THE WIDER DISTRIBUTION OF *ELDANA SACCHARINA* (LEPIDOPTERA: PYRALIDAE) IN SOUTH AFRICA AND ITS POTENTIAL RISK TO MAIZE PRODUCTION

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Abstract

Since the first outbreak of *Eldana saccharina* in 1939, this stalk borer has become the major pest of sugarcane in South Africa. Recent surveys revealed that the distribution of *E. saccharina* in the country is not confined to the sugarcane producing areas, but is much wider than previously reported. The current distribution extends from Thohoyandou in Limpopo province in the north to Mkambati Nature Reserve in the Eastern Cape province in the south. The western limit is now Boskop dam, close to Potchefstroom in the North-West province. The indigenous host plant range of the insect has also increased. The presence of *E. saccharina* in indigenous grasses in the major maize producing region of South Africa introduces the risk of its adaptation to maize. This risk is exacerbated by climate changes in the region which make the environment increasingly favourable for *E. saccharina* population build-up.

Keywords: sugarcane, *Eldana saccharina*, stalk borer, maize, climate change, indigenous host plants, South Africa

Introduction

The stalk borer *Eldana saccharina* Walker (Lepidoptera: Pyralidae) is indigenous to Africa, where it feeds naturally on several wetland sedges and indigenous grasses (Girling, 1972; Atkinson, 1980; Conlong 2001). In South Africa, *E. saccharina* was first reported as a pest of sugarcane in 1939, when an outbreak occurred in carry-over sugarcane fields on the Umfolozi Flats in KwaZulu-Natal province (Dick, 1945). Since then it has become the most serious pest of sugarcane. Its distribution was believed to be confined to the coastal belt where sugarcane is commercially produced and its natural hosts (indigenous sedges) are common (Atkinson, 1980; Way, 1994; Conlong, 2001; Webster *et al*., 2005). The insect's expansion to the south and inland was believed to be restricted by cold temperatures in these areas impacting negatively on its survival (Dick, 1945; Way, 1994), and by the dry climate limiting the availability of its indigenous sedge hosts (Atkinson, 1980).

However, recent surveys conducted in various parts of South Africa showed that *E. saccharina* is present in areas beyond the sugar belt. Furthermore, it has been found in indigenous plants that were not previously considered preferred hosts of the southern African population of *E. saccharina* (Conlong, 2001; Assefa *et al*., 2006a).

This paper reviews the historic and current range of distribution of *E. saccharina* in South Africa, and its known and newly recorded indigenous host plants. The potential threat posed to maize production in the country, based on the biology and behaviour of the insect, and also its response to global warming, are discussed.

***Eldana saccharina* distribution**

Historically in South Africa

Until the early 1990s, *E. saccharina* was known to exist only in the coastal belt and low-lying sugarcane producing areas of South Africa (Atkinson, 1980; Conlong, 1997). Its sequence of spread in eastern KwaZulu-Natal until 1980 from the original cane infestations recorded on the Umfolozi Flats and Hluhluwe was reported by Atkinson *et al*. (1981). Inland high altitude areas and the southern extreme of the sugar belt were free of this insect (Atkinson, 1980; Atkinson *et al*., 1981) and it was believed that *E. saccharina* could not survive the low winter temperatures experienced in these areas (Dick, 1945; Way, 1994). Despite the presence of natural host plants and sugarcane further south (Atkinson, 1980), no life stage of the insect was reported beyond Port Shepstone until Conlong (2001) recovered *E. saccharina* from *Prionium serratum* (L.f.) Drège ex E.Mey. (Juncaceae: Juncales) in the Mkambati Nature Reserve in the Eastern Cape. This area remains the known southerly limit of distribution for *E. saccharina*. Its expansion beyond the sugar belt, especially into the northern areas, was thought to be limited by the lack of suitable indigenous hosts in the more arid climate of these regions (Atkinson, 1980; Atkinson *et al*., 1981). *E. saccharina* was thus considered an important pest only in sugarcane producing regions. It has not been reported as a pest of cereal grains in South Africa (Conlong, 1994; 2000; 2001; Mazodze and Conlong, 2003) despite its importance in these crops in West Africa (Bosque-Perez and Schulthess, 1998). This has resulted in it receiving little or no research attention in the maize producing areas of South Africa.

Currently in South Africa

Large grasses and wetlands beyond the sugar belt had not been investigated for the presence of *E. saccharina* until 2006-2007, when extensive surveys were conducted for stem borers in potential indigenous host plants in the vicinity of maize, sorghum and sugarcane (unpublished data[1]). The surveys revealed that the distribution of *E. saccharina* now extends to Thohoyandou in Limpopo province in the north and Mkambati Nature Reserve in the Eastern Cape in the south. The new western limit recorded was Boskop dam, close to Potchefstroom in North-West province, which is a major maize producing area. Although at this stage *E. saccharina* has not been recorded from the crop, its extended range into the maize producing regions of South Africa is a cause for concern. In West Africa and Uganda, *E. saccharina* is well known as a pest of maize (Atachi *et al*., 2005; Assefa *et al*., 2006a).

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Indigenous host plant range of *Eldana saccharina*

Historically in South Africa

Atkinson (1980) and Conlong (2001) listed the indigenous host plants of *E. saccharina* in southern Africa and found them to be dominantly sedges (Cyperaceae). Several early surveys, conducted soon after *E. saccharina* was found attacking sugarcane, reported it as an insect of sedges (Dick, 1945; Atkinson, 1980). In various natural habitats, Atkinson (1980) found indigenous grasses adjacent to infested sedges to be free of *E. saccharina* damage. However, *P. serratum* growing in natural habitats outside the sugar belt of South Africa was reported to harbour *E. saccharina* (Conlong, 2001). This host shift might have been due to *P. serratum* being closely related to the Cyperaceae. DNA-sequence data indicate that the Juncales are more closely related to Cyperaceae than other Juncaceae (Munro and Linder, 1997).

Currently in South Africa

In the 2006-2007 surveys conducted in inland South Africa, *E. saccharina* was recovered from two indigenous grasses (*Phragmites australis* Cav. and *Panicum maximum* Jacq.) and a sedge (*Cyperus articulatus* L.) not previously listed as hosts of *E. saccharina* in southern Africa. This is not surprising, as *E. saccharina* was reported from several other indigenous grasses and sedges in other countries in southern Africa where sugarcane is grown, either for commercial or chewing purposes (Conlong, 2001; Mazodze and Conlong, 2003). These new records suggest that many more new indigenous host plants of *E. saccharina* would probably be found if new habitats and plant species were searched. This is supported by the fact that *E. saccharina* was identified by entomologists at the Transvaal museum in Pretoria, recovered from Macadamia nut (*Macadamia* sp.) in Limpopo province (personal communication[2]). Its extended host range, which includes many species in different families (Conlong *et al*., 2007), shows the potential of *E. saccharina* to exploit a wide range of resources.

These observations, however, may raise questions such as: (a) Does the presence of *E. saccharina* pose a threat to maize production in South Africa?, (b) Is the *E. saccharina*-indigenous grass association a new development? and (c) What factors favour *E. saccharina* population build-up in the new areas? The following sections deal with some of the possible answers to these questions.

Discussion

Presence of E. saccharina *in maize production areas in South Africa - a potential problem?*

In polyphagous insects such as *E. saccharina*, changes in host plant preference hierarchies can be for a variety of reasons, including variations in host quality or abundance (Dukas and Ellner, 1993; Dukas and Clark, 1995; Conlong *et al*., 2007). Choice-test experiments conducted by Atachi *et al*. (2005) showed that the West African population of *E. saccharina* preferred indigenous grasses (natural hosts in the region) to crops. Conlong *et al*. (2007) in similar tests reported that the southern African population of *E. saccharina* preferred sedges (natural hosts in southern Africa) to sugarcane. In a preference study conducted by Keeping *et al*. (2007), the southern African population of *E. saccharina* preferred maize to sugarcane for oviposition. However, the preference hierarchies determined from controlled laboratory trials may not be reflected under field conditions. Under field conditions phytophagous insects may fail to find a preferred host among less preferred vegetation, depending on plant neighbours (Andow, 1991). In such cases, a preferred host plant may act as a source of herbivores for the surrounding non-favoured hosts (White and Whitham, 2000). Constraints on host choice

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imposed by the spatial arrangement of host plants in the field may therefore lead to a distribution of offspring among host plants that are less preferred. This effect was observed in *E. saccharina* where the expansion of sugarcane cultivation into wetlands resulted in the destruction of the higher-quality hosts (indigenous sedges), and high population pressure led to the insect moving to the lower-quality host (sugarcane) to survive (Atkinson *et al*., 1981; Conlong 2000). *E. saccharina* has shown similar behaviour in Kenya (Waiyaki, 1974), Tanzania (Waiyaki, 1974), Uganda (Girling, 1972) and Zimbabwe (Mazodze *et al*., 1999), where it moved from indigenous host plants to field crops when constraints were placed on indigenous host plant abundance. This resulted in severe outbreaks being reported from commercial crops a few years after being reported from indigenous hosts. This could occur in the maize producing regions of South Africa should current biotic and/or abiotic factors change the indigenous/cultivated host plant balance to favour the incursion of *E. saccharina* into maize.

Implications of increased indigenous grass host plant associations in the maize production area

Available records show that, as more habitats are investigated, *E. saccharina* is being found on an increasing number of indigenous host plants. (Conlong, 1993, 2001). At the same time it is spreading as a crop pest throughout sub-Saharan Africa (Mazodze *et al*., 1999; Webster *et al*., 2005; Assefa *et al*., 2006b). Reports from studies on the mechanisms and process of host shift in phytophagous insects stresses the importance of the similarities in the plants' secondary metabolic compounds between the novel and old hosts (Thompson, 1991). Closely related host plants often meet these requirements. Hence, it is likely that *E. saccharina* residing in indigenous grasses could adapt to graminaceous crops and overcome any defense from the crops more easily than the population residing in sedges. The presence of *E. saccharina* in indigenous grasses in the extended areas therefore increases the chance of host plant shift by the insect to the graminaceous crop, and heightens the risk of infestation in maize.

Climate change in the maize producing areas and its potential to increase E. saccharina *populations*

Global warming is a fact, and is affecting species in a variety of ecosystems (Whittaker, 2001), and Africa is no exception (Warburton *et al*., 2005). Animal and plant species occurring at warm, low altitudes, that are mobile and have a widespread breeding habitat, can benefit from global warming, as they have the potential to expand their range of distribution. In the past few decades, increased minimum temperatures have allowed several lepidopteran species to move from low elevation sites to colonise sites at higher elevations that previously may have been too cold and/or dry for their survival (Hill *et al*., 2002). This movement has been described for a number of stem borer species, including *E. saccharina* (Way, 1994; Getu *et al*., 2001; Tlali *et al*., 2002; Tefera, 2004; Webster *et al*., 2005).

Until the early 1990s, *E. saccharina* was restricted to low lying coastal areas of the sugar belt, with higher altitude, inland and extreme southern areas of KwaZulu-Natal being free of this pest (Atkinson, 1980; Atkinson *et al*., 1981; Way, 1994; Webster *et al*., 2005). The absence of the insect was reported to be associated with the cold winter temperatures in these areas (Atkinson, 1980; Atkinson *et al*., 1981) which were often low enough to inhibit mating and retard larval development. In addition, *E. saccharina* eggs failed to hatch at temperatures below 15ºC (Dick, 1945; Way, 1994), and egg fertility and adult longevity were adversely affected by low temperatures (Way, 1994). However, with global warming, these southern and midland areas have experienced higher maximum and minimum temperatures that have allowed *E. saccharina* to become more prevalent in sugarcane (Way, 1994; Webster *et al*., 2005). The history of yield losses ascribed to borer damage has induced growers in these areas to implement early control measures to prevent *E. saccharina* from reaching pest status (Webster *et al*., 2005).

The inland areas of South Africa where maize is produced were also thought to have winter temperatures too cold for *E. saccharina* populations to establish. However, results from the 2006-2007 surveys indicate otherwise. *E. saccharina* was found in numbers on indigenous host plants in some inland areas (unpublished data[3]). Summer temperatures in the maize producing areas are suitable for *E. saccharina* survival, and the minimum temperature tolerated by the crop is similar to the low temperature requirements of the pest (du Toit, 1999). The coldest months of the year throughout South Africa are June, July and August (Schulze, 1997), which are the months reported to restrict the spread of *E. saccharina* to high altitude inland areas of the country. However, mean daily minimum temperatures in the interior of the country have increased (Hull *et al*., 2008), and a large number of weather stations in the Free State, Northern Cape, Mpumalanga and North-West provinces show statistically significant warming trends (Warburton *et al*., 2005). This warming might be responsible for the observed expansion by *E. saccharina* to inland South Africa. In particular, an increase in minimum temperature in the first three hours after sunset in these winter months is crucial for the survival of the insect in inland areas, as this is the time during which *E. saccharina* is reported to mate (Atkinson, 1980).

Hull *et al*. (2008) formulated a mating index for *E. saccharina* for April to September whereby the number of hours, for the first three hours after sunset, were accumulated on the condition that the temperature was above 15°C. Using this index, these authors mapped the distribution patterns in South Africa where temperatures would allow mating of the insect to occur successfully (Figure 1). Results showed that the April to September temperatures in Limpopo province are more conducive to *E. saccharina* mating than temperatures in the coastal areas of KwaZulu-Natal over the same period. This indicates that *E. saccharina* has the potential to reach pest status in Limpopo province, should it adapt to maize. Temperatures in most parts of the North-West and Eastern Cape provinces are also conducive to a population build-up by the pest (Figure 1). Increased temperatures in these regions (Warburton *et al*., 2005) make them more suitable for *E. saccharina* to establish, provided suitable habitat is available. There is thus a distinct possibility that *E. saccharina* may become a pest of maize in these areas in the future.

Researchers and maize farmers in South Africa should note that *E. saccharina* is now present in the maize producing areas and can move from its natural host plants to maize fields, as it did in sugarcane fields in Zimbabwe, Uganda and Kenya. Such a move could introduce severe financial implications in the maize industry. Factors that will prevent it from moving into maize fields in South Africa should therefore be studied and preventative measures should be initiated. Agronomic practices such as destruction of indigenous host plants and leaving maize stalks in the field after harvest could result in increased pressure on this borer to move to maize and need to be discouraged. The diversity of natural enemies occurring in indigenous host plants in South Africa and in the new indigenous habitats need to be further investigated and evaluated for their role in the management of *E. saccharina* in both the maize and sugarcane agro-ecosystems.

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Conclusion

This paper provides the first evidence of viable populations of *E. saccharina* in indigenous host plants in the maize producing areas of South Africa. Although it has not yet been recorded from the crop, a shift from indigenous hosts into maize could cause serious crop losses, as happened in the South African sugarcane industry. The paper also documents the occurrence of the insect on indigenous grasses that were not previously listed as host plants of the South African population of *E. saccharina.* Furthermore, data are presented that show that large parts of the maize producing areas of South Africa are favourable for a population build-up of this pest, based on a minimum temperature mating index.

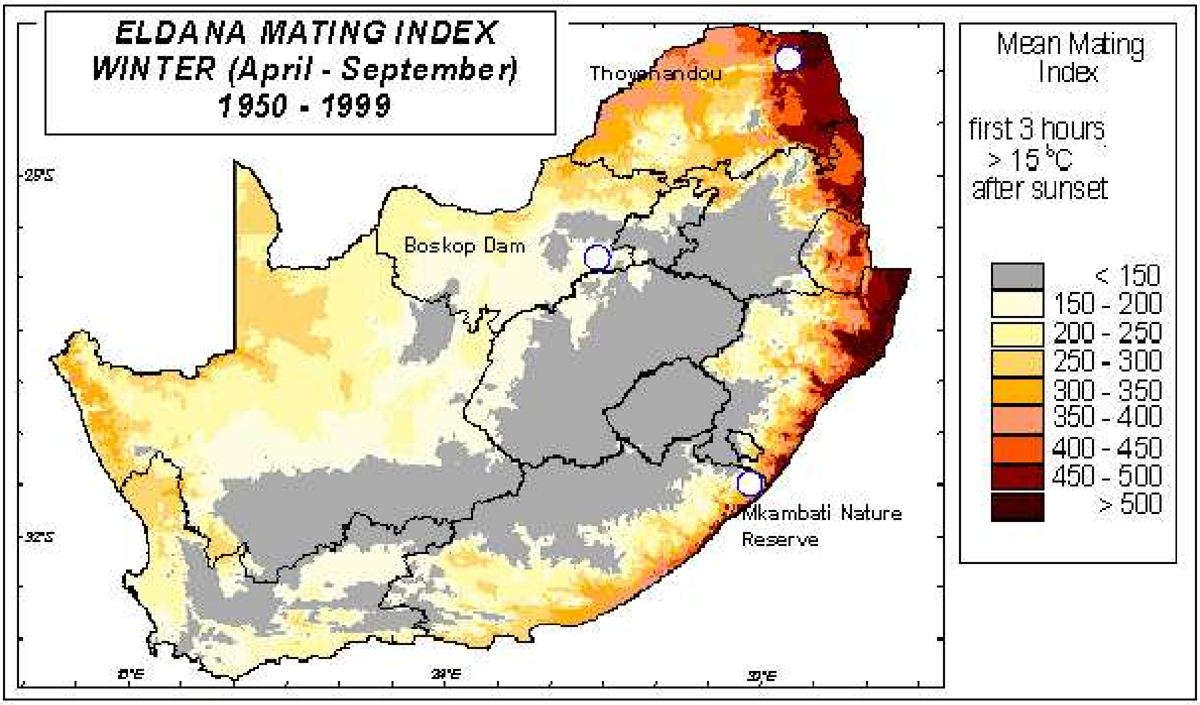

Figure 1. Suitability of areas within South Africa for the establishment of *Eldana saccharina* Walker (Lepidoptera: Pyralidae), based on mean number of potential mating hours from April to September (from Hull *et al*., 2008).

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