Survey on the distribution of the Sweet potato weevil, *Cylas* species-complex in Ghana (Coleoptera: Brentidae)

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Abstract

The Sweet potato weevils of the genus *Cylas* are the most destructive pests of sweet potato and are widely distributed in Africa. The aim of this study was to identify and document the species of *Cylas* occurring in sweet potato production zones in Ghana. A survey was conducted in 23 localities in 2015 from July to December in seven regions in Ghana in order to determine the identity of the pest. We collected nine thousand and two specimens from Central, Eastern, Greater-Accra, Northern, Volta, Upper-East, and the Upper-West regions. Two species were identified: *Cylas brunneus* Fabricius, 1797 and *Cylas puncticollis* Boheman, 1833. *Cylas puncticollis* occurred in all regions and represented 6,107 specimens (68%), while 2,895 of the specimens (32%) could be assigned to *C. brunneus*. The latter is restricted to the southern sector including Volta, Central, Eastern and Greater Accra Regions. When considering both species in the southern sector, the Volta Region accounted for 3,117 specimens (48%) followed by 1,447 (22%), 987 (15%), and 980 (15%), from the Central, Eastern, and Greater-Accra Regions, respectively. The dominant species in southern and northern sector was *C. puncticollis*.

Keywords: Sweet potato, Sweet potato weevil, *Cylas brunneus*, *Cylas puncticollis*, biogeography, Ghana.

Introduction

Sweet potato is considered as one of the most important primary crops in Africa and plays a significant role in the global food system (BOVELL-BENJAMIN, 2007). It is the third most important root and tuber crop in Ghana, cultivated largely in the Sudan and coastal savannah zones of the country (BIDZAKIN *et al.*, 2014; TANZUBIL, 2015). Sweet potato production and utilisation is often considered as a means to generate income and improve food security among the poorer segment of the rural population (LOW *et al.*, 2009). The constraints attributed to the low root yields in sub-Saharan Africa include diseases, insects and vertebrate pests, weed infestation, soil nutrient deficiencies, poor crop husbandry practices and socio-economic factors (SMIT & MATENGO, 1995). Of these, insect pests are considered the most limiting, with the *Cylas* spp. complex being the most widely distributed and destructive group (CHALFANT *et al.*, 1990). By laying their eggs directly into the roots where the larvae feed and develop, these pest species cause huge devastation to both production and food security and result in food shortages in some parts of the sub-Saharan African region.
In Ghana, the management of the weevil has little impact due to the lack of knowledge on the pest identity. Misidentification of economically important insect pests can have dire consequences on their management (BIDOCHKA *et al.*, 2001) and therefore, the successful management of *Cylas* spp. strongly hinges on its accurate identification.

WOLFE (1991) identified nine species within the genus *Cylas* as pests that attack sweet potato and placed them into three pest species groups including: *Cylas brunneus* Fabricius, 1797, *Cylas puncticollis* Boheman, 1833*,* and *Cylas formicarius* (Fabricius, 1798). The distribution of *Cylas* spp. varies between regions, with *C. formicarius* known to be the most widespread, while *C. puncticollis* and *C. brunneus* are confined to Africa (WOLFE, 1991). However, knowledge on African *Cylas* species is poor and geographical distribution data of these weevils in Ghana remains remarkably scant. Therefore, this study sought to evaluate and document the predominant species of *Cylas,* as well as their distribution in seven sweet potato cultivation regions in Ghana. Our main research questions are: (i) Which species occur in Ghana and (ii) In which regions do these species occur?

Material and methods

Field sites

Sweet potatoes are mainly grown in the interior and coastal savanna zones, and on small scale in other parts of the country. The survey was conducted in 2015, during the cropping season, from July to December in seven regions (see Fig. 1)- Central, Eastern, Greater-Accra, Northern, Volta, Upper-East, and the Upper-West regions -, which are the leading sweet potato production zones (BIDZAKIN *et al*., 2014). A total of 23 collection sites were surveyed. Table 1 represents the localities surveyed and their approximate geo-referenced positions recorded, using a hand-held Garmin eTrex® 20X device.

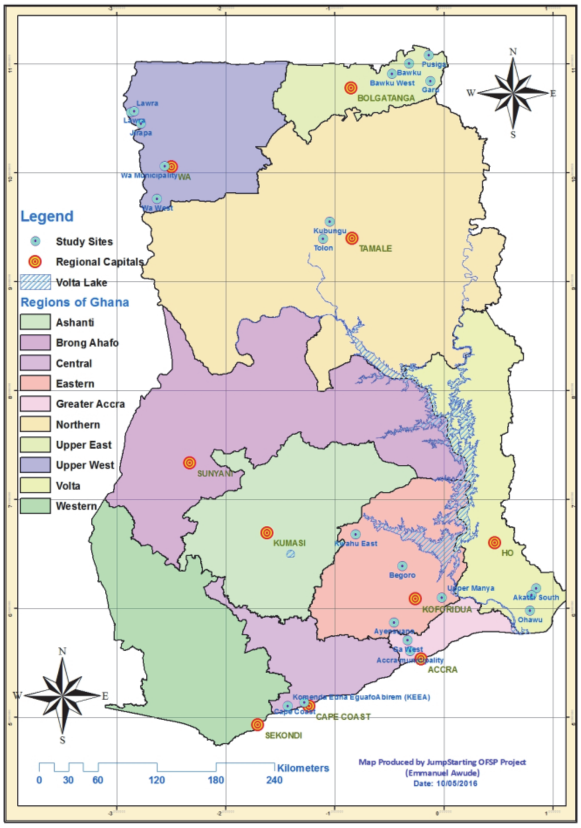

Fig. 1. Map of Ghana showing sampling localities.

Sampling procedure and collection of Cylas spp.

In each of the seven regions, potato farms of at least 0.5 acres in two different districts were selected for the study. During the survey, trips were made to selected sites during seasons/times when crops were at least three months old, and ready for root harvesting. Sampling was conducted based on the methodology reported by MCSORLEY & JANSSON (1991), with some modifications. Each field was divided into four parts (4 quadrants) and a total of 10 infested plant stands or hills were selected in each quadrant. Vines and roots with external feeding and ovipositional punctures, signs of weevil damage, were collected and placed in medium-sized (12 x 15 cm) grocery bags or envelopes, and transported to the laboratory. In localities where there were no crops of the right maturity age (at the time of visit), infested sweet potato roots were purchased at local markets for laboratory incubation.

Sweet potato root incubation and adult collection

Root samples were transported for incubation to a rearing unit established at the laboratory of African Regional Postgraduate Programme in Insect Science (ARPPIS), University of Ghana. Infested roots were carefully split into pieces, incubated in rearing boxes (17 x 17 x 9.5 cm) and held till pupae and/or adult emergence. Set ups were monitored for development of pupae and/or adults, and split samples moistened as and when necessary to prevent drying out. Pupae were collected from rearing boxes and kept in small boxes until adults emerged (Fig. 2). After emergence, weevils were allowed to feed for 5 days on freshly-introduced split sweet potato roots for full proper adult development and to attain full body coloration. At maturity, weevils were killed by freezing, and samples preserved in vials containing 70% alcohol.

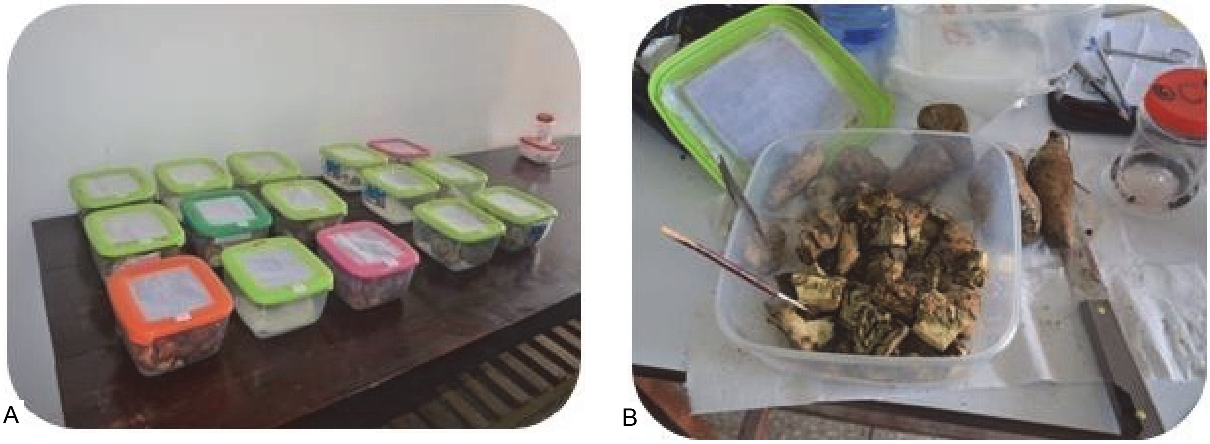

Fig. 2. Incubation set up for collecting sweet potato weevils. A = incubation boxes with samples from the field, and B. = split sweet potato roots in an incubation box.

Fig. 3. General habitus of adult sweet potato weevils. *Cylas brunneus* (female) at the left side, and *Cylas puncticollis* (female) at the right side (Pictures Camille Locatelli).

Insect identification
Identification was made with Leica EZ4 D stereo microscope based on the morphological characteristics of the collected specimens using taxonomic keys developed by Wolfe (1991). Voucher specimens were deposited at the African Regional Postgraduate Programme in Insect Science of the University of Ghana, Legon (ARPPIS-UG) and the Royal Belgian Institute of Natural Sciences, Brussels (RBINS).

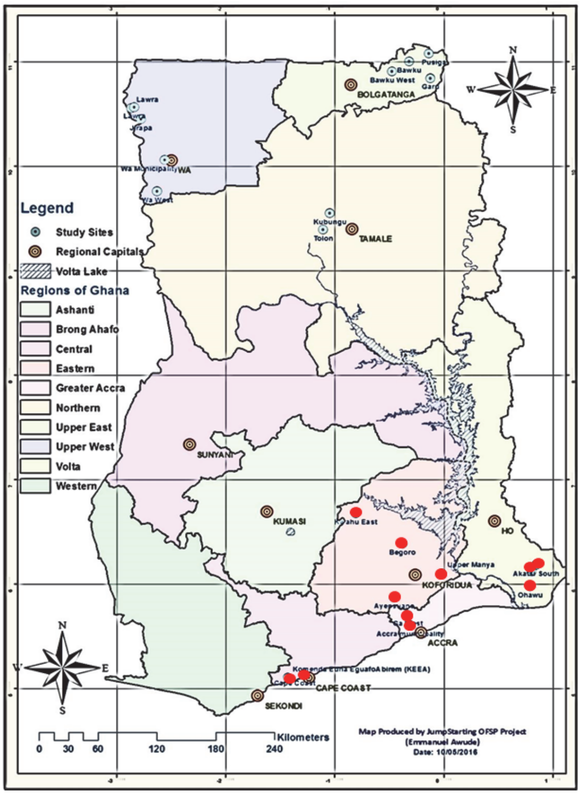

Fig. 4 Distribution map of *Cylas brunneus* in Ghana, red dots represent sites where the species was collected.

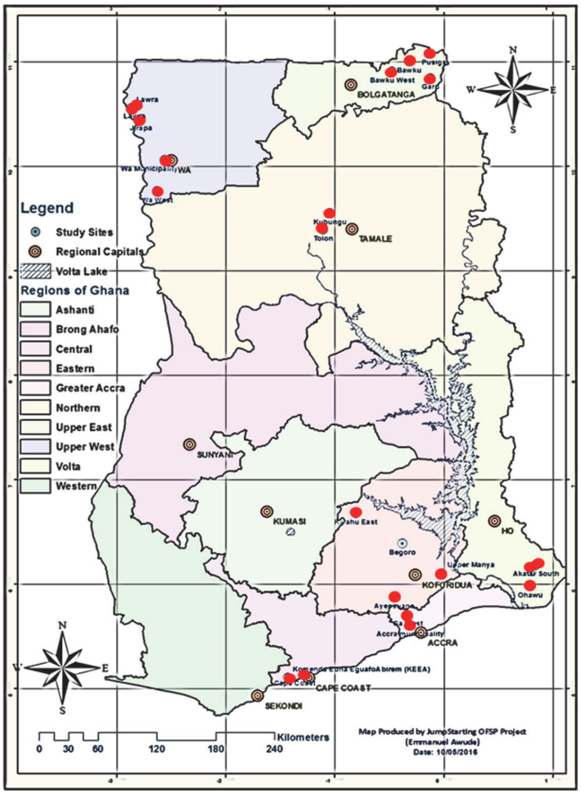

Fig. 5 Distribution map of *Cylas puncticollis* in Ghana, red dots represent sites where the species was collected.

Results

A total of 9,002 specimens were collected from the 7 regions - Central, Eastern, Greater-Accra, Northern, Volta, Upper-East, and the Upper-West –. Two species were identified: *Cylas brunneus* and *C. puncticollis* (Fig. 3). *Cylas brunneus* is small in size and not uniform in the color of the habitus, while the habitus of *C. puncticollis* is completely black. *Cylas puncticollis* accounted for 6,107 (68%) samples and *C. brunneus* for 2,895 (32%) of the samples (Table 2). In terms of the north-south divide, a total of 6,531 (73%) and 2,471 (27%) weevils were collected from the southern and northern sectors, respectively. The dominant species in both sectors was *C. puncticollis, i.e.* 56% of the samples in the south, and 100% in the north (Table 2).

When considering the southern sector, *C. puncticollis* and *C. brunneus* were collected together from 11 of the 12 localities where samples were taken, and in most of the cases, the two species were found infesting the same sweet potato root simultaneously. From one locality, only *C. brunneus* was collected.

In the northern sector, only one species, *C. puncticollis*, was identified (*C. brunneus* was not recorded from that sector) (see Fig. 4 and Fig. 5).

Discussion

This study showed that two species *C. puncticollis* and *C. brunneus* occur in Ghana and their occurrence is not evenly distributed across the seven regions. These species have been reported native to Africa in previous studies (WOLFE, 1991). In West Africa, *C. puncticollis* and *C. brunneus* are present in Côte d'Ivoire, Guinea, Mali, Nigeria, Senegal, Sierra Leone, and Togo. In other parts of the continent, *C. puncticollis* has the widest distribution and occurs for instance in Cameroun, Kenya, Rwanda, South Africa, and Uganda (WOLFE, 1991). *Cylas brunneus* is known from Central Africa and some countries in East Africa (Burundi, Kenya, Rwanda, and Uganda) (SMIT, 1997; OKONYA *et al.*, 2014) and appears to be absent in South Africa (WOLFE, 1991; CAB International, 2005). These two species are found together attacking sweet potatoes in East Africa and are of equal importance (SMIT, 1997; NDERITU *et al*., 2009). During the survey, *C. formicarius* was not recorded even though past studies have reported its occurrence in West, Central, and South Africa where it co-occurs with *C. puncticollis* in numerous localities (WOLFE, 1991). It is hypothesized that *C. formicarius* is not native to Africa and has been introduced to India from where the sweet potato crop was introduced to Africa (WOLFE, 1991). It has dispersed later to southeast Asia and the South Pacific (and attained an almost worldwide distribution). As there are only sporadic observations of *C. formicarius* in Africa (WOLFE, 1991) and its absence in our collection suggests that this species is unable to adapt to African conditions, or cannot compete with native pest species (WOLFE, 1991). However, we hypothesize that *C. fomicarius* could be present in Ghana since the pest has been discovered before outside its native area in some habitats which are similar to its native area (RISBEC, 1947).

Our findings showed that all sampled regions contain suitable habitat for *C. puncticollis,* which appears not to be the case for *C. brunneus*. While *C. puncticollis* occurs almost in the entire sampling regions (eleven of the twelve localities in southern sector and in all localities in northern sector), *C. brunneus* is restricted to only the southern sector. The sweet potato growing period varies significantly from the southern to the northern sector. The southern sector is characterized by a bimodal rainfall regime while the northern sector experiences a unimodal rainfall regime. During the period of our survey, farmers in southern sector, have planted their crop mostly in May-June and harvested in September-October while in northern sector, the planting date was in June-July and harvesting date in November-December. In most of the cases, collections of the insects were done when the roots were matured and coincided with high temperature patterns. Studies have reported that weevil populations increase when the conditions are dry (SMIT, 1997; OKONYA & KROSCHEL, 2013). High temperatures induce soil cracking which provide favourable conditions for the weevils to reach the roots, lay their eggs and build up a vital population (OKONYA & KROSCHEL, 2013).

The occurrence of *C. puncticollis* in all the seven regions shows that the pest species is very versatile and highly adapted to all different types of environments found in the sampling areas. These findings are congruent with studies of SMIT & VAN HUIS (1999) who reported that *C. puncticollis* with longer oviposition rate can survive in extended periods when oviposition sites are not available and then resume egg laying when conditions improve. The northern sector of the country is of relatively higher altitude and temperature and thus may not constitute favorable ecological niches for some insect species (BADII *et al*., 2015). The absence of *C. brunneus* in the northern sector suggests that this species prefers more stable conditions and may also have problems to colonise, disperse, or survive in areas with more temperature variation. Additionally, MUSANA *et al*. (2013) reported in their laboratory studies that *C. brunneus* is highly sensitive to extreme temperatures and cannot develop, survive or reproduce at temperature conditions less than 15 °C and above 35 °C. The optimal temperature conditions for development and fecundity occur between 25 °C and 30 °C. However, OKONYA & KROSCHEL (2013) reported the presence of both *C. puncticollis* and *C. brunneus* at high altitude (2400 m a.s.l) in Kabale district in Uganda and concluded that a possible geographical shift by the pest to higher altitudes could have been occurred due to global warming.

In the southern sector, the presence of both species in the same sweet potato roots suggests competition for resources and space between species. The sympatric occurrence of these two species in various sweet potato agro-ecosystem in southern sector underlines the historical relationship of the crop with the pest after the introduction of the crop on the continent (AUSTIN *et al*., 1991; MARVALDI *et al*., 2002). AUSTIN *et al*. (1991) speculated that the African sweet potato weevils and the sweet potato crop are originated from the New World and have co-evolved with the dispersal of the crop on the continent.

Conclusion

Sweet potato weevils are among the world's worst root and tuber crops' pests, being of major economic importance in sub-Saharan Africa. They are among primary causes of poverty, malnutrition, food production and food shortage in sub-Saharan Africa. This study has made a valuable contribution to documenting the *Cylas* species and distribution of the weevils in the major sweet potato production zones in Ghana. These findings may help to develop Integrated Pest Management field programmes of the pest in order to achieve sustainable food production. Since the two identified species occur unevenly in the country, distinct and species-specific management strategies of each pest species should be developed.

Table 1. Sites where *Cylas* specimens were collected from sweet potato roots with their geographic coordinates.

Region	District	Agro-eco zone	Community	Potato Variety	Latitude	Longitude	Altitude (m)
Volta	Ohawu	Coastal Savannah	Bedjame	Apomuden	05°39'17N	00°11'04W	113
	Akatsi South	Coastal Savannah	Kpotavi	Sauti	06°11'19N	00°50'58E	63
		Coastal Savannah	Tadzevu	Sauti	06°07'35N	00°48'13E	55
		Coastal Savannah	Awalavi	Sauti	06°07'35N	00°48'13E	55
		Coastal Savannah	Ative	Sauti	06°07'35N	00°48'13E	55
Central	Komenda Edna EguafoAbirem (KEEA)	Coastal Savannah	Komenda	TIS	05°04'14N	00°14'31W	16
	Cape Coast	Coastal Savannah	Mpaesem	Apomuden and Orange Flesh Sweet Potato	05°07'17N	01°16'06W	18
Eastern	Ayensuano	Semi-deciduous Forest	Marfo	Faara	05°51'91N	00°26'78W	155
	Upper Manya	Semi-deciduous Forest	Poponyafantem	Sauti	06°06'06N	00°00'57W	98
	Begoro	Semi-deciduous Forest	Ehiamakyene	Sauti	06°23'29N	00°22'46W	470
	Kwahu East	Semi-deciduous Forest	Akwasiho	TIS and Faara	06°32'18N	00°45'19W	260
Upper East	Bawku	Sudan Savannah	Tinsongo	Obare	11°05'09N	00°15'00W	228
	Pusiga	Sudan Savannah	Nikoe	Local red and local white	11°04'50N	00°08'16W	215
Upper West	Wa West	Guinea Savannah	Siiru	Ligri, Apomuden, Fara, Nanyunkpong, Nanyunbile	09°32'76N	02°32'79W	286
	Lawra	Guinea Savannah	Kunyukuo	Otoo, Fara, Okumkom, Dadanyuie, Apomuden, Hi-Starch, SantomPona, Ligri	10°33'27N	02°52'09W	238
	Lawra	Guinea Savannah	Tanchara Koro	Santompona, Fara, Hi-Starch and Sauti	10°34'03N	02°50'20W	230
	Jirapa	Guinea Savannah	Orifani	Otoo, Ligri, Dadanyuie	10°27'14N	02°46'42W	251
	Wa Municipality	Guinea Savannah	Sombo	Okumkom, Apomuden, Ogyefo, Fara, Santompona, TU-purple	10°03'46N	02°32'98W	323
Northern	Tolon	Guinea Savannah	Saari	Kuffour, TU-Orange, Obare, TU-purple, Apomuden, Voggu, Nanungungungu	09°25'57N	01°03'34W	172
		Guinea Savannah	Dimadi	Apomuden, TU-purple, Kuffour, Asamaring	09°23'40N	01°05'94W	150
	Tubungu	Guinea Savannah	Voggue-Kushebo	Apomuden, TU-purple, Obare, TU 112	09°32'76N	01°01'98W	136
Greater Accra	Accra municipality	Coastal Savannah	University farm	ITS2	05°10'21N	01°17'49W	76
	Ga West	Coastal Savannah	Manchie	Fara, Apomuden, High starch	05°45'57N	00°00'57W	67

Table 2. Distribution of *Cylas* species from seven regions in Ghana.

Region	District	Agro-ecological zone	Locality	No of weevils	C. puncticollis	C. brunneus
					Male/Female	Male/Female
Volta	Ohawu	Coastal Savannah	Bedjame	340	107/138	43/52
	Akatsi South	Coastal Savannah	Kpotavi	1338	95/118	542/583
		Coastal Savannah	Tadzevu	134	60/53	11/10
		Coastal Savannah	Awalavi	640	148/147	159/186
		Coastal Savannah	Ative	665	141/129	209/186
Central	Komenda-Edna-Eguafo-Abirem (KEEA)	Coastal Savannah	Komenda	880	430/447	1/2
	Cape Coast	Coastal Savannah	Mpaesem	567	142/129	153/143
Greater-Accra	Accra Municipality	Coastal Savannah	University Farm, Legon	655	315/322	11/7
	Ga West	Coastal Savannah	Manchie	325	16/13	147/149
Eastern	Ayensuano	Transitional zone forest	Marfo	651	250/262	66/73
Eastern	Begoro	Transitional zone forest	Ehiamakyene	76	-	32/44
	Kwahu East	Transitional zone forest	Akwasiho	105	46/32	10/17
Upper-East	Bawku	Sudan Savannah	Tinsongo	635	305/330	-
	Pusiga	Sudan Savannah	Nikoe	7	1/6	-
Upper-West	Wa West	Sudan Savannah	Siiru	192	89/103	-
	Lawra	Sudan Savannah	Kunyukuo	310	162/148	-
	Lawra	Sudan Savannah	Tanchara Koro	20	8/12	-
	Jirapa	Sudan Savannah	Orifani	216	100/116	-
	Wa Municipality	Coastal Savannah	Sombo	70	38/32	-
Northern	Tolon	Guinea Savannah	Saari	638	310/328	-
		Guinea Savannah	Dimadi	215	107/108	-
	Tubungu	Guinea Savannah	Voggue-Kushebo	168	80/88	-

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