



## SPECIES ABUNDANCE OF WEEVILS (COLEOPTERA: CURCULIONIDAE) ASSOCIATED WITH TWO AMARANTH HOSTS IN MAIDUGURI, NORTH EASTERN NIGERIA

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**ABSTRACT:** This study determined the species of weevils, their host distribution and abundance in two amaranth hosts, *Amaranthus dubius* C.Mart. ex Thell and *Amaranthus hybridus* L., cultivated in Maiduguri, northeastern Nigeria. Weevil stem tunneling activity was inspected in rainfed amaranth from 16 farmers' fields each in 2014 and 2015. Weevils were recovered using destructive sampling, followed by laboratory observations of emergence. Eight weevil species including *Coniocleonus?* sp. (Lixinae), *Temnorhinus* sp. (Cleonini), *Gasteroclisus rhomboidalis* Boheman, *Hypolixus nubilosis* (Boheman), *Hypolixus truncatulus* (F.), Lixini (*Lixus?*), *Hypolixus* sp. and *Lixus* sp. were found infesting these amaranth hosts. *Hypolixus truncatulus* and *G. rhomboidalis*, followed by *H. nubilosis* were the most abundant species, while *Coniocleonus?* sp. and *Temnorhinus* sp., followed by *Lixus* sp. had the lowest abundance. All individuals (100%) of four weevil species (*Coniocleonus?* sp., *Temnorhinus* sp., Lixini and *Hypolixus* sp.) were recovered in a single amaranth host, *A. hybridus*. Out of the four species recovered in both amaranth hosts, three (*G. rhomboidalis*, *H. nubilosis* and *H. truncatulus*) had high abundance (54%-84%) in *A. hybridus*, while one (*Lixus* sp.) had high abundance (72%) in *A. dubius*. Mean weevil abundance was neither significantly different between amaranth hosts each year (2014, 78-103; 2015, 117-155), nor significantly different between years in each amaranth host (*A. hybridus*, 103-155; *A. dubius*, 78-116). In summary, several stem-boring weevil species with high seasonal abundance infest both *A. dubius* and *A. hybridus* in this region. To establish the true pest status of these weevils, more studies are needed on each weevil species infestation, destruction level and densities in different amaranth hosts.

**Keywords:** Pest infestation, *Amaranthus* host plants, stem-boring weevils, seasonal abundance

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### 1. INTRODUCTION

Amaranth (*Amaranthus* spp.) (Caryophyllales: Amaranthaceae) is extensively cultivated in the tropics primarily as green leaf vegetable, and secondarily for the seeds. The leaves contain moderate to high amounts of protein balanced in amino acids, essential vitamins (A and C) and minerals including potassium, calcium, phosphorus and iron (Yang and Keding, 2009; Alegbejo, 2013; Achigan-Dako *et al.*, 2014; Denton *et al.*, 2016). The leaves are also an important source of dietary fiber. Several parts of amaranth are used medicinally in different communities to regulate blood pressure and cholesterol levels in humans, improve the

immunity and anti-oxidant status of the body, and cure/relieve suffering from coronary heart disease, ulcers, diarrhea, swollen mouth/throat, constipation and anaemia (AVRDC, 2003; Martirosyan *et al.*, 2007; Sahoo *et al.*, 2015).

Amaranth yield in Africa ranges between 17 t/ha and 40 t/ha (Schippers, 2000, 2004). The species cultivated in Nigeria include *Amaranthus hybridus* L., *Amaranthus dubius* C.Mart. ex Thell., *Amaranthus cruentus* L., *Amaranthus caudatus* L., *Amaranthus viridis* L., *Amaranthus gurgenticus* L., *Amaranthus tricolor* L., *Amaranthus hypochondriacus* L., whereas *Amaranthus spinosus* L. and *Amaranthus blitum* L. are weeds (Degri

and Randy, 2014; Oke *et al.*, 2015; Akin-Idowu *et al.*, 2016). Amaranth is cultivated either under rainfed or irrigated system in all the agroecological zones of the country. The relative ease of cultivation across seasons, its vigorous growth/early maturity with even little moisture, resistance to heat/drought, low labour requirement and high adaptability to a wide range of soils/new environments (Norman, 1992; Maundu *et al.*, 2009), make amaranth a valuable source of diet and income to small-scale farmers.

Weevils (Coleoptera: Curculionidae) are important taxa capable of causing significant damage in amaranth. Adult weevils feed heavily on leaves and tender plant stems, whilst boring activities of hatched larvae, particularly during tender ages at between 2 and 3 weeks, destroys host stems causing plants to wilt and die (Ekechukwu and Eluwa 2008). Heavy leave feeding by adult weevils alone can severely destroy host plants over a short period of time. Weevils on average can complete their life cycle in 40 days. Weevils are amongst the abundant insect pests of amaranth in south western Nigeria (Aderolu *et al.* 2013). At present, data on weevil species activities in amaranth and most crops cultivated in northern Nigeria are very limited. This study therefore determined associated weevil species, their host distribution and abundance in two amaranth,

*A. dubius* and *A. hybridus*, commonly cultivated in Maiduguri, north eastern Nigeria.

## 2. MATERIALS AND METHODS

### 2.1 Field Collection and Laboratory Work

Farmers' fields were sampled during 2014 and 2015 cropping seasons in Maiduguri (meters above sea level, 354; latitude 11°45' N-11°51' N; longitude 13°2' E-13°9' E), northeastern Nigeria. Local climate is generally semi-arid, with mean annual rainfall, humidity and temperature respectively 553 mm, 45.2% and 32° C (BOSG 2013). Each year, weekly sampling was carried out over ten weeks, during July to September, in 16 farmers' fields. In each farmers' field, planted with both *A. dubius* and *A. hybridus*, 25 plants of each amaranth host were randomly checked for weevil larval feeding activities or pupation (Fig. 1). Each infested stem, per amaranth host, was uprooted, dissected and placed in a single large jar with a perforated lid (Oke *et al.* 2015). Each jar, was kept for further observation in the Entomology laboratory (Department of Crop Protection, University of Maiduguri) at 30±8 °C and 55±7 % relative humidity. Daily count of emerged adult weevils was performed for each set of stems (Fig. 2-5), until there was no more emergence.

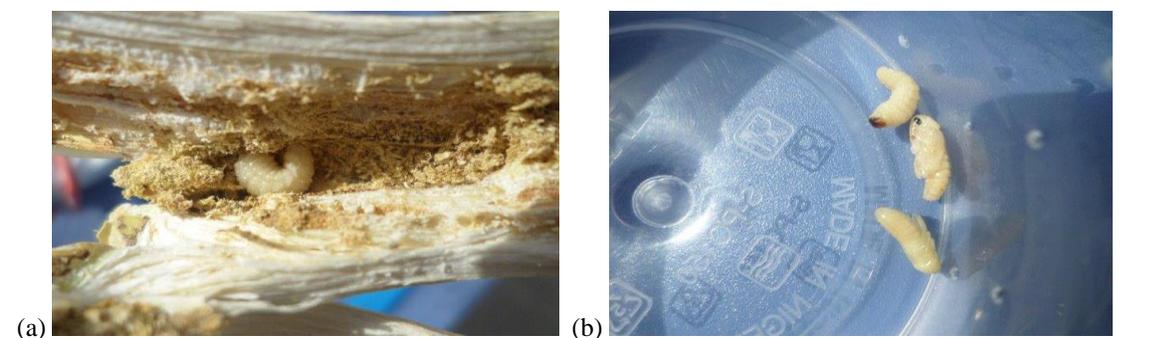


Figure 1. Curculionid weevil: (a) Larva (about to pupate) inside *A. hybridus* stem and (b) larva (top) and pupae (middle and bottom) in the laboratory

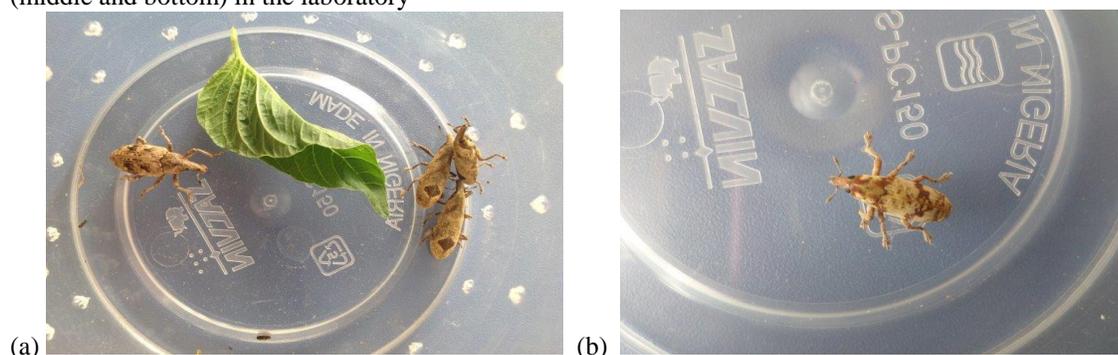


Figure 2. Adults: (a) *Coniocleonus?* sp. (Lixinae) (left) and *Gasteroclisus rhomboidalis* (right) and (b) *Temnorhinus* sp. (Cleonini)

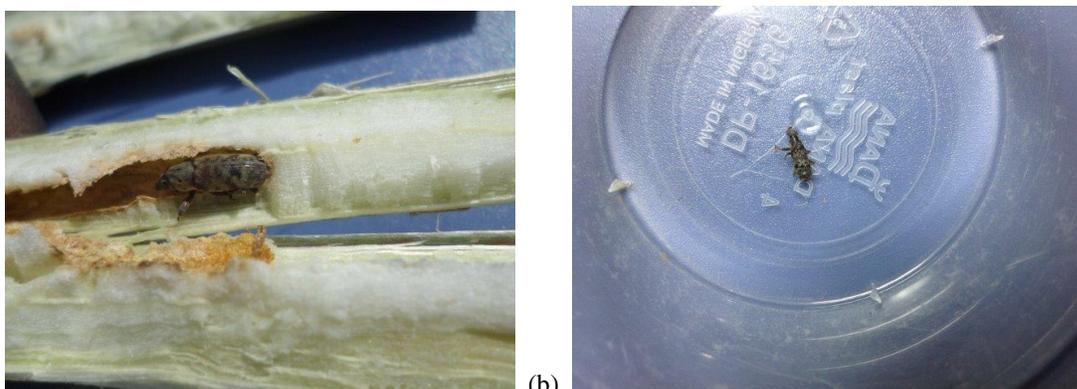


Figure 3. Adult *Hypolixus nubilosis*: (a) Inside *A. dubius* stem and (b) in the laboratory

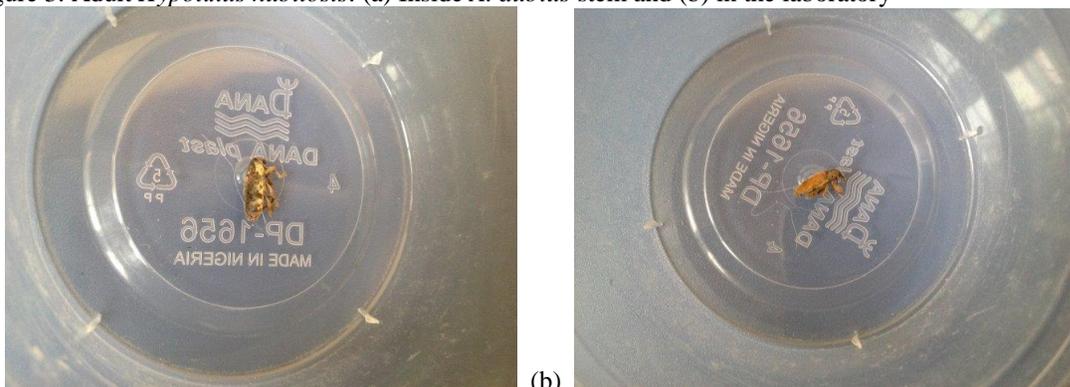


Figure 4. Adults: (a) *Hypolixus truncatulus* and (b) Lixini in the laboratory

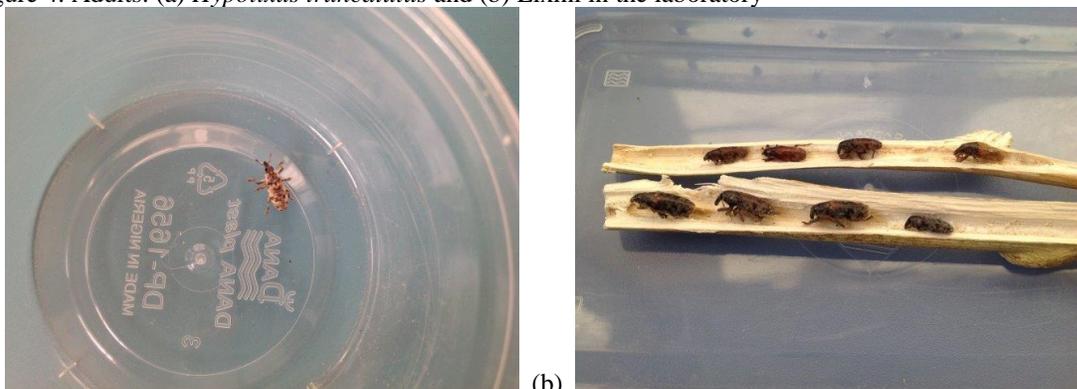


Figure 5. Adults: (a) *Hypolixus* sp. and (b) *Lixus* sp. (top left, 1-3), Lixini (top right, 4), and *Hypolixus nubilosis* (bottom 1-4) in the laboratory

## 2.2 Data Analysis

Kruskal-Wallis test ( $\alpha = 0.05$ ) was performed in SAS (2011) to estimate significant differences in stem weevil abundance between years and amaranth hosts.

## 3. RESULTS

A total of 25558 *A. hybridus* and 21935 *A. dubius* rainfed plants were inspected for the presence of weevils during both 2014 and 2015. Eight curculionid

species belonging to five genera, two tribes and one subfamily were found living in these amaranth hosts (Table 1). These species include *Coniocleonus?* sp. (Lixinae), *Temnorhinus* sp. (Cleonini), *Gasteroclisus rhomboidalis* Boheman, *Hypolixus nubilosis* (Boheman), *Hypolixus truncatulus* (F.), Lixini (*Lixus?*), *Hypolixus* sp. and *Lixus* sp. All eight-weevil species were recovered in *A. hybridus*, whereas only four species were recovered in *A. dubius* (Table 2).

*Hypolixus truncatulus* (5274 weevils) and *G. rhomboidalis* (4126 weevils), followed by *H. nubilosis* (1677 weevils) had the highest species abundance. The abundance of *Hypolixus* sp. and *Lixus* sp. was also high, ranging between 891 and 968 weevils; whilst that of Lixini was low, with 252 weevils. *Temnorhinus* sp. (89 weevils) and *Coniocleonus?* sp. (21 weevils) had the lowest species abundance. Majority of species (*G. rhomboidalis*, *H. nubilosis* and *H. truncatulus*) recovered in both amaranth hosts had high percentage of

weevil abundance in *A. hybridus*. *Lixus* sp. had high percentage of weevil abundance in *A. dubius*. Mean number of weevils in *A. hybridus* per farmers' field ranged from 103 in 2014 to 155 in 2015, whilst that in *A. dubius* ranged from 78 in 2014 to 117 in 2015. In both *A. dubius* and *A. hybridus*, mean number of weevils per farmers' field was not significantly different between years. Likewise, in both 2014 and 2015, mean number of weevils per farmers' field was not significantly different between amaranth hosts.

Table 1: Species of weevils living in rainfed *A. dubius* and *A. hybridus* during 2014 and 2015 in Maiduguri

Family	Subfamily	Tribe	Genus	Species
Curculionidae	Lixinae	Cleonini	<i>Coniocleonus?</i>	sp.
Curculionidae	Lixinae	Cleonini	<i>Temnorhinus</i>	sp.
Curculionidae	Lixinae	Lixini	<i>Gasteroclisus</i>	<i>rhomboidalis</i> Boheman
Curculionidae	Lixinae	Lixini	<i>Hypolixus</i>	<i>nubilosis</i> (Boheman)
Curculionidae	Lixinae	Lixini	<i>Hypolixus</i>	<i>truncatulus</i> (Fabricius)
Curculionidae	Lixinae	Lixini	<i>Lixus?</i>	sp.
Curculionidae	Lixinae	Lixini	<i>Hypolixus</i>	sp.
Curculionidae	Lixinae	Lixini	<i>Lixus</i>	sp.
Total	1	1	2	5
				8

Table 2: Host distribution and abundance of stem weevils living in rainfed *A. dubius* and *A. hybridus* during 2014 and 2015 in Maiduguri

Species	Host distribution		Abundance		
			Total No.	Percentage (%)	
	<i>A. dubius</i>	<i>A. hybridus</i>		<i>A. dubius</i>	<i>A. hybridus</i>
<i>Coniocleonus?</i> sp. (Lixinae)	-	+	21	-	100
<i>Temnorhinus</i> sp. (Cleonini)	-	+	89	-	100
<i>Gasteroclisus rhomboidalis</i>	+	+	4126	16	84
<i>Hypolixus nubilosis</i>	+	+	1677	33	67
<i>Hypolixus truncatulus</i>	+	+	5274	46	54
Lixini ( <i>Lixus?</i> )	-	+	252	-	100
<i>Hypolixus</i> sp.	-	+	968	-	100
<i>Lixus</i> sp.	+	+	891	72	28

+, recovered; -, not recovered

Table 3: Mean number of stem weevils (larvae and adults) ( $\pm$ SD) per farmers' field living in rainfed *A. dubius* and *A. hybridus* during 2014 and 2015 in Maiduguri

Year	Host plant		N	Statistics	
	<i>A. dubius</i>	<i>A. hybridus</i>		<i>H</i>	<i>P</i>
2014	78.17 $\pm$ 18.99	103.02 $\pm$ 21.12	10687	8.24	0.5518
2015	116.89 $\pm$ 33.51	154.94 $\pm$ 52.02	11417	2.85	0.3115
<i>N</i>	21935	25558			
Statistics: <i>H</i>	19.33	15.17			
<i>P</i>	0.7912	0.5006			

*N*, number of field observations; *H*, Kruskal-Wallis statistic; *P*, Probability value

#### 4. DISCUSSION

Evidence shows that amaranth is infested in parts of north eastern Nigeria by at least eight weevil species. Six of which appear to be specialized in either or both

amaranth hosts, with *H. truncatulus* and *G. rhomboidalis* as the most abundant weevils or major pests, followed by *H. nubilosis*, *Hypolixus* sp. and *Lixius* sp. Lixini, with low abundance appears to be a minor pest of *A. hybridus*. Two other species recovered

in *A. hybridus*, *Coniocleonus?* sp. and *Temnorhinus* sp., seem to be opportunistic, since both species had very low abundance and were restricted to one amaranth host. Some of these results align, at least in part, with those from various parts of the country. In Akure, south western Nigeria, 54% of farmers interviewed by Okunlola and Ofuya (2010) included *G. rhomboidalis* amongst major pests in *A. hybridus* farms during wet season. In Ibadan, within the same region, *G. rhomboidalis* along with *Baris circumscutellata* Hustache, *Leucogrammus paykulli* Boheman, *Lixus camerunus* Kolbe, *H. nubilosus* and *Hadromerus sagittarius* Olivier were recorded as major amaranth stemborers causing boring and galling of stems, branches and some time the leaf petioles (Oke *et al.*, 2015). In Nsukka, south eastern Nigeria, *G. rhomboidalis* is responsible for extensive stem breakage and premature death of young *Amaranthus viridis* L. crops (Ekechukwu and Eluwa, 2009). In Benin, south southern Nigeria, *G. rhomboidalis* is an important pest of both *A. cruentus* and *A. hybridus* (red seed), with two to three times more density than *Hypolixus* sp. (Ogedegbe and Ezeh, 2015).

Amaranth stem weevils, *Hypolixus* sp. including *H. truncatulus*, *H. nubilosus* or *H. haerens* (Boheman) are serious pests of amaranth in several African and Asian countries (Louw *et al.*, 1995; James *et al.*, 2010; Kigali *et al.*, 2013; Oke *et al.*, 2015; Mureithi *et al.*, 2017). In Kenya, *H. nubilosus* along with coreid bugs (*Cletus* sp.) and webworm (*Herpertogramma bipunctalis* (Fabricius)) are responsible for significant yield losses of up to 27% on both amaranth grain and leaves (Kigali, 2014). In India and Sri Lanka, the stem borer complex of *H. truncatulus* and *L. truncatulus* results in up to 81% or 92% infestation of amaranth; compelling farmers in certain districts to abandon cultivation (Tara *et al.*, 2009; Bhagat, 2016; Rajaeshkauna *et al.*, 2017). Interestingly, in India, *H. truncatulus* populations are kept in check by a complex of natural enemies belonging to parasitic hymenoptera including *Telenomus javensis* Dodd (Vidhyasekaran *et al.*, 2001).

The richness of weevils obtained in this study is somewhat high compared to that in most studies conducted in Nigeria by Ekechukwu and Eluwa (2009), Okunlola and Ofuya (2010), Aderolu (2013) and Ogedegbe and Ezeh (2015), Borisade *et al.* (2017), which reported a maximum of three weevil species. Those studies considered recovering general pests of amaranth in different insect families including Lepidoptera, Coleoptera and Diptera, while ours focused on the richness of weevils in the family Curculionidae. Accordingly, we uprooted all infested stems and placed them in jars, allowing all larvae or pupae present to

develop into adults and emerge (Oke *et al.*, 2015). Considering the protocol employed, none recovery of *L. camerunus* in this study suggest that its distribution is confined to parts of south western Nigeria. Wherein, it is a dominant pest along with *Zonocerus* spp. in amaranth or *C. argentea* during the dry season (Anno-Nyako *et al.*, 1991; Okunlola and Ofuya, 2010).

The recovery of majority of weevil species in *A. hybridus* (100% abundance of half the species (four) recovered, and higher percentage abundance (54%-84%) of most species (three-quarters) recovered in both amaranth hosts) suggest great host suitability to these weevils. The high abundance (72%) of *Lixius* sp. in *A. dubius* was therefore not understood but thought to be somewhat connected with host nutrition (Ogedegbe and Ezeh, 2015).

Non-significant difference in abundance between host plants and between years indicate high seasonal weevil abundance in both *A. hybridus* and *A. dubius*. This is not surprising with *H. truncatulus*, since the weevil harbours and feeds across seasons in *Chromolaena odorata* (L.) R.M. King & H.E. Robins (Ambika and Jayachandra, 1990). Especially, because *C. odorata* is a serious weed in Nigeria and an aggressive colonizer in different habitats such as cleared agricultural fields, pasture lands, fallow fields, waste lands, road sides, river banks, rocky areas, slashed or burnt areas, etc. High seasonal abundance of *G. rhomboidalis* is also not surprising due to year-round infestation of its primary alternate host, *Amaranthus spinosus* L., which is capable of sustaining weevil populations through different seasons (Banjo, 2007). Notably, amaranth infestation by *G. rhomboidalis* may be complicated in the following ways: i) The stem borer complex of *G. rhomboidalis* and *H. nubilosus* cause economic damage to grain amaranth in a mixed infestation (Borisade *et al.*, 2017), and ii) Field studies and screen house investigations (in Ibadan) indicate a positive relationship between the populations of *G. rhomboidalis* and *L. camerunus* and the incidence of brown stem rot and die-back in *A. hybridus*, with the latter pest implicated as major disease vector (Anno-Nyako *et al.*, 1991).

## 5. CONCLUSION

1. In this locality, *A. dubius* and *A. hybridus* are attacked by at least eight species of weevils, with *H. truncatulus* and *G. rhomboidalis* as the most abundant pests.
2. Results suggest that weevil abundance in farmers' fields is seasonally high in both amaranth hosts.
3. To further establish the importance of these weevils, future investigations should determine the:

- i) Infestation rates or damage levels and densities of these weevils in different amaranth hosts, and ii) Activities of natural enemies in regulating their populations.

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