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Preliminary investigation on insect pests of sugarcane in the northern sugar belt region of Belize

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Abstract
A preliminary investigation was done on the insect pests of sugarcane (*Saccharum* sp) in the northern sugar belt region of Belize. Three sites each were identified in the Corozal and Orange Walk districts of Belize which comprised the northern sugar belt region. The study sites were Sugar Industry Research and Development Institute's demonstration plots. Insects were collected by hand picking; sticky traps and bottle traps with bait from each of the study sites. Two such collections were made in the month of January, 2018. Froghopper (*Aneolamia varia),* and sugarcane borer (*Diatraea saccharalis)* were collected from all the sites and was found to cause the most damage to sugarcane crops in the northern sugar belt region. Sugarcane Mealy bug (*Saccharicoccus sacchari*)**,** Weevils **(***Apinocis subnudus* and *Sphenophorus incurrens),* Nitudilid beetles and sugarcane lace bug (*Leptodictya tabida*) were also identified. The biology and ecology of these insect pests including control methods for the major pests are reviewed in this paper. Further detailed study over an extended period of time is recommended on the pests of sugarcane and the damage caused by them to the sugar industry of Belize to get a more accurate picture and to plan effective control measures for the same.

Keywords: Sugarcane, insect pests, Belize, *Aneolamia varia*, *Diatraea saccharalis*

1. Introduction
The sugar industry in Belize has become a vital component of Belize's economy in the past decade, accounting for an average of 7.8% of the country's GDP and earning about 34% of total foreign exchange in agricultural exports [1]. Sugarcane (*Saccharum* sp.) in Belize was first introduced into the northern district of Corozal in 1848 by Mexican immigrants from Yucatan and was grown in small amounts to harvest molasses and sugar by animal-powered mills. The industry took root and grew with the arrival of the American expatriates during the late 1860s and 1870s. By the late 1890s and early 1900s, East Indians brought in as indentured laborers to work in the sugarcane fields further boosted the sugar industry. The industry is largely concentrated in the Northern districts of Corozal and Orange Walk, also called the 'Sugar Belt' with approximately 27,518.6 ha or about 30% of the total agricultural area in the country under sugarcane cultivation [2].
The sugarcane fields in the Northern districts are plagued by many different insect pests affecting the quality and quantity of sugar produced [3]. In 2006-2007 severe infestation by frog hopper (*Aneolamia varia)* in the northern sugar belt region led to a 10% loss of sugarcane production. Hence, a preliminary investigation was conducted in 2018 in the northern sugar belt region of Belize to document the insect pests prevalent in the sugarcane fields. This would enable Sugar Industry Research and Development Institute (SIRDI) of Belize to take adequate measures to combat these insect pests. The biology and ecology of the insect pests collected and identified in the study including control methods for the two major pests are reviewed in this paper.

2. Materials and methods
2.1 Study sites: A total of six sites (Table 1; Fig. 1A) were selected at random from each of the two districts representing the sugar belt: three in Corozal district and three in Orange Walk district of Belize. The sites were primarily SIRDI demonstration plots (Fig. 1B).

Table 1: Study Site Location and Sugarcane crop information

Site #	Location (District)	Variety	Ratoon
1	Buena Vista (Corozal)	B79474	R16
2	Santa Clara (Corozal)	Bbz80240	R2
3	San Joaquin (Corozal)	B52298	R20
4	La Savannah (Orange Walk)	B79474	R15
5	Arnulfo Muñoz (Orange Walk)	B79474	R5
6	Tower Hill – BSI (Orange Walk)	B79474	R9

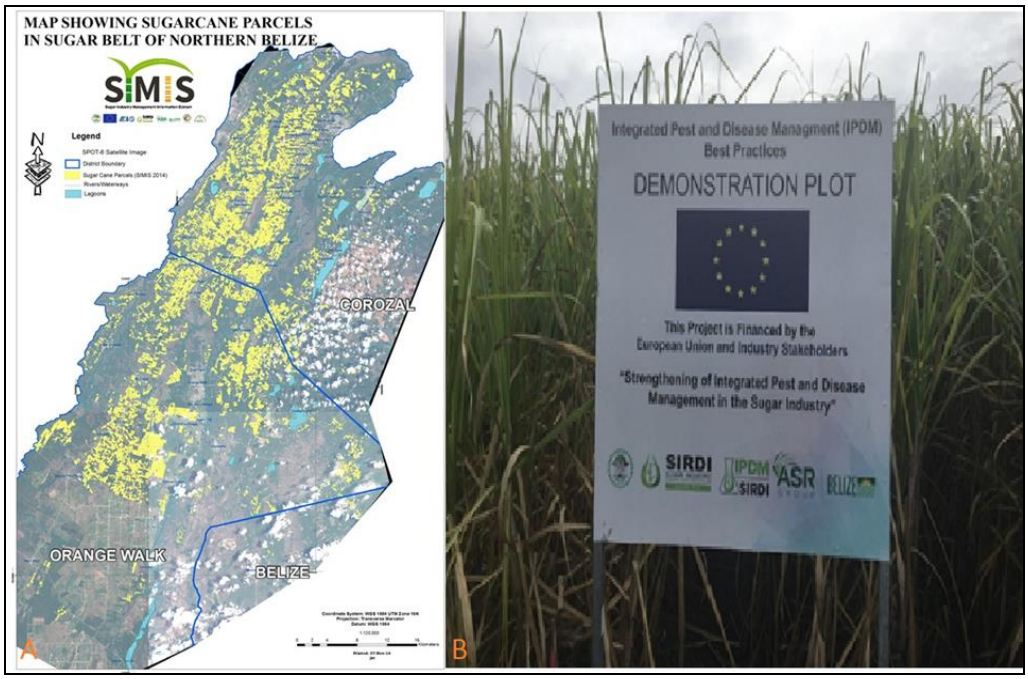

Fig 1: (A) Map showing sugarcane parcels (yellow) in Sugar belt of Northern Belize; (B) SIRDI demonstration plot at Tower Hill

2.2 Sample collection

Samples were collected in the month of January, 2018 on two separate occasions. The pest samples were collected using a combination of hand picking, sticky traps and bottle traps. Three sticky traps (courtesy of SIRDI) were placed in each of the collection sites (Fig. 2 A). Three, 1liter plastic bottles containing an attractant (pineapple) and a preservative fluid at the bottom quarter was used as bottle traps (Fig. 2 B). Four days after the placement of the traps, specimens were collected and preserved in labelled vials containing 70% alcohol and brought to the University of Belize's laboratory for identification.

The insect pests collected were observed, identified and photographed by using stereo microscopes. Identifications were done using morphological characteristics to the closest taxa possible.

Fig 2: (A) Sticky Trap at La Savanna; (B) Bottle trap set up at Tower Hill demonstration plot

3. Results and discussions

The insect pests collected from the Northern Sugar belt region of Belize are summarized in Table 2. Froghopper *(Aeneolamia varia)* and Sugarcane Borer (*Diatraea saccharalis*) were collected from all the sites and are considered as the major pests of sugarcane in northern Belize because of their increased prevalence and damage caused to the sugarcane production. Mealy Bug (*Saccharicoccus sacchari*), Nitidulid beetles, Weevil (*Apinocis subnudus* and *Sphenophorus incurrens*) and Sugarcane lacebug (*Leptodictya tabida*) which were also collected during the study do not cause any significant loss to sugar industry of Belize. The biology and ecology of these insect pests including control methods for the major pests are reviewed in this paper.

Table 2: Table showing location, cane variety, ratoon, trap types and insect pests collected from the sugarcane fields of Northern Belize

Site #	Location (District)	Variety	Ratoon	Insect pest hand picked	Insect pest bottle trapped	Insect on sticky trap
1	BuenaVista (Corozal)	B79474	R16	Froghopper *(Aeneolamia varia)*	Nitidulid beetles, Sugarcane lace bug *(Leptodictya tabida)*	
2	SantaClara (Corozal)	Bbz80240	R2	*A. varia*, Sugarcane borer *(Diatraea saccharalis) L. tabida*	Nitidulid beetles	
3	SanJoaquin (Corozal)	B52298	R20	*A. varia*, *D. saccharalis*	Nitidulid beetles, Weevil *(Apinocis subnudus, Sphenophorus incurrens)*	
4	LaSavannah (Orange Walk)	B79474	R15	*D. saccharalis* Sugarcane mealybug *(Saccharicoccus sacchari)*	Nitidulid beetles, Weevil (*A.subnudus, S. incurrens*)	*A.varia*
5	Arnulfo Muñoz (Orange Walk)	B79474	R5		Nitidulid beetles	*A.varia*
6	Tower Hill –BSI +(Orange Walk)	B79474	R9		Nitidulid beetles	*A.varia*

3.1 Froghopper *(Aeneolamia varia)*

Species belonging to *Aeneolamia* are one of the major pests of sugarcane (Fig. 3). They belong to the order Hemiptera, family Cercopidae and subfamily Tomaspidinae. The genus includes eight species and 34 subspecies, which have wide variation in the color pattern on the Tegmina (fore wing) [3]. There is also considerable variation in color between specimens of the same species of *Aeneolamia*, found in same or separate localities. But the characters from male genitalia are conservative within the genus and are reliable to identify the species [3]. *A. varia* and *A. albofasciatus* are reported from Belize.

3.1.1 Life cycle

Adult *A. varia* females mate immediately after emergence. Females lay around ~150 spindle shaped eggs in soil or decaying plant parts [4]. Incubation takes 2-40 weeks depending on the presence or absence of diapause. Photoperiod and soil moisture influences egg development and diapause [5, 6, 7, 8, 9]. Nymphs ingest sap from the roots and excrete excess sap to produce spittle mass that protects it from desiccation [5, 10]. There are around 5 nymphal instars and life cycle takes about two months. Adult *A. varia* live for approximately 20 days [4]. There are generally 2-4 generations per year [5] (Fig. 3).

3.1.2 Damage caused

The border parenchyma cells of sugarcane leaves are the primary feeding site of adult *A. varia* [5]. Enzymes in saliva cause necrosis of plant tissue which appears as longitudinal brown streaks; uncontrolled infestations can cause 30-70% reduction of sucrose content [5]. On the roots, nymphs are xylem-feeders, although the first and second instars also ingest the contents of parenchyma cells in the cortex of young roots. Cellular damage is extensive in all cases, and occlusion of the xylem elements often occur following feeding by fourth and fifth instars [11]. In heavy attacks the leaves turn yellow and then brown and finally wilt and die, a condition called 'froghopper blight' [5]. In 2006/2007 season, *Aneolamia spp* alone was responsible for 10% loss of sugar production in northern Belize. The froghopper insect becomes a problem for sugarcane when it exists in very high numbers, which escalate especially in hot, humid conditions.

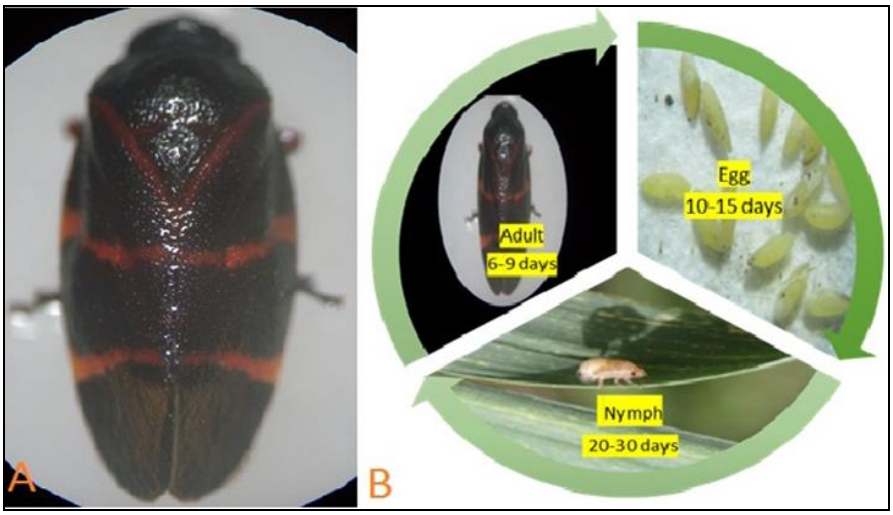

Fig 3: (A) *A. varia* adult; (B) Life cycle of *Aeneolamia* sp.

3.1.3 Control

Cultural control methods include maintaining sugarcane fields free of weeds; crop rotation or intercropping; special cultivation methods such as trash lining and retention, inter-row tillage and special land preparation techniques before re-planting [2]. Physical or Mechanical methods include developing improved drainage or irrigation systems; destruction or removal of alternate host species in and around the sugarcane ecosystem; use of clean sugarcane seeds and/or planting materials; use of traps to trap the pest; promotion and encouragement of good harvesting strategies such as minimizing dead and decaying high stump remains and stalk droppings, which constitutes a source of food for some pest species [2]. Entomopathogenic fungi, *Metarhizium anisopliae* (Hypocreales: Clavicipitaceae) is used as an effective biological control of froghoppers in Belize. Insecticide Actara

WG with active ingredient thiamethoxam, Engeo 247SC with active ingredient Thiamethoxam and Lambda, Jade 0.8 GR with active ingredient Imidacloprid are used as chemical control of froghoppers in Belize [2].

3.2 Sugarcane Borer (*Diatraea saccharalis*)

Diatraea spp. commonly called the "moth borer" or the "lesser moth borer" is a major pest of sugarcane in the region (Fig. 5). They are represented by 41 species [12]. They belong to the order Lepidoptera, family Pyralidae and subfamily Crambinae. The species *D. saccharalis* is a pest of economic importance in the northern sugar belt region.

3.2.1 Life cycle

Female *D. saccharalis* usually mate only once in their lifetime, but sometimes mates several times in a period of 48 hrs. [13]. Mating usually takes place in darkness [14]. Eggs are deposited from dusk through night on either side of a leaf in clusters. The eggs are round-oval, flattened with average of 30 eggs per cluster [15]. In *D. saccharalis* maximum fecundity may range from 250 to 700 eggs per female [4, 16].

The eggs are white at first with microscopic network of depressed lines but later takes on reddish brown color. The eggs of *D. saccharalis* hatch after 4-9 days and the small larvae congregate in the terminal buds of the plants and feed on the tender whorls. Rows of holes appear on the leaves as they expand. Many of the larvae seem to perish during this period partly because of their cannibalistic habits [17].

In their 3rd and 4th instar, the larva crawls down the outside of the stem to a point near or even below the surface of the ground and bore into the stalk, where they continue to develop [17]. Stalk penetration usually occurs through an immature internode [18, 19]. Gnawing a hole through the outer layer of the stem, it works its way to the interior of the plant. When full-grown they are about an inch long by one-eighth inch wide. The head is brown and the body white with brown spots [16]. The larva of *D. saccharalis* undergoes 5-10 molts on sugarcane [20, 21, 22]. Before pupation, the larva enlarges the tunnel, makes an exit opening covered only by a thin layer of plant tissue for the moth to escape on emergence from the pupal stage [17]. On molting for the last time, the larva enters the pupal stage, the quiescent period of the insect. The pupa at first is white, but soon changes to dark brown. Duration of the pupal stage can be 6–11 days in *D. saccharalis* [20, 22].

The adult is a straw-colored moth, the forewings marked with darker lines. It varies in size, average specimens measuring about an inch across the wings [17]. Adult longevity ranges from 5–10 days for *D. saccharalis* [23]. *Diatraea* spp. typically produce 6–11 generations per year in the tropics [4] (Fig. 4).

Fig 4: *Diatraea saccharalis* life history stages: A. Egg; B. Larva; C. Pupa; D. Adult

3.2.2 Damage caused

Larvae of *D. saccharalis* bores into the tender inner shoot of sugarcane forming a "dead heart." Small plants are killed and larger stalks usually do not die [17]. Insect tunneling in stalks can interfere with the movement of nutrients and photosynthates in later crop stages, increase the level of fiber in the stalk, and decrease its value [24, 25]. Injury of stalk can disrupt apical dominance and promote growth of multiple lateral shoots, diverting resources from sucrose synthesis to vegetative growth [26]. Multiple entry and exit holes in stalks provide points of entry for microorganisms that can further degrade cane quality and sugar content [26, 27, 25]. Stalks bored by the larvae becomes infected with fungus *Colletotrichum falcatum* causing red rot [17].

3.2.3 Control

Management of *Diatraea* spp. in many sugarcane regions has largely focused on biological control since the larvae develop inside the sugarcane stalks, which diminishes efficacy of the insecticides [28]. Ants, particularly imported red fire ant, *Solenopsis invicta* Buren, are reported to be important predators of sugarcane borer in sugarcane fields, and capable of reducing damage from borers by over 90%. Other ant species such as *Pheidole dentata* Mayr and *Pheidole floridana* Emery (all Hymenoptera: Formicidae) are also important.

Egg parasitoids, *Trichogramma* sp. (Hymenoptera: Trichogrammatidae), are possibly the most important naturally-occurring parasitic insects. Predators could be *Orius* spp. pirate bugs (Hemiptera: Anthocoridae), lacewings (Neuroptera: Chrysopidae), tiger beetles (Coleoptera: Cicindelinae), spiders, and foliage-dwelling ground beetle larvae (Coleoptera: Carabidae). Entomopathogenic fungi, *M. anisopliae* [29, 30, 31] has also been used to control *D. saccharalis* larva.

3.3 Sugarcane mealy bug (*Saccharicoccus sacchari*)

It is a common pest of sugarcane in the warm regions of the world (Fig. 5). They belong to order Hemiptera, family Pseudococcidae. Besides sugarcane they also attack several Poaceae (Graminae), Sorghum, rice.

3.3.1 Life cycle

Female lay upto 1000 eggs under the leaf sheath which hatch quickly in 10-14 hrs. [5]. First instar nymphs are generally active, moving to younger parts of the plant or to adjacent plants; older nymphs are less active [5]. Females molt three times before attaining maturity and the males molt four times [32, 33, 34, 35, 36]. Males cease feeding at the end of the second instar and the third and fourth instar of males are without functional mouth parts [37].

Adult female is pink in color, 7mm long, elongate-oval to round in shape with well-developed anal lobes and short legs. Adult male exists as apterous or winged form and is rare. Though parthenogenesis is considered the normal mode of reproduction, it was reported that in Hawaii, *S. sacchari* females failed to produce eggs or produced inviable egg when they did not mate [37]. Life cycle takes about 30 days to complete.

The mealybugs secrete a covering of wax, and also produce a syrupy 'honey dew' on which a black, sooty mold usually develops. Cane which has been infested with mealybugs can thus almost always be identified by the presence of wax and sooty mold, even when the insects have disappeared [5].

3.3.2 Damage caused

Nymphs and adults suck sap from leaves, nodes, and internodes of canes; severe infestation results in yellowing of leaves, stunting of canes and poor germination in the case of *S. sacchari* attack [38]. High populations can produce large

amounts of honeydew and sooty mold growing on the honey dew will disfigure crops. *S. sacchari* is associated with filtration and clarification problems of syrup, lower quality of the syrup and reduced crystallization [38, 39, 40] which is related to the production of honeydew and associated polysaccharides and gums and/or the close association of *S. sacchari* with acetic-acid-producing bacteria [41]. The pest may also transmit plant viruses [42].

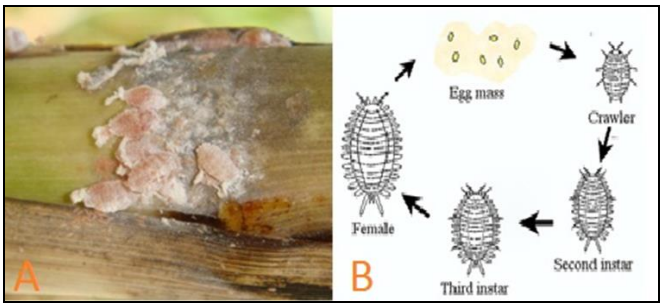

Fig 5: *Saccharicoccus sacchari* A. adult B. Life cycle

3.4 Nitidulid beetles

Also called sap beetles, belong to the order: Coleoptera, family: Nitidulidae. They are important pest of wide variety of important fruits and grains and also vectors of harmful microorganisms. Nitidulid beetles are 3-4 mm long, small shiny black or dark brown in color with clubbed antennae. The clubbed portion, however, is quite variable within species, being quite distinct or only slightly developed [43]. The elytra or wing covers are entire or shortened to expose two or three abdominal segments. The larvae are slender, creamy-white grubs which reach a length of about 6 mm. Larvae and beetles are sometimes found in setts that have failed to germinate. They may be attracted there by fungal growth or by fermenting vegetable matter. They are regarded as a secondary pest.

3.4.1 Damage caused

Pineapple disease of sugarcane are transmitted by Nitidulid beetles [44]. It is an economically important sugarcane disease that occurs in almost all countries where sugarcane is grown. The disease is caused by the fungus *Ceratocystis paradoxa.* It primarily affects sugarcane setts in the first weeks of planting. The fungus infects the setts mainly through the cut ends and from there spreads rapidly through the parenchyma. Infected tissue first becomes reddened; the parenchyma then breaks down and the interior of the setts become hollow and blackened. In the early stages of the rotting, the strong odor of overripe pineapples is often present and may help in diagnosing the disease.

Fig 6: Nitidulid beetles

3.5 Weevils

The weevils identified from the bottle traps belonged to the species *Apinocis subnudus* and *Sphenophorus incurrens* (Fig.7A, B). Weevils belongs to the order: Coleoptera, family: Curculionidae. Main damages are caused by weevil larvae rather than adults.

3.5.1 Damage caused

The weevil larva penetrates the base and underground parts of the stem of the cane making galleries in different regions. They can feed on several stems and the rhizome of the strain. The secondary damage caused by the larvae is by the entry of phytopathogenic fungi, *Colletotrichum falcatum* causing decay resulting in red rot disease [45].

The larvae of *A. subnudus* usually penetrate the lower part of the stem; the galleries are distinguished by being smaller than those caused by *S. incurrens* and *Metamasius hemipterus*. All species pupate inside the cane generally in the lower and underground parts. Weevils feed on the buds, root primordial, and from the lateral parts of the cut internodes, where the females form galleries and oviposit. The new plant may show symptom of "dead heart" which differs from that caused by lepidoptera such as *Diatraea* spp. and *Eoreuma loftini* because they do not present entry hole in the bud [46].

Fig 7: A. *Apinocis subnudus* B. *Sphenophorus incurrens*

a) Sugarcane Lace bug *(Leptodictya tabida)*

They belong to the order: Hemiptera, family: Tingidae.

3.6.1 Life cycle

The adult lace bug (*Leptodictya tabida*) is about 1/8" (3.5 mm) long, flat and light-brown or straw colored (Fig. 8A). The forewings are semi-transparent and finely laced or netlike (Fig. 8A). Five long, erect spines are present on the head. Eggs are laid singly into leaf tissue usually on the underside of the leaves. The tip of the egg is left outside the leaf tissue but is covered with a protective cap secreted by the adult female. Nymphs are flat and whitish in color with many long, branched, erect spines. A generation of lace bugs, from egg to adult, may take 20 to 30 days, with 5 nymphal molts [47, 48][49].

3.6.2 Damage caused

Lace bug feeding results in light green or yellow speckles on leaves. Many cultivars develop a red discoloration (russetting) on the leaves that expands beyond the area of feeding (Fig. 8B) [50]. Another characteristic diagnostic character of sugarcane lace bug are the small, black, oily fecal deposits (i.e., frass spots) they deposit on the leaves [50]. Predators of these plant-sucking insects include earwigs and spiders.

Fig 8: A. Adult Lace bug; B. Adult, nymph and damaged leaf

4. Conclusion

Preliminary investigation on sugarcane pests of northern sugar belt region of Belize revealed that froghopper *Aneolamia varia* and sugarcane borer *Diatraea saccharalis* were the major pests of sugarcane during the 2018 study period. Further detailed study on pests of sugarcane over an extended period of time is recommended to get a more accurate picture of the pests of sugarcane and the damage caused by them to the sugar industry of Belize. This will enable SIRDI to develop effective protocol to control these common pests of sugarcane in the northern sugar belt region of Belize.

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