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SURVEYING WHITE GRUBS (SCARABAEIDAE) IN THE SWAZILAND SUGARCANE INDUSTRY: THE 2006-2012 SURVEYS

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Abstract

In Swaziland, damage by scarab beetle grubs/larvae to sugarcane roots is of concern and occasionally necessitates replanting. Annual white grub surveys are carried out by the industry to detect fields with excessive infestations. Survey records from 2006 to 2012 showed that most larvae were recovered from fields on Tambankulu Sugar Estate, specifically sections 1 and 2, and fewer on the Umbuluzi Sugar Estate. Over this survey period, 11 618 larvae were recovered from 29 096 pits, representing an average area-wide density of 0.4 larvae/pit. The highest mean larval infestation was recorded in 2009 of 0.62 larvae from 30x30x30 cm sized pits dug beneath sugarcane stools. The maximum number of larvae found in a single pit was 7 individuals, and it was believed that these localities were where replant was required. From the specimens recovered the field teams identified a large proportion of the specimens as *Asthenopholis minor* (Melolonthinae). For example, in 2010 there were 94.4% of this species. In the same year, *Heteronychus licas* (Dynastinae) comprised 2.7% of larval recoveries. Past area-wide surveys showed that, during the 1960s, *H. licas* was the most common species encountered in this sugar industry, and then during the 1980s, *A. minor* was recorded as the predominant species. The other two taxa usually recorded during these surveys are *Anomala* spp. and *Adoretus* spp. that typically represented a substantially lower proportion of 0.9% and 1.6%, respectively, during the 2010 survey, while a group of unknown scarab taxa routinely recorded each year comprised 0.43%. Low density and relatively small body size of the last mentioned three groups probably preclude them from causing appreciable damage. The subject of the identity of white grub larvae in sugarcane fields is being studied at present. To this end, this paper gives a simple identification key that can be used in the field to identify third instar larvae of *A. minor* and *H. licas*. Additional research is recommended to confirm the identity of all four species recorded during these surveys and the unknown taxa using integrative (morphological and molecular) taxonomic techniques.

Keywords: sugarcane, Swaziland, Scarabaeoidea, *Adoretus, Anomala, Asthenopholis, Heteronychus*

Introduction

In the Swaziland sugarcane industry white grubs (mixed Scarabaeidae) are sporadic and localised pests that occasionally destroy sections of plant fields that then have to be replanted (Carnegie and Conlong, 1994; Carnegie, 1988). Instituting control measures is difficult to justify, partly because it is almost impossible to predict where the next infestation will occur.

Moreover, feasibility and efficacy of controls are hampered by the soil habitat of these pests, which renders them hidden and well protected. In addition, there are many species of white grub involved, of which only a few reach pest status.

The current approach to managing these pests in Swaziland is to conduct soil-pit sampling programmes each year to detect the presence of infestations where action such as replanting the crop in those parts of the field without any stools may be warranted. The data collected, which is regarded as an 'industrial' dataset because the sample strategy was not designed with a specific research objective in mind, has been analysed to determine the distribution of infestation levels.

The long term aim of this scientific approach is to investigate any possible relationship between biotic and abiotic factors that might indicate where outbreaks are likely to occur, thus enabling predictions. For example, there is anecdotal evidence that red soils might favour larval survival. Secondly, this particular data-mining exercise has been used to determine the species complexes currently recovered during these surveys in the Swaziland sugar industry. Correct identifications of any pest species are essential prior to developing control measures targeting susceptible life stages.

This paper therefore deals with the topics of monitoring white grub pests through extensive surveying on an area-wide scale, and includes a discussion and a short study of the key species that are routinely encountered. The study draws extensively on local survey information (Anon, 1997; Dittrich-Schröder *et al*., 2009; Way, 1997; Way *et al*., 2011; Way *et al*., 2012), as well as on comprehensive unpublished reports compiled by Sweeney (1967) and Williams (1985) on white grub pests in Swaziland.

Materials and Methods

The Swaziland industry survey data collected between May and December, from 2006 to 2012, at Tambankulu Estates in the northern part of Swaziland (26°06'26"S; 31°55'34"E), were synthesised and summarised. To survey, 30x30 cm pits were dug to a depth of 30 cm beneath sugarcane stools. Selection of sites within fields was random, and the number of pits surveyed differed in each field (on average 33, and between 3 and 87 pits), therefore the following calculation was used to obtain an estimate of larval density: number of larvae recovered per pit (larvae/pit) = total number of larvae recovered/total number of pits sampled. There were also different numbers of farms sampled in each of the Sugar Estates, therefore an average larvae per pit was calculated as the sum of the larvae recovered on each estate divided by the total number of pits sampled, expressed as larvae/pit. The larvae recovered were identified in the field, based on the pattern of hairs or rasters that are visible using a 20x eyepiece (Sweeney, 1967).

A separate preliminary study was carried out to identify the main features of the most common white grubs collected from pits sampled in Swaziland. These specimens were fixed in boiling water for about one minute to retain colour and render rigidity, and then preserved in 70% EtOH (ethanol). At the South African Sugarcane Research Institute (SASRI) the specimens were identified by the first author as *A. minor* or *H. licas* based on morphological features, *viz.* features of the whole body, raster pattern and head. To capture digital images, an example of one of each of these two taxa were photographed with a Nikon digital camera D3100 mounted onto a Nikon SMZ 1500 dissecting microscope.

A simple key was constructed based on morphological features to distinguish between the third larval stages of these most abundant species: the leaf chafer *A. minor* and sugarcane beetle *H. licas*. Photographic images of *A. minor* used in the field key were taken from the white grub 142 stored in the white grub Image-Library at SASRI, that was collected from Swaziland on Tambankulu Sugar Estate near Mhlume Mill, by M Way on 31 May 2012, from the 9th ratoon of variety NCo376, and those of *H. licas* from a specimen (assigned to white grub 107) collected from Mozambique on Mafambisse Sugar Estate, by J Piwalo on 23 April 2012, from a 3 ha plant crop of variety N25.

Results and Discussion

From 2006 to 2012 this surveying programme recovered 11 618 larvae from 29 096 pits, which represented an average density over the seven-year survey of 0.4 larvae/pit. Table 1 indicates that the larval density varied each year. Most larvae were recovered in 2009, when the density was 0.62 larvae/pit. Within the region of Swaziland that was routinely surveyed, most larvae were recovered from the Tambankulu region, specifically sections 1 and 2 (Table 2) rather than from the Umbuluzi region. Since the number of pits sampled in each field was not the same, it was not possible to compute precisely an exact figure for the larval density per pit. In future, the survey strategy will be structured so that the same number of pits are sampled per unit area, thereby enabling the estimation of larval distribution more precisely. It is recommended that five pits are sampled per 10 hectares.

Table 1. Sample size (expressed as number of pits sampled), total number of larvae recovered, the mean number of larva per pit (expressed as l/pit), and proportion of all the white grub taxa collected (expressed as a percentage of the total) in sugarcane fields on Tambankulu and Umbuluzi Sugarcane Estates in Swaziland from 2006 to 2012.

Year/(pits sampled)	Variable	*H. licas*	*Asthenopholis* sp.	*Anomala* spp	*Adoretus* spp.	Other spp.	Total
2006 (4328)	No. larvae recovered	145	1723	81	43	0	1992
	Mean larvae/pit	0.03	0.40	0.02	0.01	0.00	0.46
	% of total recoveries	7.3	86.5	4.1	2.2	0.0	
2007 (4303)	No. larvae recovered	144	2045	154	54	19	2416
	Mean larvae/pit	0.03	0.48	0.04	0.01	0.00	0.56
	% of total recoveries	6.0	84.6	6.4	2.2	0.8	
2008 (3509)	No. larvae recovered	27	580	33	18	4	662
	Mean larvae/pit	0.01	0.17	0.01	0.01	0.00	0.19
	% of total recoveries	4.1	87.6	5.0	2.7	0.6	
2009 (5350)	No. larvae recovered	127	3025	39	101	4	3296
	Mean larvae/pit	0.02	0.57	0.01	0.02	0.00	0.62
	% of total recoveries	3.9	91.8	1.2	3.1	0.1	
2010 (4590)	No. larvae recovered	63	2207	21	38	10	2339
	Mean larvae/pit	0.01	0.48	0.00	0.01	0.00	0.51
	% of total recoveries	2.7	94.4	0.9	1.6	0.43	
2011 (4521)	No. larvae recovered	67	391	20	16	34	528
	Mean larvae/pit	0.01	0.09	0.00	0.00	0.01	0.12
	% of total recoveries	12.7	74.1	3.8	3.0	6.4	
2012 (2495)	No. larvae recovered	56	288	12	20	9	385
	Mean larvae/pit	0.02	0.12	0.00	0.01	0.00	0.15
	% of total recoveries	14.5	74.8	3.1	5.2	2.3	

Of the taxa identified, *Asthenopholis minor* Brenske (Melolonthinae) was the most common, followed by *Heteronychus licas* Klug (Dynastinae), *Anomala* spp., *Adoretus* spp. and a group of unknown scarab taxa. In 2009, the year when the highest number of larvae (3296) were recovered, these taxa made up proportionally, in order of decreasing abundance, 91.78%, 3.85%, 1.18%, 3.06% and 0.12% of larval counts, respectively. This trend was confirmed each year and, in 2010, *A. minor* comprised 94.36% of recoveries compared to the next, substantially lower, value of 2.69% for the next most abundant species, *H. licas.*

According to the identification of the taxa recovered as carried out by the field teams who are trained to use the identification keys from Sweeney (1967), the medium to large sized melolonthid, *A. minor* was the most common species recovered in these regions of the Swaziland sugarcane industry. Regarding the correct name for this species, Harrison (2009) reported, "Williams (1985) records *A. minor* (as *A. subfasciata*) to have a limited distribution in the Nokwane (Mhlume) and S.I.S. (Swaziland Irrigation Scheme) sugarcane farms in Swaziland. Carnegie (1988) mentions *A. minor* and *A. subfasciata* as sugarcane pests in Swaziland and Emoyeni, KwaZulu-Natal. White grubs of *A. subfasciata* (Anonymous 1992) are reported from sugarcane fields from the Mhlume area (Vuvulane) in Swaziland. However, *Asthenopholis subfasciata* does not occur in Swaziland or KwaZulu-Natal (i.e. Port Natal = Durban), save for a few old and questionable records. *Asthenopholis minor* is more likely to be a sporadic pest of sugarcane in these regions." Harrison (2009) concluded that *A. minor* is not conspecific with *A. subfasciata*. In the mid-1960s, *H. licas* was the major sugarcane pest in Swaziland (Sweeney, 1967), and 20 years later this species has been replaced by *A. minor* as the most abundant recovered during field surveys (Williams, 1985).

Specimens of *Anomala* spp. and *Adoretus* spp. larvae were identified by the field teams during the annual survey programme in Swaziland. *Anomala* spp. were identified as larvae with a raster pattern forming parallel lines, whereas *Adoretus* spp. forms an inverted weakly V-shaped pattern. These identifications are done using the key produced by Sweeney (1967). Some of the larvae that the teams collected were not identified, and were classified as 'other' taxa. The category of 'other' taxa is usually physically small sized larvae which are seldom encountered, and are therefore regarded as the cause of negligible damage.

A study of the raster pattern carried out at SASRI by the first author of a specimen that the pest team had identified as *A. minor,* showed that it was most likely consistent with Larva series CG as identified in Way *et al*. (2012), which he suggested concurred with *A. minor* as described by Sweeney (1967). Through similar comparisons, *H. licas* identified in the data collated and analysed for this paper is consistent with Larva AA series, also identified in Way *et al*. (2012). A simple field key was developed from a short study that has been developed to separate *A. minor* and *H. licas*, and includes photographs illustrating key diagnostic features of these two species. It is recommended that molecular techniques are employed to complement the morphological methods used thus far to separate these taxa.

Correct identification of white grub larvae recovered during these surveys is a challenge that warrants pursuing further, because the accuracy of the results depends on accurate identifications. More work is needed to be completely certain about the identity of these taxa. The field teams are usually trained by the supervisors, who refer to Sweeny's (1967) published identification key. It is recommended, especially given that appreciable resources are allocated to these surveys, that additional detailed taxonomic studies are conducted to further the available knowledge on the identity of these pests. The information then needs to be transferred to the field teams conducting the white grub surveys through training courses.

Table 2. Density of *Asthenopholis minor* larvae expressed as larvae/pit recovered in three sections of Tambankulu (TAMB), and three sections of Umbuluzi (UMB) Sugarcane Estates in Swaziland from 2006 to 2012.

Year	Variable	TAMB1	TAMB2	TAMB3	UMB1	UMB2	UMB3
2006	Mean larvae/pit	1.23	0.33	0.01	0.02	0	0
	Standard Error	0.251	0.181	0.01	0.01	0	0
	Maximum	5.80	2.00	0.13	0.13	0	0
2007	Mean larvae/pit	1.04	0.52	0.02	0.28	0.01	0.04
	Standard Error	0.272	0.169	0.01	0.153	0.012	0.015
	Maximum	4.38	2.67	0.09	1.79	0.20	0.30
2008	Mean larvae/pit	0.25	0.37	0	0.19	0	0
	Standard Error	0.14	0.127	0	0.118	0	-
	Maximum	1.98	1.50	0	1.85	0	-
2009	Mean larvae/pit	0.59	1.62	0.02	0.14	0	0
	Standard Error	0.167	0.35	0.01	0.056	-	-
	Maximum	2.48	7.69	0.11	0.75	-	-
2010	Mean larvae/pit	0.24	0.99	0.01	0.07	-	-
	Standard Error	0.116	0.36	0.008	0.042	-	-
	Maximum	1.68	4.92	0.10	3.04	-	-
2011	Mean larvae/pit	0.14	0.2	0.01	0.15	0	0.01
	Standard Error	0.041	0.092	0.004	0.07	0	0.006
	Maximum	0.52	0.84	0.05	1.00	0	0.16
2012	Mean larvae/pit	0.08	0.74	0.02	0.05	0	0
	Standard Error	0.045	0.334	0.01	0.037	0	0
	Maximum	0.49	2.69	0.10	0.27	0	0

Field key to distinguish the larvae of *Asthenopholis minor* from *Heteronychus licas*

(a) Physically large with bluish-grey body, clustered raster and brown commas on side of head = *A. minor*

(b) Physically large with whitish body, no raster, abdominal sac each side of body, brown circular indents on head and black spot at base of antenna = *H. licas*

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