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Occurrence, Abundance and Control of the Major Insect Pests Associated with Amaranths in Ibadan, Nigeria

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Abstract

Beetworm Moth (BM), *Hymenia recurvalis* F. is a major defoliator of *Amaranthus* species causing severe yield loss. Control with synthetic insecticide is being discouraged for its adverse effects. Information on sustainable management of BM with ecologically friendly methods is scanty. Three *Amaranthus* species: *A. cruentus, A. blitum* and *A. hybridus* were evaluated for insect diversity and abundance during wet and dry seasons of two years following standard procedures. Data collected were Leaf Area Damage (LAD) (cm^2); Infestation per plant (I) and Field Abundance (FA). Three neem extracts: 0.125 g Aqueous Neem Leaf (ANL) w/v; 0.125 g Aqueous Neem Bark Ash (ANBA) w/v and Aqueous Modified ANL+ANBA (AMAN) (1:1) all at 3l/25 m^2 were bioassayed against BM using λ-cyhalothrin at 2.5 ml/25m^2 and water as controls. Data collected were analysed using descriptive statistics, ANOVA at P>0.05, Shannon index (H), Simpson index (1-D) and evenness. Sixty insect species from 29 families and 12 orders; comprising 31 defoliators, 12 predators, one pupa parasitoid (*Apanteles hymeneae*) and 16 non-economic species were encountered on *Amaranthus* species. The BM was the most damaging causing 69.4 ± 0.16% loss of foliage compared to control. The species abundance in both seasons was BM (2916.8 ± 138.83)>***Hypolixus truncatulus*** (2262.7 ± 94.1) >*Lixus* ***truncatulus*** (2088.7 ± 36.4). Shannon (3.52), 1-D (0.96) and evenness index (0.65) of diversity were high with few dominant species. The AMAN at 3l/25 m^2 w/v extract caused significant reduction of leaf damage (72 ± 0.05%) and field infestation (78 ± 0.06%) compared to the untreated control; but comparatively less effective by only 5% to λ-cyhalothrin; implying suitability as environmentally safe control measure.

Keywords: *Hymenia recurvalis*; *Amaranthus* species; Neem extracts; *Apanteles hymeneae*

Introduction

Amaranth (*Amaranthus species*) is believed to have originated from Central and South America [1,2] where it has been cultivated for more than 8,000 years [3,4]. It has now become cosmopolitan, spreading to and becoming established in Africa, Asia (Nepal, India, China and Russia), parts of Eastern Europe and South America [5-7] and its now been grown by a large number of farmers over the past few decades [8].

In Africa, Nigeria is the largest producer and consumer of amaranth followed by Ghana, Benin Republic and Senegal in West Africa; Kenya, Uganda, Cameroon, Gabon, Tanzania and Ethiopia in East and Central Africa; South Africa, Zambia and Zimbabwe in Southern Africa [9-13]. Smith and Eyzaguirre [12] noted that different vegetable parts are useful for several purposes. Amaranth is one of those rare plants whose leaves are eaten as vegetables and seeds as cereal [14-16]. These are otherwise referred to as vegetable and grain amaranths, respectively.

Vegetable amaranth is cultivated and consumed in many parts of the world, with *A. cruentus, A. dubius, A. blitum* and *A. tricolor* being the documented cultivated species in East Africa. In West Africa, especially Nigeria where it is a common vegetable, the edible species include *A. cruentus, A. dubius, A. caudatus* and *A. hypochondriacus* [17]. Kamalanathan et al. [18], Oke [19], Banjo [20] stated that popularity of vegetable amaranth is due to its earliness to maturity, palatability and high nutritive value. Its protein content is well balanced in amino acids such as lysine and rich in minerals (Fe, I and Ca) and vitamins A and C [16,21,22]. Therefore, regular consumption reduces blood pressure, cholesterol levels and improves the body's antioxidant status and immunity [23].

However, one of the greatest limiting factors in increasing the productivity of amaranths is the range of insect pests with which they are associated and the level of losses suffered in unimproved and improved agriculture [20]. Akinlosotu [24] implicated insects of various orders namely; Coleoptera, Hemiptera, Lepidoptera and Orthoptera. Lepidopterous insect pests of *Amaranthus* include *Psara bipunctalis, Sylepta derogata* [25] as well as *Hymenia recurvalis, Helicoverpa armigera and Spodoptera litura* [26]. Furthermore, the publication by Tamil Nadu Agricultural University, Coimbatore, India on 'Insect Pests of Amaranthus' recorded that Leaf caterpillar, *Hymenia recurvalis* and *Psara basalis* are the most important pests of *Amaranthus species*.

The Beetworm Moth, *Hymenia recurvalis* Fab. (Lepidoptera: Pyralidae) causes severe losses to *Amaranthus species*. The caterpillar rolls the leaf into distinctive leaf shelter and voraciously feed on the green matter. Severe attack results in complete skeletonisation and drying up of the leaves within a short time [27,28]. This has necessitated the need to control the insect pest and other pests of *Amaranthus species*.

The management of these insect pests has been through the use of insecticides. Dales [29] noted that the use of synthetic insecticides pose health risk and result in environmental pollution. Also, Schmutterer [30] reported that the World Health Organization (WHO) had reported the poisoning of at least 3 million agricultural workers from which 20,000 deaths are recorded annually due to pesticide usage. Awasthi [31] also noted that consumers of vegetables may be at risk from pesticide residues. Thus, research has been geared towards identifying non-chemical methods of pest control, which are safe, cheap, easy to

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apply and accessible to farmers [32]. In this regard botanicals from neem have shown considerable potential [25,33].

The leaf and seed extracts of the neem tree *Azadirachta indica* A. Juss have been shown to affect over 200 insect species including some species of aphids, beetles, caterpillars, leafminers, mealybugs, scales, thrips, true bugs and whiteflies; it is also the most popular botanical pesticide against foliage feeding pests. The aqueous extract of *A. indica* bark has been shown to be as effective as a synthetic insecticide (Cymbush®) in controlling foliage feeders of vegetables [25]. Meanwhile, Copping [34] has earlier reported no known incompatibilities of neem extracts with other crops protection agents. There is evidence available for the synergistic action of neem with microbial pesticides such as NPVs of tomato fruit worm [35] and common armyworm [36], and entomopathogenic fungi (*Beauveria bassiana*) against common army worm [37]. Asian Vegetable Research and Development Centre (AVRDC) has developed IPM strategies for tomato and vegetable soybean involving neem as an integral component with microbial pesticides such as *Bacillus thuringiensis* and NPVs in managing phytophagous insects [38]. Such IPM strategy would only be possible through a thorough knowledge of the pest under consideration.

Therefore, in view of the need to control the beet webworm moth, potential locked up in *A. indica* and the need to develop non-toxic, safe and effective biodegradable alternative to synthetic insecticides which could be deployed in a site specific IPM approach which in turn depends on adequate information on the pest as well as appropriate pest population estimates. Consequently, this study evaluates the biology and management of the leaf caterpillar, *H. recurvalis* (Lepidoptera: Pyralidae) on Amaranths in Ibadan, Nigeria.

Parameters	Measurement
Experimental Area	13 m×11.5 m
Experimental Block Dimension	1 m×11.5 m
Experimental Plot Dimension	1 m×2.5 m
Alley	0.5 m
Test Plots	
Number of rows	4
Row length	2.5
Inter row spacing	30 cm
Number of replicates	4
Inter plant spacing	5 cm
Row width	1 m

Table 1: Field Parameters and Measurement.

Plate 1: Seedlings at 2 weeks after sowing: showing period of insect infestation.

Materials and Methods

The study site

This research was carried out at the valley bottom site of the Practical Year Farm Training Plot of the Faculty of Agriculture and Forestry, University of Ibadan and in the Entomology Research Laboratory of the Department of Crop Protection and Environmental Biology, University of Ibadan, Ibadan, Nigeria. Ibadan is the capital of Oyo State, Nigeria.

The study area lies approximately between longitude N07°26'850" to N07° 27'087" and latitude E003°53'899" to 003°53'552 with elevation ranging from 205 m-227 m above sea level [39]. The climate of the area is divided into wet season (April-October) and dry season (November-March) with bimodal rainfall which peaks in June and September. The bimodal rainfall pattern with onset at around March/April corresponds to the period when *Hymenia recurvalis* moths were abundant due to availability of wild *Amaranthus species*, *Amaranthus spinosus* and other hosts range supported by persistent rainfall. Except where otherwise stated, all laboratories and screen houses experiments were conducted under ambient conditions of 27 ± 3°C temperature and 75 ± 3% RH.

Field survey for abundance and diversity of insects associated with *Amaranthus* spp.

The survey aimed at identifying insect pests that attack *Amaranthus* grown in two seasons in Ibadan Southwest Nigeria. In this study, three methods of insects trapping were employed, namely hand capture for wingless insects, hand net for flying insects and improvised pitfall trap for soil dwelling insects. The first set of field trials were conducted to assess the abundance and diversity of insects associated with *Amaranthus species* during the rainy season in May and June followed by dry season planting in November and December 2009. The second trial was conducted during the rainy season in May and June followed by dry seasons in November and December 2010. The site was manually cleared and the debris packed along the borders to ensure clean seed-bed for sowing. The land area 13×11.5 m^2 was laid out into nine blocks of 11.5 m long each, with a spacing of 0.5 m between each block of 1 m wide. Each block contained four plots each measuring 2.5×1 m^2 with 0.5 m spacing between plots in each block (Table 1). The plots were assigned to the amaranth varieties studied in a randomized complete block design and replicated four times. Beds were constructed manually with hoe. Seeds of each variety were sown by drilling with inter row spacing of 30 cm apart. Plant were later thinned to 25 stands per row at an average spacing of 5 cm within each row (200,000 plant stands/ha) at two weeks after sowing (WAS) as shown in Plate 1 [40]. Weeds were manually removed from the plots at two weeks after planting. Standard management practices such as manure application, regular watering and thinning were employed for the duration of the growing seasons.

However, the abundance and diversity of insect population associated with the amaranth species were estimated by quadrat sampling. The quadrat of dimension 0.5×0.5 m^2 was laid randomly in each plot five times between 07.00 and 09.00 hrs (local time). The number of insects species per quadrat was taken at 14 DAS and thereafter weekly till 70 DAS. The quadrat samples were taken in five replicates. This was used to determine the frequency of occurrence of insect pest on the *Amaranthus* spp being evaluated at different season, which was in turn used in computing percentage occurrence of insect pests of the *Amaranthus* spp.

All samples collected were identified by comparing their morphological characteristics with insect paratypes at the Insect Reference Collection Centre of the Department of Crop Protection and

Environmental Biology, University of Ibadan using taxonomic keys, hand lens as well as light microscope for checking fine structures. Data was analysed using analysis of variance (ANOVA) with descriptive statistics and standard diversity indices at P=0.05.

Results

Occurrence and abundance of insect diversity associated with Amaranthus species in Ibadan

The overall mean of spectral analysis of species and abundance associated with *Amaranthus sp.* during the wet seasons of 2009 and 2010 and dry seasons of 2009 and 2010 are as shown in Figures 1-4 respectively. The peak frequency (0.3897) during wet season was not significantly (P>0.05) higher than peak frequency (0.3114) during dry season in the two years.

Abundance and diversity of insects associated with *Amaranthus* sp. in the wet season

The diurnal insects associated with *Amaranthus* sp. in Ibadan varied significantly in the wet seasons of 2009 and 2010 as presented in Table 2 total of 37, 593.2 ± 16.38 individuals in 2009 and 36,464.0 ± 15.85 in 2010 comprising adults and immature stages of different insects from

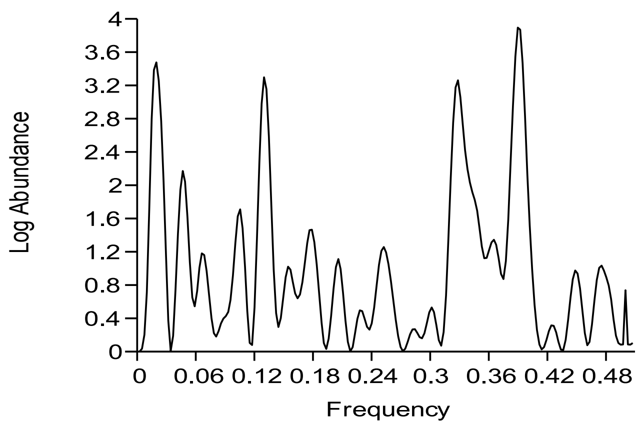

Figure 1: Overall mean of spectral analysis of species abundance associated with Amaranthus sp. during the wet seasons of 2009.

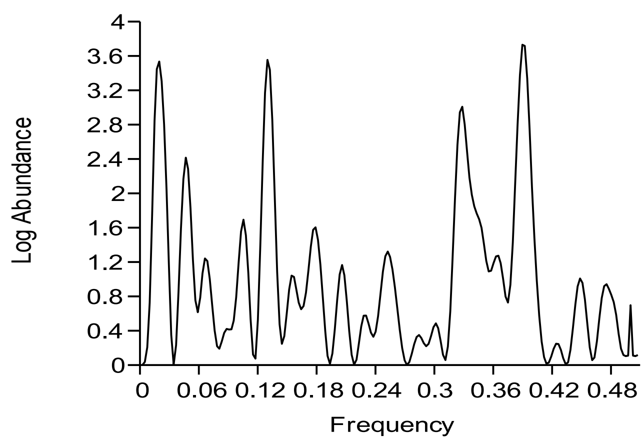

Figure 2: Overall mean of spectral analysis of species abundance associated with Amaranthus sp. during the wet seasons of 2010.

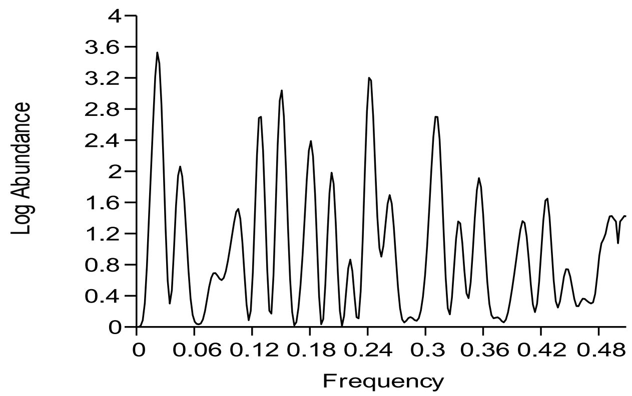

Figure 3: Overall mean of spectral analysis of species abundance associated with Amaranthus sp. during the dry seasons of 2009

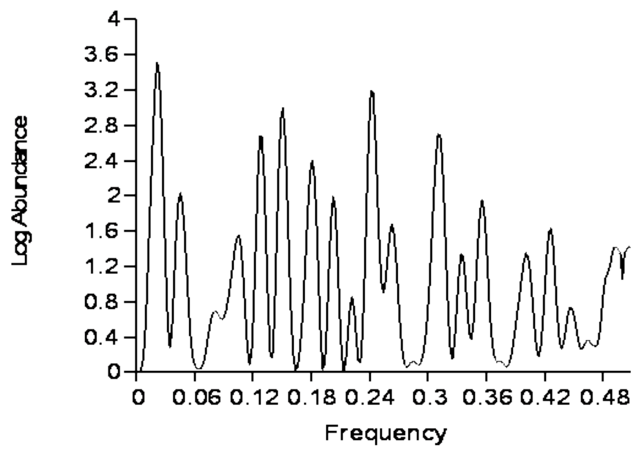

Figure 4: Overall mean of spectral analysis of species abundance associated with Amaranthus sp. during the dry seasons of 2010.

29 families and 12 orders of insects were encountered during the field assessments. The six most abundant species were *Hymenia recurvalis* 2916.8 ± 138.83 (7.76%), *Hypolixus truncatulus* 2262.7 ± 94.10 (6.02%), *Lixus truncatulus* 2088.7 ± 36.37 (5.56%), *Gastroclisus rhomboidalis* 2011.4 ± 12.03 (5.35%), *Aspavia armigera* 1733 ± 49.41 (4.61%), and *Mirperus jaculus* 1454.3 ± 44.99 (3.87%). In 2010, the populations of *H. recurvalis* 2632.1 ± 111.17 (7.22%) and *L. truncatulus* 2076.6 ± 35.74 (5.69%) were not significantly (P>0.05) different from 2009 and no significant (p>0.05) difference were recorded in the population of *H. truncatulus* 2236.8 ± 96.36 (6.13%), *A. armigera* 1741.3 ± 43.59 (4.78%), *G. rhomboidalis* 2006.3 ± 13.59 (5.50%), and *M. jaculus* 1455.4 ± 54.86 (3.99%) from that of 2009. The most abundant species encountered during the study period was *H. recurvalis* with a total of 2916.8 ± 138.83 in 2009 and 2632.1 ± 111.18 individuals in 2010. This was followed by *H. truncatulus* with a total of 2262.7 ± 94.10 in 2009 and 2236.8 ± 96.36 individuals in 2010. The species were highly diversified with Simpson diversity index of 0.964 in 2009 and this was not significantly (p>0.05) different with species diversity recorded in 2010. Similarly, the index of evenness was high being 0.651 and 0.650 for 2009 and 2010 respectively as presented in Table 3.

Species (n=10)	Order	Family	2009 (N=52)	2010 (N=52)
Tetranychus cinnabarimus	Acarina	Tetranychidae	35.7 ± 3.38	36.2 ± 3.24
Tetranychus urticae	Acarina	Tetranychidae	201.9 ± 6.11	198.7 ± 5.45
Apate monachaus	Coleop.	Bostrichidae	623.3 ± 14.06	618.9 ± 12.29
Stenaspis v. insignis	Coleop.	Cerambycidae	15.5 ± 1.01	14.5 ± 1.12
Crioceris asparagi	Coleop.	Chrysomelidae	351.1 ± 11.58	344.8 ± 11.63
D. undecimpunctata	Coleop.	Chrysomelidae	380.7 ± 13.28	374.4 ± 13.97
Othreis fullonica	Coleop.	Chrysomelidae	414.8 ± 16.66	410.7 ± 17.57
Ootheca mutabilis	Coleop.	Chrysomelidae	333.2 ± 18.20	328.9 ± 18.88
Podagrica sjostedti	Coleop.	Chrysomelidae	22.7 ± 1.74	22.3 ± 1.94
Cheillomenes vicina	Coleop.	Coccinellidae	338.6 ± 9.21	331.7 ± 12.92
Epilachna chrysomelina	Coleop.	Coccinellidae	532.1 ± 25.26	520.1 ± 27.90
Gastroclisus rhomboidalis	Coleop.	Curculionidae	2011.4 ± 38.05	2006.3 ± 13.59
Hypolixus truncatulus	Coleop.	Curculionidae	2262.7 ± 94.1	2236.8 ± 96.36
Lixus truncatulus	Coleop.	Curculionidae	2088.7 ± 115.01	2076.6 ± 35.74
Lagria villosa	Coleop.	Lagriidae	417.3 ± 10.28	410.5 ± 7.31
Efferia pogonias	Diptera	Asilidae	43.8 ± 2.09	40.9 ± 3.26
Macrosiphum spp.	Hemip.	Aphididae	1089.7 ± 32.34	1083.3 ± 31.00
Riptortus dentipes	Hemip.	Alydidae	1168.6 ± 34.74	1161 ± 37.18
Empoasca spp.	Hemip.	Cicadellidae	487.8 ± 26.36	481.9 ± 27.21
Clavigralla tomentosicollis	Hemip.	Coreidae	1617 ± 59.55	1609.5 ± 60.95
Cletomorpha unifasciata	Hemip.	Coreidae	201.1 ± 14.20	199.4 ± 4.31
Cletus ochraceus	Hemip.	Coreidae	1456.7 ± 111.65	1448.9 ± 110.9
Mirperus jaculus	Hemip.	Coreidae	1454.3 ± 44.99	1455.4 ± 45.91
Lygus lineolaris	Hemip.	Miridae	76 ± 4.83	74.7 ± 5.38
Podisus aculissimus	Hemip.	Pentatomidae	1528 ± 60.49	1524.5 ± 62.15
Aspavia armigera	Hemip.	Pentatomidae	1733 ± 49.41	1741.3 ± 43.59
Nezara viridula	Hemip.	Pentatomidae	1517.2 ± 56.05	1508.2 ± 58.03
Philaenus spumaris	Hemip.	Cercopidae	31.3 ± 2.03	30.4 ± 2.37
Apanteles hymenaea	Hymeno.	Braconidae	161.7 ± 6.87	160.8 ± 6.73
Pogonomyrmex barbatus	Hymeno.	Formicidae	50.8 ± 1.90	49.3 ± 2.45
Solenopsis geminate	Hymeno.	Formicidae	45.7 ± 42.08	44 ± 2.13
Armitermes evuncifer	Blattodea	Termitidae	33.6 ± 2.48	33 ± 2.54
Spilosoma oblique	Lepidop.	Arctidae	324.1 ± 17.93	317.9 ± 19.91
Psara basalis	Lepidop.	Crambidae	796.5 ± 32.34	790.7 ± 33.19
Pholisora Catullus	Lepidop.	Hesperiidae	98.1 ± 4.25	96.1 ± 4.21
Agrotis nigrum	Lepidop.	Noctuidae	859.1 ± 26.02	877.2 ± 25.50
Helicoverp armigera	Lepidop.	Noctuidae	910.5 ± 16.22	905.2 ± 18.39
Chrysodeixis eriosoma	Lepidop.	Noctuidae	842.3 ± 18.20	833.5 ± 21.20
Earias biplaga	Lepidop.	Noctuidae	1157.8 ± 39.01	1170.3 ± 27.37
Othreis fullonica	Lepidop.	Noctuidae	520.1 ± 8.69	510.3 ± 8.29
Spodoptera exempta	Lepidop.	Noctuidae	872.5 ± 21.48	868.2 ± 21.59
Spodoptera litura	Lepidop.	Noctuidae	931 ± 39.03	605.7 ± 5.79
Junonia orithya	Lepidop.	Nymphalidae	224.8 ± 8.05	218.8 ± 6.45
Hymenia recurvalis	Lepidop.	Pyralidae	2916.8 ± 138.82	2632.1 ± 111.2
Hymenia perspectalis	Lepidop.	Pyralidae	807.8 ± 24.38	803.8 ± 23.28
Maruca vitrata	Lepidop.	Pyralidae	1014.3 ± 9.41	1005.1 ± 13.78
Sylepta derogate	Lepidop.	Pyralidae	1081.5 ± 69.75	763.3 ± 22.71
Plutella xylostella	Lepidop.	Plutellidae	433.6 ± 7.73	429.7 ± 8.44
Eretmocera impactella	Lepidop.	Scythrididae	249.7 ± 12.37	240.9 ± 11.11
Ophiogomphus susbehcha	Odonata	Gomphidae	94 ± 14.95	91.9 ± 5.17
Gryllotalpa similis	Orthop.	Gryllotalpidae	10.3 ± 0.90	10.1 ± 0.87496
Frankliniella spp.	Thysanop.	Thripidae	722.4 ± 9.12	715.3 ± 11.25
		Total	1733 ± 49.41	36464 ± 15.85

Table 2: Occurrence of insects associated with Amaranthus sp. during wet season in Ibadan.

Abundance and diversity of insects associated with *Amaranthus* sp. in the dry season

The diurnal insects associated with *Amaranthus* sp. in Ibadan varied significantly (P>0.05) in the dry season of 2009 and 2010 as presented in Table 3. In total, there were 26296.5 ± 15.17 individuals in 2009 and 26151.6 ± 15.26 individuals in 2010 of 59 species from 29 families and 12 orders of insects. In 2009, the six most abundant

Species (n=10)	Order	Family	2009 (N=59)	2010 (N=59)
Tetranychus cinnabarimus	Acarina	Tetranychidae	30.1 ± 1.44	30.9 ± 0.86
Tetranychus urticae	Acarina	Tetranychidae	185.2 ± 4.05	188.9 ± 3.28
Apate monachaus	Coleop.	Bostrichidae	401.2 ± 11.71	408.3 ± 8.10
Stenaspis v. insignis	Coleop.	Cerambycidae	11.5 ± 1.02	12.3 ± 0.70
Crioceris asparagi	Coleop.	Chrysomelidae	126.4 ± 4.80	128.2 ± 4.11
D. undecimpunctata	Coleop.	Chrysomelidae	211.3 ± 10.71	218.7 ± 5.24
Othreis fullonica	Coleop.	Chrysomelidae	300.3 ± 6.30	304.4 ± 7.25
Ootheca mutabilis	Coleop.	Chrysomelidae	286.1 ± 3.87	288 ± 4.31
Podagrica sjostedti	Coleop.	Chrysomelidae	20.6 ± 1.00	21.7 ± 0.54
Cheillomenes vicina	Coleop.	Coccinellidae	196.8 ± 9.37	204.9 ± 3.13
Epilachna chrysomelina	Coleop.	Coccinellidae	308.4 ± 9.09	309.9 ± 8.87
Gastroclisus rhomboidalis	Coleop.	Curculionidae	1037.7 ± 22.03	1046.3 ± 17.37
Hypolixus truncatulus	Coleop.	Curculionidae	1135.9 ± 31.72	1171 ± 25.42
Lixus truncatulus	Coleop.	Curculionidae	1142.3 ± 25.58	1153.1 ± 26.01
Lagria villosa	Coleop.	Lagriidae	202.1 ± 3.87	205.2 ± 3.77
Liriomyza brassicae	Diptera	Agromyzidae	594.6 ± 11.62	608.4 ± 8.13
Diopsis longicornis	Diptera	Diopsidae	49.1 ± 2.31	51.3 ± 1.71
Efferia pogonias	Diptera	Asilidae	23.1 ± 1.97	24.4 ± 1.19
Macrosiphum spp.	Hemip.	Aphididae	690.3 ± 12.20	702.3 ± 7.03
Empoasca spp.	Hemip.	Cicadellidae	209 ± 6.24	210.6 ± 5.62
Clavigralla tomentosicollis	Hemip.	Coreidae	1456.3 ± 17.77	1472.8 ± 16.78
Cletomorpha unifasciata	Hemip.	Coreidae	117.3 ± 4.59	120.1 ± 4.61
Cletus ochraceus	Hemip.	Coreidae	1010.9 ± 28.08	1027.9 ± 22.03
Mirperus jaculus	Hemip.	Coreidae	990.9 ± 30.40	1004.7 ± 23.60
Lygus lineolaris	Hemip.	Miridae	54.8 ± 1.99	57.2 ± 1.33
Podisus aculissimus	Hemip.	Pentatomidae	699.2 ± 14.88	712 ± 9.11
Rhynocoris bicolor	Hemip.	Reduviidae	36.9 ± 1.75	39 ± 0.79
Myzus persicae	Hemip.	Aphididae	479.3 ± 11.36	454.4 ± 17.24
Bemisia tabaci	Hemip.	Aleyrodidae	101.4 ± 1.86	102.6 ± 1.93
Aspavia armigera	Hemip.	Pentatomidae	1107 ± 21.92	1057.1 ± 20.68
Nezara viridula	Hemip.	Pentatomidae	995.2 ± 14.90	1003 ± 13.16
Dysdercus superstitiosus	Hemip.	Pyrrhocoridae	11.7 ± 0.86	12 ± 0.88
Apanteles hymenaea	Hymeno.	Braconidae	141 ± 4.66	147.7 ± 1.31
Pogonomyrmex barbatus	Hymeno.	Formicidae	33.9 ± 2.11	35.3 ± 1.98
Solenopsis geminata	Hymeno.	Formicidae	29.2 ± 1.70	30.4 ± 1.59
Vespula vulgaris	Hymeno.	Vespidae	18.6 ± 1.33	19.8 ± 0.88
Armitermes evuncifer	Blattodea	Termitidae	28.9 ± 1.22	30.6 ± 0.88
Spilosoma obliqua	Lepidop	Arctidae	186.3 ± 5.23	188.1 ± 4.94
Psara basalis	Lepidop.	Crambidae	596 ± 4.64	600.6 ± 5.30
Pholisora catullus	Lepidop.	Hesperiidae	98.5 ± 2.28	100.7 ± 2.37
Agrotis nigrum	Lepidop.	Noctuidae	575.9 ± 11.83	582.1 ± 9.86
Helicoverp armigera	Lepidop.	Noctuidae	794.9 ± 16.45	722.1 ± 17.18
Chrysodeixis eriosoma	Lepidop.	Noctuidae	306 ± 13.16	312.2 ± 11.78
Earias biplaga	Lepidop.	Noctuidae	1012.5 ± 10.08	1021.4 ± 11.02
Othreis fullonica	Lepidop.	Noctuidae	278.3 ± 11.84	282 ± 11.17
Spodoptera exempta	Lepidop.	Noctuidae	496.8 ± 10.28	506.4 ± 6.10
Spodoptera litura	Lepidop.	Noctuidae	921.4 ± 41.80	856.5 ± 47.44
Junonia orithya	Lepidop.	Nymphalidae	197.4 ± 5.54	195.3 ± 2.93
Hymenia recurvalis	Lepidop.	Pyralidae	2311.5 ± 32.46	2122.4 ± 16.33
Hymenia perspectalis	Lepidop.	Pyralidae	591.4 ± 12.20	605.4 ± 8.96
Maruca vitrata	Lepidop.	Pyralidae	679.8 ± 15.37	687.4 ± 13.34
Sylepta derogata	Lepidop.	Pyralidae	1071.1 ± 63.51	1029.8 ± 53.00
Plutella xylostella	Lepidop.	Plutellidae	292.9 ± 10.37	297 ± 11.15
Eretmocera impactella	Lepidop.	Scythrididae	160.7 ± 3.89	166 ± 1.71
Ophiogomphus susbehcha	Odonata	Gomphidae	79 ± 1.28	80.1 ± 0.95
Gryllotalpa similis	Orthop.	Gryllotalpidae	11.4 ± 0.50	11.9 ± 0.43
Zonocerus variegatus	Orthop.	Pyrgomorphidae	27.5 ± 1.014	28.4 ± 0.97
Frankliniella spp.	Thysano.	Thripidae	531.5 ± 10.88	535.8 ± 1.00
		Total	26296.5 ± 15.17	26151.6 ± 15.26

Table 3: Occurrence of insects associated with Amaranthus sp. during dry season in Ibadan.

Citation: Aderolu IA, Omooloye AA, Okelana FA (2013) Occurrence, Abundance and Control of the Major Insect Pests Associated with Amaranths in Ibadan, Nigeria. Entomol Ornithol Herpetol 2: 112. doi:10.4172/2161-0983.1000112

species were ***Hymenia recurvalis*** 2311.5 ± 32.46 (8.79%), *Clavigralla tomentosicollis* 1456.3 ± 17.77 (5.54%), *Lixus truncatulus* 1142.3 ± 25.58 (4.34%), *Hypolixus truncatulus* 1135.9 ± 31.72 (4.32%), *Aspavia armigera* 1107 ± 21.92 (4.21%) and *Sylepta derogata* 1071.1 ± 63.51 (4.07%). In 2010, there were significant (P>0.05) increases in the populations of *C. tomentosicollis* 1472.8 ± 16.78 (5.63%), *L. truncatulus* 1153.1 ± 26.01 (4.41%), *H. truncatulus* 1171 ± 25.42 (4.48%). Also, in 2010, there was a significant decrease (p>0.05) in the populations of *H. recurvalis* 2122.4 ± 16.33 (8.12%) and *S. derogata* 1029.8 ± 53.00 (3.94%)) while no significant (P>0.05) difference was recorded in the population of *A. armigera* 1057.1 ± 20.68 (4.04%). However, the most abundant species encountered during the study period in dry season was *H. recurvalis* with a total of 2311.5 ± 32.46 and 2122.4 ± 16.33 individuals in 2009 and 2010 respectively. This was followed by *H. truncatulus* with a total of 1135.9 ± 31.72 and 1171 ± 25.42 individuals in 2009 and 2010 respectively. Similarly, the trend of species diversity of insect associated with *Amaranthus species* in the dry season follow the pattern of wet season except that the number of species increases from 52 to 59 which include: *Liriomyza brassicae*, *Diopsis longicornis, Myzus persicae, Bemisia tabaci, Dysdercus superstitiosus* and *Vespula vulgaris*. Plate 2 above showed adult stage, newly laid eggs (in batch) and 3rd larva instar of the *H. recurvalis.*

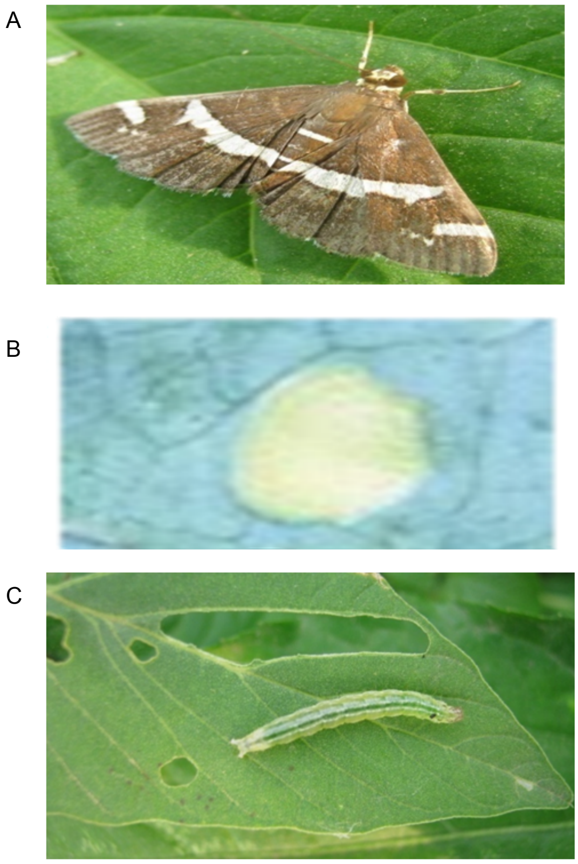

Plate 2: A=Adult stage of *Hymenia recurvalis*, B=Newly laid eggs (in batch) of *Hymenia recurvalis* C=3rd larva instar of H. *recurvalis*.

Diversity indices	2009	2010	Remarks
Taxa_S	52a	52a	Insect species in the study area
Individuals	37593.2a	36464b	Total number of insects in the study area
Dominance	0.03602a	0.036a	No species dominate the ecosystem in both year
Simpson Index	0.964a	0.964a	Species are evenly distributed in the study site
Shannon Index	3.522a	3.521a	Species diversity is high in both year
Evenness_e^H/S	0.6509a	0.6504a	Even distribution within each family in both years
Brillouin	3.517a	3.516a	Species diversity is high in both year
Menhinick	0.2682a	0.2723a	Species richness/plot is low
Margalef	4.81b	4.855b	Overall species richness is moderate
Equitability_J	0.8913a	0.8911a	Even distribution within each family in both years
Fisher_alpha	5.941b	5.964a	Species diversity is high in both year
Berger-Parker	0.07759a	0.07218b	No species dominate the ecosystem in both year

Table 4: Summary of the diversity of insects associated with Amaranthus species in wet-season in Ibadan, Southwest Nigeria.

The summary of species diversity obtained from PAST software Hammer et al. [41] revealed that the species were highly diversified with Simpson diversity index of 0.964 in both 2009 and 2010. Likewise, the index of evenness was high being 0.651 and 0.650 for 2009 and 2010 respectively as presented in Table 4.

Relationships between abundance of *H. recurvalis* and weather parameters-temperature, humidity and rainfall.

Figure 5 and 6 showed the relationship between weekly average abundance of *H. recurvalis* and weather parameters during rainy and dry season respectively. For both seasons, beetworm moth population are not significantly (p>0.05) different and the highest mean population (68.75 ± 0.274) and (68.15 ± 0.651) was recorded at third week after planting in rainy and dry season respectively. The relative humidity peaked in June at 8WAS and 7WAS with values of 87.84% and 88.23% for 2009 and 2010, respectively. The steady decline in the population of BM in December corresponds with the fall in the relative humidity of 70.58 and 73.80 in 2009 and 2010, respectively. Table 5 showed the correlation matrices of the relationship between weather factors (rainfall, temperature and relative humidity) and BM population during rainfall and dry season in 2009 and 2010 respectively. The correlation analysis showed that among the three climatic factors under consideration only relative humidity was positively (p<0.05) associated with BM population during the rainy season in 2009 and 2010. On the other hand, during dry season, only temperature was positively correlated with BM population in 2009 and 2010.

Comparative efficacy of selected botanical extracts against field infestation of *H. recurvalis* on *Amaranthus* spp.

Generally, the neem leaf had better values of % N and P than neem bark ash (NBA). Neem bark as extract had higher values of % K, Ca and Mg than neem leaf. The λ-Cyhalothrin 2.5EC did not have any component of N, P, K, Ca and Mg. The functional groups responsible for insecticidal properties of neem leaf extract are Azadirachtin and calcium carbonate in neem bark extract respectively while that in λ-Cyhalothrin 2.5EC is *Lambdacyhalothrin*.

Effect of insect infestation on the susceptible amaranthus plant under different control treatment solutions is as presented in Table 6. There were significant decreases (P<0.05) in the *Hymenia recurvalis* population per plant and number of damaged leaves per plant under the neem leaf, wood ash, modified neem leaf extracts and λ-Cyhalothrin compared to the control treatment. Modified neem

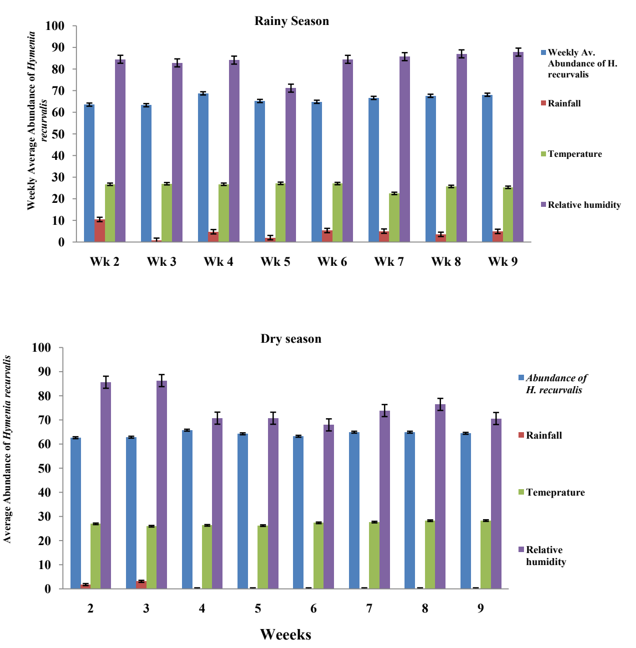

Figure 5: Relationship between weekly abundance of *Hymenia recurvalis* and weather parameters during rainy and dry season in 2009.

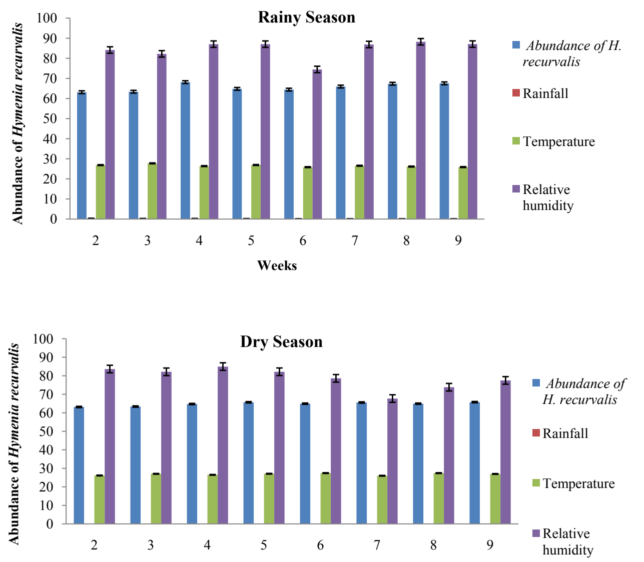

Figure 6: Relationship between weekly abundance of *Hymenia recurvalis* and weather parameters during rainy and dry season in 2010.

leaf extracts decreased the insect population and number of damaged leaves per plant in amaranthus by 30% and 41% respectively compared to the neem leaf extract. λ-Cyhalothrin also decreased significantly the number of damaged leaves per plant by 37% compared to the modified neem leaf extract. However, there was no significant decrease in the insect population between modified neem leaf extract and λ-Cyhalothrin as marginal decrease of 10% was observed in favour of λ-Cyhalothrin. Among the treatment extracts, modified neem leaf was the most effective in reducing *H. recurvalis* population and number of damaged leaves per plant followed by both neem bark ash and neem leaf extract respectively.

Table 7 shows yield of susceptible amaranthus plants under different pest control treatment. There were significant increases ($P<0.05$) in the weight of amaranthus leaf (t/ha) under different treatment extracts compared to the control treatment. Modified neem leaf extract (wood ash + neem leaf extracts) increased the amaranthus leaf by 15% and 14% compared to neem leaf and neem bark ash extracts respectively. It also increased amaranthus leaf yield by 6% compared to λ-Cyhalothrin treatment. Generally, among the treatment extracts, modified neem leaf extract had the best values of amaranthus leaf yield followed by λ-Cyhalothrin while the neem bark ash and neem leaf extract did not differ significantly in amaranthus yield.

Discussion

Insect pest infestations are perhaps the most important constraint to production of amaranths in Nigeria and one of the primary causes of low quality and yields. From the result of the survey conducted, it

Diversity indices	2009	2010	Remarks
Taxa_S	59a	59a	Insect species in the study area
Individuals	26296.5b	28060.6a	Total number of insects in the study area
Dominance_D	0.03474b	0.04432a	No species dominate the ecosystem in both year
Simpson Index	0.9653a	0.9557a	Species are evenly distributed in the study site
Shannon Index	3.591a	3.509a	Species diversity is high in both year
Evenness_e^H/S	0.6149a	0.5663b	Even distribution within each family in both years
Brillouin	3.583a	3.502b	Species diversity is high in both year
Menhinick	0.3638a	0.3522b	Species richness/plot is low
Margalef	5.699a	5.663b	Overall species richness is moderate
Equitability_J	0.8807a	0.8606b	Even distribution within each family in both years
Fisher_alpha	7.191a	7.127b	Species diversity is high in both year
Berger-Parker	0.0879b	0.1437a	No species dominate the ecosystem in both year

Table 5: Summary of the diversity indices of the insects associated with Amaranthus species in Dry-Season in Ibadan, Southwest Nigeria.

Trts	Insect pop. plant^{-1}	No. of damaged leaves
Ctrl	10.08e	33.0a
NLE	2.82a	15.54b
WAE	3.18a	14.55c
MNL	1.98c	9.16d
K720EC	1.79c	5.80e

Means followed by the same letters are not significantly different from each other using Duncan Multiple Range Test (DMRT) at 5% level.

Table 6: Effect of insect infestation on the susceptible amaranthus plant under different control treatment solutions.

Treatments	Weight of amaranthus leaves (t/ha)
Control	10.028d
Neem leaf extract	18.680c
Wood ash extract	18.880c
Modified neem leaf extract	21.880a
Karate 720EC	20.480b

Means followed by the same letters are not significantly different from each other using Duncan Multiple Range Test (DMRT) at 5% level.

Table 7: Yield of susceptible amaranthus plants under different pest control treatment.

was established that species diversity and abundance of insect pests associated with *Amaranthus species* in Ibadan varied from season to season in the study site, but *Hymenia recurvalis*, beetworm moth was the most abundant Lepidoptera pest, while *Hypolixus truncatulus* was the most abundant coleoptera pest causing considerable damage to the crop. This was not in support of earlier study by Akinlosotu [24] that reported *Sylepta derogata* and *Gastroclisus rhomboidalis* as the major pest of *Amaranthus cruentus* in Nigeria. This alteration in pest incidence and abundance may be due to rivalry for food and space between insect's pests of different species on *Amaranthus* leaf in the field. Also, there had been changes in climatic factors, like temperature and humidity overtime. As regards *G. rhomboidalis*, the ranking of Akinlosotu [24] might probably not take into consideration *Amaranthus* leaf as the desired product, rather, the indirect damage caused by *G. rhomboidalis* on *Amaranthus* stem. This assertion was supported by Ruesink and Kogan [42] as quoted by Banjo [20], who referred to *G. rhomboidalis* as an indirect pest of *Amaranthus*, damaging parts that may not affect yield. However, increase in temperature overtime might be a reason why moths (especially *H. recurvalis*) were able to uphold their status as a major pest of *Amaranthus*. Even though, the influence of these climatic factors were not studied in this work, earlier report by Shirai [43] showed that *H. recurvalis* are ectothems and the adult fly and survive longest at temperature range between 17°C and 23°C on honey-based diets. This suggested that adaptability of *H. recurvalis* to a wide range of temperature and relative humidity was high within different locations and could migrate from cooler regions, especially during winter, to regions with relatively higher temperature.

Other Lepidoptera pest of economic importance encountered were *Erias biplaga*, *Sylepta derogata*, *Psara basalis*, *Maruca vitrata*, *Spodoptera sp*., *Helicoverpa armigera*, *Agrotis nigrum*, *Chrysodeixis eriosoma* and *Othreis fullonica* which were observed at varying levels on all the *Amaranthus* accessions being assessed. This implies that any of these lepidotera pests have potentials of becoming the major insect pest of *Amaranthus* in Nigeria as they could out-compete *H. recurvalis* if not well-managed and this was corroborated by Ebert et al. [26], who listed *Spodoptera litura*, *H. armigera* and *Psara basalis* as important but often ignored Lepidoptera pests of *Amaranthus*. This is also in consonance with earlier study reported by Sileshi et al. [44], Cherian and Brahmachari [45], Thompson and Simmonds [46] (listed in prey-host record) that *Sylepta derogata*, *H. armigera* and *Psara basalis* respectively under favorable conditions can exceed *H. recurvalis* in competition for food and space especially on a laboratory diet. This study showed that an array of insect pests' complex infests *Amaranthus* leaves on the field at ambient temperature and relative humidity in association with one another in a competitive manner. This trend of insect species confirms the presence of the insect species previously reported as pests of amaranth [47,48] and this requires multifaceted and integrated management approach.

Three neem extracts: 0.125 g Aqueous Neem Leaf (ANL) w/v; 0.125 g Aqueous Neem Bark Ash (ANBA) w/v and Aqueous Modified ANL+ANBA (AMAN) (1:1) all at 3l/25 m^2 were bioassayed as ecologically friendly field protectant against BM using λ-cyhalothrin at 2.5 ml/25 m^2 and water as controls. The AMAN at 3l/25 m^2 w/v extract was most effective botanical formulation, causing significant reduction of leaf damage (72 ± 0.05%) and field infestation (78 ± 0.06%) compared to the untreated control; but comparatively less effective by only 5% to λ-cyhalothrin; implying suitability as environmentally safe control measure.

Conclusion

This study revealed that there are significant differences ($p \leq 0.05$) in the seasonal abundance and diversity of insect pests of amaranths in Ibadan Southwest Nigeria. Loss of foliage was highly dependent on the infesting insect pest especially defoliators.

Sixty insect species associated with amaranth crop were determined; of these, the species with the major presence level on the foliage were *H. recurvalis* and *Sylepta derogata* with 8.8% and 4.1% of occurrence, respectively. The borers group, curculionids, caused infestations of 12.6%, while the white grubs group infests 7.3% of the plants. The most voracious and damaging stage of *H. recurvalis* is the third instar larva which prefers tender leaf. Hence, availability of amaranths is very peculiar and germane to the seasonal abundance and population dynamic of *H. recurvalis* on the field.

There was considerable variation in the effectiveness of the extracts at the minimum inhibitory concentration of the neem and ash extracts used in the control of *H. recurvalis.* Modified neem extracts at 1200 l/ha was the most effective among the screened neem and ash extracts and has synergistic effect in the control of *H. recurvalis*. Beetworm Moth was the most important defoliator of *Amaranthus species.* The resistant donor cultivar *Amaranthus hybridus* along with aqueous modified neem leaf with bark ash extracts could be used in integrated management of the insect pest. Therefore, it is recommended as environmental safe alternative, practicable, available and sustainable form of control compare to synthetic pesticides.

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