threat to food security because its preferred host plant is a staple food in the region (Hailu *et al.*, 2018; Midega *et al.*, 2018; Prasanna *et al.*, 2018; Harrison *et al.*, 2019). In Mozambique for example, between 21 and 90% of the households depend on maize for daily subsistence (MASA, 2016).

Since the detection of FAW in the African continent, the majority of studies have been concentrated on options for management of the pest on maize (Bateman *et al.*, 2018; Hailu *et al.*, 2018; Midega *et al.*, 2018; Assefa and Ayalew, 2019; Tambo *et al.*, 2019; Feldmann, Rieckmann and Winter, 2019; Kansiime *et al.*, 2019; Sisay *et al.*, 2019; Agboyi *et al.*, 2020; Chimweta *et al.*, 2020; Ngangambe and Mwatawala, 2020), and little is known about its alternative host plants in the new environment. Economically important crops such as cabbage, cassava, tomato and common bean, which are among the reported hosts of FAW (Montezano *et al.*, 2018), are largely grown in Mozambique by smallholder farmers. Being a polyphagous insect pest, the knowledge of the population dynamics of FAW in various host plants can be used as a tool for the design of effective pest management strategies (Fuxa, 1989; Montezano *et al.*, 2018). This study aimed to assess the host range of FAW in food crops usually mixed with maize or located in the vicinity of maize fields in the central province of Manica, Mozambique.

MATERIALS AND METHODS

Description of the study area

This study was carried out in the districts of Macate (19o24′50.9″ South and 33o30′54.6″ East), Manica (18o56′13.2″ South and 32o52′33.6″ East), Sussundenga (19o24′39.0″ South and 33o16′33.0″ East) and Vanduzi (18o57′09.4″ South and 33o15′51.6″ East) in the central province of Manica, Mozambique (fig. 1). According to MASA (2016), the area of the survey belongs to the Agro-Ecological Region (AER) number 4, which is characterized by the large occurrence of ferralsols and litosols with an annual mean temperature around 24oC and annual mean precipitation ranging between 800 and 1000 mm. During the dry season, maize is cultivated mainly in areas with irrigation systems or in valleys and riverbanks with sufficient soil moisture to allow the normal growth of crops. Maize is often grown in small plots (less than 1ha), in different cropping systems and mainly for family consumption. In general, no fertilizers and chemicals are used for maize production at smallholder farmers' level. Maize is usually intercropped with roots and tubers, legumes and cucurbits. Vegetables such as tomatoes, cabbage and kale are

typically grown in monocrop systems occasionally adjacent to maize fields. Surrounding environment is mainly dominated by fruit trees like avocado, banana, mango, litchi and gramineous plants.
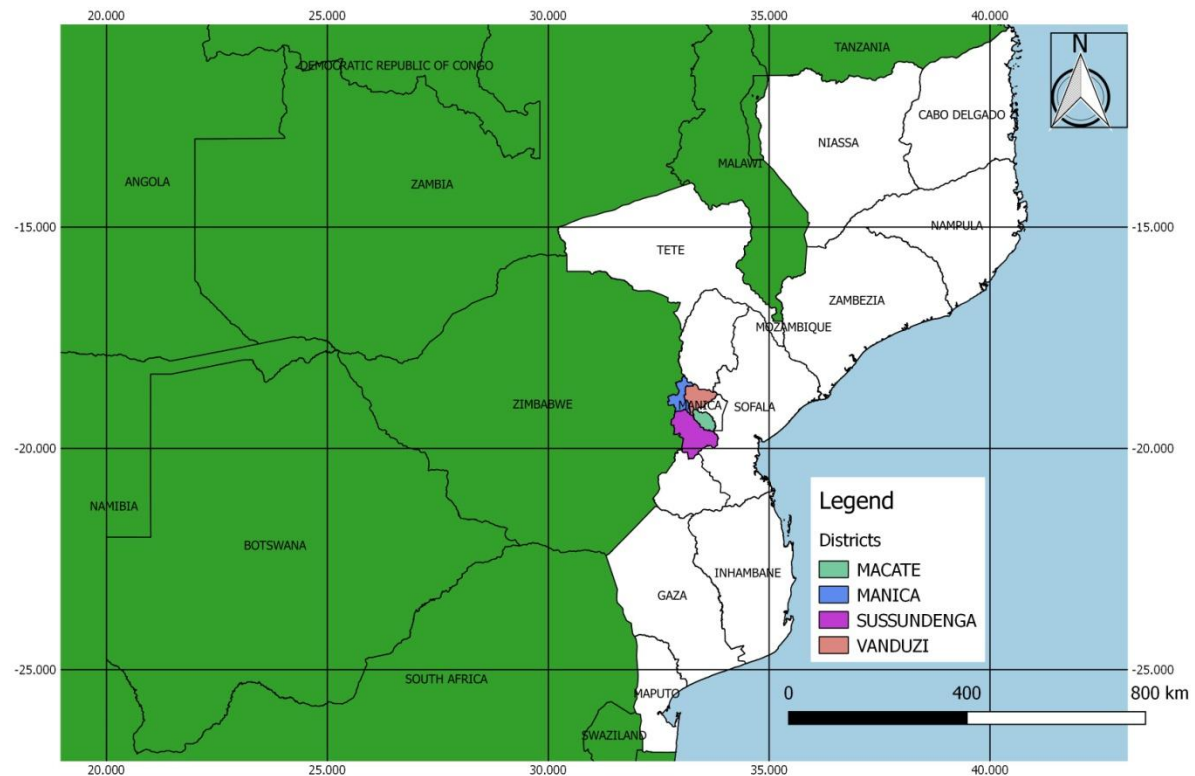

Figure 1: Sampling locations in Mozambique

Field survey

The survey was carried out from May to August 2019 (dry season of the 2018/2019 cropping season) and in December 2019 and January 2020 (rainy season of the 2019/2020 cropping season). Districts were selected based on their potential for maize production, combined with the reported occurrence of FAW. Maize fields and crops normally mixed with maize or located in the proximity of maize fields were surveyed. Fields were selected through snowball sampling technique. Each field was visited once during the study period. To avoid border effects, the first two border rows were excluded from the survey in fields where crops were planted in rows. In fields where crops were not planted in rows, an estimated distance of 1 meter from the border was excluded from the survey on either side of the field. Based on the illustration of maize growth stages by Beckingham (2007), only maize fields in which the plants were in stages 1 to 5 were sampled as described: (stage 1): five leaves fully emerged; (stage 2): eight leaves fully emerged; (stage 3): 12 leaves; (stage 4): 16 leaves and; (stage 5): Tasseling/Silking. In crops different from maize, plants in vegetative stages were sampled. In each field, 20 plants were selected in a "W" pattern

and checked for the presence of FAW egg masses and/or larvae. A distance of 3 meters between plants was observed. Stalks and both upper and lower surfaces of the plant leaves were inspected. Field surveys were carried out during the daylight period from 7h to 17h. The names of the crops assessed were recorded. Where crops were found to be mixed or intercropped in the same field, a separate survey was carried out for each crop according to the number of crops in the field.

RESULTS

Table 1 shows the crops assessed for the presence or absence of FAW per district and season of sampling. A total of 1291 fields with different food crops were surveyed. Thirty-five 35 different crops belonging to 13 families were covered. The top 3 most cultivated crops in Manica province are, in order of their importance: maize with 622 fields, pumpkin with 134 fields and cassava with 99 fields. Although they are grown in both seasons, a close analysis shows that they also share the same seasonality as most of the fields of these crops were recorded during the rainy season.

Table 1: Crops assessed for the presence of FAW

Family name	Common name	Scientific name	Macate DS	Macate RS	Manica DR	Manica RS	Sussundenga DS	Sussundenga RS	Vanduzi DS	Vanduzi RS	Total	Absence or Presence of FAW
Amaranthaceae	Beetroot	*Beta vulgaris* L.							1		1	a
Amaryllidaceae	Garlic	*Allium sativum* L.			1		6				7	a
	Onion	*Allium cepa* L.	2		1		3				6	a
Apiaceae	Carrot	*Daucus carota* L. subsp. *sativus*			1						1	a
Araceae	Madumbe	*Colocasia esculenta* (L.) Schott	1			2		1		1	5	a
Asteraceae	Lettuce	*Lactuca sativa* L.			5	1	1				7	a
	Sunflower	*Helianthus annuus* L.		1			1				2	a
Brassicaceae	Cabbage	*Brassica oleracea* L. var. *capitata*	3		17	5	7		12	4	48	a
	Chinese cabbage	*Brassica rapa* L. subsp. *pekinensis*	1		4		3				8	a
	Portuguese kale	*Brassica oleracea* L.var. *acephala*	7		16	5	5	1	4	2	40	a
	Rape	*Brassica napus* L.	1		4		1		1		7	a
Cucurbitaceae	Cucumber	*Cucumis sativus* L.		2				7		2	11	a
	Melon	*Cucumis melo* L.						6		3	9	a
	Pumpkin	*Cucurbita moschata* Duchesne	5	23	3	18	4	53	1	27	134	a
	Watermelon	*Citrullus lanatus* (Thunb.)		1				5		9	15	a
Euphorbiaceae	Cassava	*Manihot esculenta* Crantz	9	31	4	5	7	24		19	99	a

Table 1 (continued)

Family name	Common name	Scientific name	Number of fields/district									Absence or Presence of FAW
			Macate		Manica		Sussundenga		Vanduzi		Total	
			DS	RS	DR	RS	DS	RS	DS	RS		
Fabaceae	Common bean	*Phaseolus vulgaris* L.	2	1	10	2	4		1		20	a
	Cowpea	*Vigna unguiculata* (L.) Walp.	1	8	1	4	4	15		13	46	a
	Green bean	*Phaseolus vulgaris* L.	1		2	1	3			1	8	a
	Peanut	*Arachis hypogaea* L.		1		4		3		4	12	a
	Peas	*Pisum sativum* L.			2		2				4	a
	Pigeon pea	*Cajanus cajan* L.	6	6	1	2	2	8		2	27	a
	Yoke beans	*Vigna aconitifolia* (Jacq.) Maréchal						2		2	4	a
Malvaceae	Okra	*Abelmoschus esculentus* (L.) Moench		1		2	1	10		11	25	a
Pedaliaceae	Sesame	*Sesamum indicum* L.					7				7	a
Poaceae	Maize	*Zea mays* L.	25	130	29	137	28	141	59	73	622	present
	Rice	*Oryza sativa* L.	1								1	a
	Sorghum	*Sorghum bicolor* (L.) Moench	3				5				8	a
	Wheat	*Triticum aestivum* L.					3				3	a
Solanaceae	Eggplant	*Solanum melongena* L.							1		1	a
	Irish potato	*Solanum tuberosum* L.	5		1		3		7		16	a
	Piri Piri	*Capsicum frutescens* L.		1	2						3	a
	Sweet peeper	*Capsicum annuum* L.	2		3	1	1			3	10	a
	Sweet potato	*Ipomoea batatas* (L.) Lam	5	3			2	5	1	11	27	a
	Tomato	*Solanum lycopersicum* L.	13		27	2	3		1	1	47	a

DS = Dry Season, RS = Rainy Season, a = absent

DISCUSSION

Out of 35 different crops belonging to 13 families surveyed in the four districts in both seasons, maize was the only crop in which FAW was recorded. Although FAW can attack many crops of different families including cabbage, pumpkin, cassava, pigeon pea, cowpea and okra as stated by Montezano *et al.* (2018), the present study could not confirm this behaviour as all of the above-mentioned crops were surveyed but with no recorded presence of FAW. Several studies (Pitre, Mulrooney and Hogg, 1983; Buntin, 1986; Kennedy and Storer, 2000), have suggested that despite its ability to survive in different host plants, FAW has a preference for gramineous plants such as maize and sorghum. Being in the group of the most preferred host plants like maize, it was expected to record FAW on sorghum, wheat and rice, but no egg masses and/or larvae were recorded in these crops.

The simultaneous occurrence of the most preferred host with alternative hosts may lead to the concentration of the pest population in fields where the most preferred host is located (Kennedy and Storer, 2000). It is also believed that in case of continuous availability of the most preferred host plant, FAW may confine its attack to that host (Johnson, 1987). Results from this study seem to follow these hypotheses, as in addition to the fact that maize is the most preferred host plant, it happens that it is also grown throughout the year regardless of the season, making it easier for FAW to keep feeding solely and continually on maize, avoiding thus its alternative host plants.

Another important thing to be noted is the fact that FAW is composed of two genetically differentiated but morphologically identical strains, each exhibiting different host specificity (Pashley, 1986; Nagoshi *et al.*, 2012). There is the maize-strain feeding primarily on maize, and the rice-strain feeding primarily on forage grasses and rice (Veenstra, Pashley and Ottea, 1995). Shortly after the presence of FAW was confirmed in Africa, both maize-strain and rice-strain were detected in Uganda feeding on maize fields (Otim *et al.*, 2018). In the African continent, the maize strain is believed to be the most predominant of the two (Early *et al.*, 2018), which may explain the fact that FAW was only recorded in maize fields in this study.

While the strain development is strongly influenced by the host plant (Whitford *et al.*, 1988), it should be observed that host plant per se does not determine the identity of colonizing strain (Virla *et al.*, 2008). Due to the existence of these morphologically identical strains, it is hard to understand the field behaviour of FAW (Nagoshi and Meagher, 2004). When host-specific strains feed and reproduce on alternative host plants, its development can be compromised. Meagher *et al*. (2004) observed poor larval development and high mortality rates on FAW larvae of a maize-specific strain fed on different hosts. Studying the behaviour and distribution of the FAW host strains, Nagoshi and Meagher (2004) concluded that the maize-specific strain was primarily found in agricultural areas. A study published by Fuxa (1989) suggested that when maize reaches the maturation stage becoming thus unsuitable for oviposition, maize-specific strain populations may migrate to other locations where maize is still in its vegetative stages avoiding different host plants.

Prevailing climatic conditions of the regions where FAW occurs may have a certain influence on its behaviour. Within this line, Groot *et al.* (2010) questioned if there was a geographic variation in host preference of FAW. Although we did not study the distribution or occurrence of the two reported host-strains of FAW, it seems that the population of FAW occurring in Manica province might be a geographical distinct strain, and it may explain why no FAW egg masses and/or larvae were detected in different crops other than maize.

As a surviving instinct, insects choose the best conditions possible including their host plant species for a successful offspring. Wiseman and Davis (1979), noted that the lack of certain substances or qualities for oviposition, food and/or shelter may lead an insect pest to avoid some plants. Most of the plant species recorded in this study has a very different architecture compared to that of maize. Depending on the ecology of the pest, plant architecture may also play an important role when choosing its host plants as it may define the suitability of the plant for shelter. Pumpkins for example, according to Baudron *et al.* (2019), may provide better shelter habitat for FAW than maize due to its closed-canopy leaves. Based on this assumption, FAW should have been recorded in plants with closed-canopy leaves such as sweet potato and pumpkins.

CONCLUSION

Results from this study should not be taken as conclusive, because defining host plants based on surveys over a limited period can be misleading as suggested by Nagoshi *et al.* (2007). Additionally, it may also be too soon that in its new environment, FAW might not yet have adapted to other host plants such as wheat and sorghum which are close relatives of maize. Future surveys should be conducted in other regions of the country and include gramineous grasses traditionally known to host FAW. Concerning the issue of host-specific strains, the use of molecular techniques should be used to determine if both strains of FAW occur in Mozambique as they are visually indistinguishable. Although the present study is not conclusive, it suggests that FAW is at the present feeding solely on maize. The information brought by this study may assist farmers and both researchers and the government to concentrate their efforts on Integrated Pest Management (IPM) strategies for FAW on maize, as these strategies work better as many as only one pest and one crop are involved.

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