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Insects Associated with Underutilized Crop: Grain, Leafy and Ornamental Amaranth in Ibadan, Nigeria

O. A. Oke[1*], C. A. Odiyi[2] and T. I. Ofuya[2]

[1]Department of Vegetable Programme, National Horticultural Research Institute, P.O.Box 41922, Eleyele, Ibadan. Nigeria.
[2]Department of Crop, Federal University of Technology, Akure. Soil and Pest Management, P.M.B. 704, Akure, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Author OAO designed the study, managed the experimental process, managed the literature searches, analyzed the data and wrote the first draft of the manuscript. Author CAO and TIO read, corrected and approved the final manuscript.

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ABSTRACT

Aim: Staple crops face major challenges in the near future and a diversification away from over-reliance on staples is important towards the achievement of global food security, this stimulate the retrieving and field evaluation of underutilized amaranth accessions for pest infestation before recommendation for wider adoption in Nigeria.
Study Design: Field experiments were laid out in a randomized complete block design while the laboratory experiments were laid out in a completely randomized design.
Place and Duration of Study: Experiments were conducted at the vegetable field and entomology laboratory of the National Horticultural Research Institute, Ibadan, Nigeria, during the rainy and dry seasons of 2008–2009.
Methodology: The 91 accessions of amaranth which comprised of 28 grain amaranth type (26 introduced and 2 indigenous accessions), 54 leafy amaranth type (2 introduced and 52 indigenous

**Corresponding author: Email: oke2abiola@yahoo.com;*

accessions) and 9 ornamental amaranth type (6 introduced and 3 indigenous accessions), were planted in the field. All the plants were observed daily in the morning, a week after transplanting through grain maturity and all insects were collected with sweep nets and aspirators.

Results: The most abundant insect pests on all the 3 amaranth types were from the orders *Coleoptera*, Lepidoptera and *Hemiptera*. Among the natural enemies, the heteropterans were the most abundant belonging to the Reduviidae. All the twelve (12) major pests from the families: Curculionidae, Coreidae, Pentatomidae and Pyralidae were observed on all the 3 amaranth types planted. The major leaf eating larvae were *Hymenia recurvalis* Fabricius*, Psara bipunctalis* Fabricius and *Psara palpalis* Hampson all from Pyralidae. The major stem borers were *Baris circumscutellata* Hustache, *Gasteroclisus rhomboidalis* Boheman, *Leucogrammus paykulli* Boheman, *Lixus camerunus* Kolbe*, Hypolixus nubilosus* Boheman and *Hadromerus sagittarius* Olivier all belonging to Curculionidae. The major grains sucking bugs were the coreids *Cletus fuscescens* Walker and *Cletomorpha unifasciata* Blote and the pentatomid *Aspavia armigera* Fabricius.

Conclusion: The introduced underutilized grain amaranth accessions could be cultivated alongside the indigenous leafy amaranth with the application of the same pest control methods.

Keywords: Underutilized; amaranth types; insect order; major common pests.

1. INTRODUCTION

The human population today derives most of its calories from a very narrow set of crops, with only about 30 species providing 95% of the global food energy [1,2]. Only three crops: wheat, rice and maize, covered 555 million ha or 40% of all arable land globally in 2011 [3,4] delivering more than 50% of human calorie intake [4,5,6]. On the contrary, over 7,000 species are known as edible and are either partly or fully domesticated, suggesting that a large share of potential food sources is underutilized [7, 8].

However, a focus purely on the productivity of current major crops, often selected and developed under high intensity agriculture, cannot meet the challenge of food insecurity and potentially makes agriculture even more vulnerable to future biotic and abiotic stresses.

The challenge of feeding the expected 9 billion world population by 2050 in a sustainable manner can be met, among other measures, by rescuing and using more diversity in agricultural and food production systems, both in terms of crop as in terms of varieties within any given crop [9,10]. An example of such underutilized crop requiring rescue is grain amaranth which is used traditionally for their food, fibre, fodder, oil or medicinal properties but its potential to contribute to food security, nutrition, health, income generation and environmental services is under-exploited.

In order to contribute to combating the challenge of food insecurity through biodiversity in agriculture National Horticultural Research Institute, Ibadan, Nigeria has introduced new accessions of grain amaranth from the North Central Regional Plant Introduction Station (NCRPIS) of the United States National Plant Germplasm System to the institute focusing on exploiting the potential of grain amaranth for wider adoption and commercial exploitation. However before these new accessions could be recommended for wider adoption and commercial exploitation it is important that the accessions be evaluated and selected for pest and disease infestation and yield performance especially with little or no information on the insect pests of grain amaranth and ornamental amaranth in Nigeria. This study therefore provides information on pests that fed differentially on every stage of the life cycle of grain, leafy and ornamental amaranth in Ibadan, Nigeria

2. MATERIALS AND METHODS

2.1 Planting materials and experimental sites

Ninety one accessions of grain amaranth comprising of 28 grain amaranth type (26 introduced and 2 indigenous accessions), 54 leafy amaranth type (2 introduced and 52 indigenous accessions) and 9 ornamental amaranth type (6 introduced and 3 indigenous accessions) were used in this experiment. The introduced accessions, for the first time came into Nigeria through North Central Regional Plant Introduction Station of the United States National Plant Germplasm System to National

Horticultural Research Institute, Ibadan, Nigeria, where the field experiments were carried out at the vegetable field of the Institute, (3º5´E, 7º3´N, 168m above sea level). Laboratory studies were carried out in the entomology laboratory of the institute during the rainy and dry seasons of 2008 – 2009.

2.2 Identification of Insects Associated with *Amaranthus* spp

Each accessions were established in sterilized sandy loam soil in nursery tray (38×38 cm) kept in a netted nursery house. Soil was moistened with water every 48 hrs. Pesticide and fertilizer were not applied. Seedlings were transplanted into the field 3 weeks after germination at a spacing of 50 cm within row and between rows. Plot size was 2×2 m with 1 m between plots. There were three replications laid out in a Randomized Complete Block Design. There was no pesticide treatment and the plots were weeded by hand when necessary. Production was under rainfed conditions during the rainy seasons, but irrigated twice weekly during the dry seasons. All the plants were observed daily commencing a week after transplanting with observations continuing through grain maturity in the morning between 7.00 am and 10.00 am when the insects were relatively inactive.

Insects were collected with sweep nets and aspirators. Adult insects collected were killed with cotton wool soaked in ethyl acetate in a kilner jar. Specimens were mounted, labelled and dried in an oven at 35ºC for 24 hrs and stored in insect boxes. Immature specimens found on the plants were reared to adults on the host plants in a cage (17cm x 17cm x 24cm height) with glass top and wire mesh sides. Identification of specimens was done at the insect museums of National Horticultural Research Institute, Ibadan, Department of Crop Protection and Environmental Biology, University of Ibadan and Department of Crop Protection, Institute for Agricultural Research, Ahmadu Bello University, Zaria. Frequency composition of the insects observed by order and family were calculated.

Five plants with holes on stems and/ or galled stem were uprooted and dissected. Each of the collected larvae was kept on soil in kilner jar that was mesh covered. Amaranth stem was cut and put in the jar as food for the larva and the soil was moistened with distilled water as necessary. Jars were observed daily for adult emergence and emerged adults were identified.

Species were indicated as major or minor pests. Major pests are those which always cause significant reduction in yield or quality of leaves, fruits or seeds while minor pests are those which although always present, cause less serious damage but which may under certain circumstances assume major significance [11].

3. RESULTS

The 91 accessions of underutilized amaranth studied comprised of 28 grain amaranth, 54 leafy amaranth and 9 ornamental amaranth, all from 7 species which includes *Amaranthus caudatus, A. cruentus, A. dubius, A. hybridus, A. hypochondriacus, A. viridis* and some hybrids (*Amaranthus* spp.) (Table 1). The indigenous leafy amaranth which had been widely cultivated in Nigeria throughout the year had the most insects (76) attack from 7 orders and 22 families and 17 predators from 4 orders (Coleoptera, Diptera, Hemiptera and Hymenoptera) and 4 families (Coccinelidae, Calliphoridae, Reduviidae and Ichneumonidae) preying or parasitizing on insects such as aphids, bugs, larvae and pupae of Coleoptera and Lepidoptera (Table 2 and 4). The insects attacked the leaf, stem and inflorescence of the plants (Tables 3). Species with different destructive stages such as adult, larva or nymph which caused appreciable damage to the leaf, stem or inflorescence were considered important and marked as major. There were 12 major pests from the families: Curculionidae, Coreidae, Pentatomidae and Pyralidae observed on all the 3 amaranth types planted. At the vegetative and pre-flowering stages, 55 different species of pests were recorded on the leaves but the 3 major leaf eating larvae that scrape the epidermal tissues of the leaves and webbed the leaves are the pyralid moths: *Hymenia recurvalis* Fabricius*, Psara bipunctalis* Fabricius and *Psara palpalis* Hampson. From vegetative stage to harvesting of inflorescence, 15 different species of pests were recorded on the stems but the 6 major stem borers which cause boring and galling of stem, branches and some time the leaf petioles are the curculionids: *Baris circumscutellata* Hustache, *Gasteroclisus rhomboidalis* Boheman, *Leucogrammus paykulli* Boheman, *Lixus camerunus* Kolbe*, Hypolixus nubilosus* Boheman and *Hadromerus sagittarius* Olivier. At the inflorescence stage 14 different species of pests were observed on the inflorescence but the 3 major bugs sucking the embryo of the grains were *Cletomorpha unifasciata* Blote and *Cletus*

fuscescens Walker of the family Coreidae and a pentatomid *Aspavia armigera* Fabricius.

The percentage occurrence of pests in their orders on the 3 amaranths types studied revealed that the coleopterans were the most abundant representing 40.30% on grain amaranth, 36.84% on leafy amaranth and 47.17% on ornamental amaranth, followed by the lepidopterans and hemipterans while the dermapteran, *Chelisoches flavipennis* Fabricius was only found on leafy amaranth. The curculionids were the most abundant coleopterans on grain, leafy and ornamental amaranth with 40.74%, 39.29% and 40.0% respectively followed by the lagriids and chrysomelids (Table 5). The most abundant lepidopterans found within the 3 amaranth types were the pyralids and noctuids while the hemipterans were mainly the pentatomid bugs and coreids (Table 5).

Among the predators and parasitoids collected on the 3 amaranth types, the Reduviidae belonging to the heteropterans were the most abundant. The hymenopteran parasitoids collected were all ichneumonids. The only coleopteran and dipteran natural enemies collected were *Cheilomenes lunata lunata* Fabricius and *Stomorhina apta* Curran respectively (Tables 4 and 5)

Table 1. Amaranth type, species and number of accessions planted

Amaranth type	*Amaranthus* species	No of accessions introduced	No of accessions repatriated
Grain	*Amaranthus caudatus*	4	0
	Amaranthus cruentus	6	2
	Amaranthus hybrid	6	1
	Amaranthus hypochondriacus	8	1
	Sub-total	26	2
Leafy	*Amaranthus cruentus*	2	44
	Amaranthus dubius	0	4
	Amaranthus hypochondriacus	0	1
	Amaranthus viridis	0	3
	Sub-total	2	52
Ornamental	*Amaranthus cruentus*	1	0
	Amaranthus hybrid	1	3
	Amaranthus hybridus	1	0
	Amaranthus hypochondriacus	3	0
	Sub-total	6	3
	Total	34	57

Table 2. Number of insects and predators, order and family found on the amaranth types planted

Amaranth type	**No of insect**	**Order**	**Family**
Grain amaranth	67b	7a	18a
Leafy amaranth	76c	7a	22b
Ornamental amaranth	53a	6a	17a
	No of predator	**Order**	**Family**
Grain amaranth	17a	3ab	3ab
Leafy amaranth	17a	4b	4b
Ornamental amaranth	14b	2a	2a

Means in the same column followed by the same letters are not significantly different (P = .05; SNK)

Table 3. List of insects observed on the amaranth types planted

Order	Family	Species	Pest tatus	Plant part attacked	Stage causing damaging
Coleoptera	Carabidae	*Calleida fasciata* Dejean **	Minor	Leaf	Adult
Coleoptera	Carabidae	*Paussus cilipes* Westwood ***	Minor	Leaf	Adult
Coleoptera	Chrysomelidae	*Asbecesta cyanipennis cyanipennis* Harold	Minor	Leaf	Adult
Coleoptera	Chrysomelidae	*Buphonella agittar* Jacoby *	Minor	Leaf	Adult
Coleoptera	Chrysomelidae	*Eryxia holosericea* Klug *	Minor	Leaf	Adult
Coleoptera	Chrysomelidae	*Lema rubicollis* Klug	Minor	Leaf	Adult
Coleoptera	Chrysomelidae	*Podagrica sjostedti* Jacoby ***	Minor	Leaf	Adult
Coleoptera	Chrysomelidae	*Podagrica uniforma* Jacoby ***	Minor	Leaf	Adult
Coleoptera	Curculionidae	*Alcidodes guessfeldi* Kolbe	Minor	Stem	Adult
Coleoptera	Curculionidae	*Araecerus fasciculatus* Deg ***	Minor	Stem	Adult
Coleoptera	Curculionidae	*Baris circumscutellata* Hustache	Major	Stem	Larva and Adult
Coleoptera	Curculionidae	*Gasteroclisus rhomboidalis* Boheman	Major	Stem	Larva and Adult
Coleoptera	Curculionidae	*Hadromerus sagittarius* Olivier	Major	Stem	Larva and Adult
Coleoptera	Curculionidae	*Hypolixus nubilosus* Boheman	Major	Stem	Larva and Adult
Coleoptera	Curculionidae	*Leucogrammus paykulli* Boheman	Major	Stem	Larva and Adult
Coleoptera	Curculionidae	*Lixus camerunus* Kolbe	Major	Stem	Larva and Adult
Coleoptera	Curculionidae	*Mitophorus acerbus* Faust	Minor	Stem	Adult
Coleoptera	Curculionidae	*Omotrachelus spp*	Minor	Stem	Adult
Coleoptera	Curculionidae	*Tetragonothorax retusus* Faust	Minor	Stem	Adult
Coleoptera	Elateridae	*Cardiophorus phaeopterus* Candeze *, **	Minor	Leaf	Adult
Coleoptera	Lagriidae	*Chrysolagria cuprina* Thomson	Minor	Leaf	Adult
Coleoptera	Lagriidae	*Chrysolagria nairobana* Borchmann	Minor	Leaf	Adult
Coleoptera	Lagriidae	*Derolagria dermatodes* Fairm	Minor	Leaf	Adult
Coleoptera	Lagriidae	*Lagria* spp	Minor	Leaf	Adult
Coleoptera	Lagriidae	*Lagria villosa* Fabricius	Minor	Leaf	Adult
Coleoptera	Lycidae	*Lycus nr. Foliaceus* Dalman***	Minor	Leaf	Adult
Coleptera	Lycidae	*Lycus semiamplexus* Murray ***	Minor	Leaf	Adult
Coleoptera	Scarabaeidae	*Leucocelis* spp *	Minor	Stem	Adult
Coleoptera	Tenebrionidae	*Alogista serricorne* Kolbe	Minor	Stem	Adult
Coleoptera	Tenebrionidae	*Gonocephalum simplex* Fabricius	Minor	Stem	Adult
Coleoptera	Tenebrionidae	*Opatrinus ovalis* Mols & Roy **	Minor	Stem	Adult
Dermaptera	Chelisochidae	*Chelisoches flavipennis* Fabricius **, ***	Minor	Leaf	Adult
Dictyoptera	Blattellidae	*Blattella loviventris* Saussure ***	Minor	Inflorescence	Adult

Order	Family	Species	Pest tatus	Plant part attacked	Stage causing damaging
Dictyoptera	Blattellidae	*Theganopteryx aethiopica* Saussure *, ***	Minor	Inflorescence	Adult
Dictyoptera	Perisphaeridae	*Gyna spp* **	Minor	Inflorescence	Adult
Hemiptera	Coreidae	*Cletomorpha unifasciata* Blote	Major	Inflorescence	Nymph and Adult
Hemiptera	Coreidae	*Cletus fuscescens* Walker	Major	Inflorescence	Nymph and Adult
Hemiptera	Coreidae	*Psilocoris spp*	Minor	Leaf	Adult
Hemiptera	Lygaeidae	*Stilbocoris natalensis* Distant ***	Minor	Leaf	Adult
Hemiptera	Pentatomidae	*Acrosternum acutum* Dall.	Minor	Inflorescence	Adult
Hemiptera	Pentatomidae	*Acrosternum pallidoconspersum* Stal *	Minor	Inflorescence	Adult
Hemiptera	Pentatomidae	*Aspavia armigera* Fabricius	Major	Inflorescence	Adult
Hemiptera	Pentatomidae	*Aspavia hastator* Fabricius	Minor	Inflorescence	Adult
Hemiptera	Pentatomidae	*Halyomorpha annulicornis* Sign ***	Minor	Inflorescence	Adult
Hemiptera	Pentatomidae	*Macrorhaphis acuta* Dall.	Minor	Inflorescence	Adult
Hemiptera	Pentatomidae	*Nezara viridula* Linnaeus	Minor	Inflorescence	Adult
Hemiptera	Plataspidae	*Brachyplatys* spp **, ***	Minor	Leaf	Adult
Hemiptera	Pyrrhocoridae	*Dysdercus superstitiosus* Fabricius *, ***	Minor	Inflorescence	Adult
Homoptera	Cercopidae	*Locris Maculata maculate* Fabricius	Minor	Leaf	Nymph
Homoptera	Cercopidae	*Poophilus adustus* Walker	Minor	Leaf	Nymph
Homoptera	Cercopidae	*Ptyelus flavescens* Fabricius ***	Minor	Leaf	Nymph
Homoptera	Cercopidae	*Ptyelus grossus grossus* Fabricius **, ***	Minor	Leaf	Nymph
Homoptera	Dictyopharidae	*Centromeriana* spp **	Minor	Leaf	Adult
Homoptera	Flatidae	*Phromnia limbata* Fabricius **, ***	Minor	Leaf	Adult
Lepidoptera	Arctidae	*Chionaema* spp ***	Minor	Leaf	Larva
Lepidoptera	Lymantridae	*Euproctis fasciata* Walker **	Minor	Leaf	Larva
Lepidoptera	Noctuidae	*Amyna punctum* Fabricius **, ***	Minor	Leaf	Larva
Lepidoptera	Noctuidae	*Cyligramma magus* Guenee ***	Minor	Leaf	Larva
Lepidoptera	Noctuidae	*Oraesia emarginata* Fabricius ***	Minor	Leaf	Larva
Lepidoptera	Noctuidae	*Plusia indicator* Walker	Minor	Leaf	Larva
Lepidoptera	Noctuidae	*Plusia microstigma* Hampson ***	Minor	Leaf	Larva
Lepidoptera	Noctuidae	*Spodoptera littoralis* Boisduval	Minor	Leaf	Larva
Lepidoptera	Noctuidae	*Strigicincta concinnula* Mabille ***	Minor	Leaf	Larva
Lepidoptera	Nymphalidae	*Acraea terpsichore* Linnaeus	Minor	Leaf	Larva
Lepidoptera	Nymphalidae	*Precis sophia* Fabricius ***	Minor	Leaf	Larva
Lepidoptera	Pyralidae	*Bocchoris onychinalis* Guenee *, ***	Minor	Leaf	Larva
Lepidoptera	Pyralidae	*Diaphana stolalis* Guenee ***	Minor	Leaf	Larva
Lepidoptera	Pyralidae	*Eldana saccharina* Walker	Minor	Leaf	Larva

Order	Family	Species	Pest tatus	Plant part attacked	Stage causing damaging
Lepidoptera	Pyralidae	*Epipages cancellalis* Zeller	Minor	Leaf	Larva
Lepidoptera	Pyralidae	*Hymenia recurvalis* Fabricius	Major	Leaf	Larva
Lepidoptera	Pyralidae	*Margaronia indicator* Saunder ***	Minor	Leaf	Larva
Lepidoptera	Pyralidae	*Margaronia sericea* Drury **, ***	Minor	Leaf	Larva
Lepidoptera	Pyralidae	*Maruca vittrata* Geyer	Minor	Leaf	Larva
Lepidoptera	Pyralidae	*Pardomima phaleromima* Meyrick **	Minor	Leaf	Larva
Lepidoptera	Pyralidae	*Psara bipunctalis* Fabricius	Major	Leaf	Larva
Lepidoptera	Pyralidae	*Psara palpalis* Hampson	Major	Leaf	Larva
Lepidoptera	Pyralidae	*Sylepta balteata* Fabricius	Minor	Leaf	Larva
Lepidoptera	Pyralidae	*Syngamia abruptalis* Walker	Minor	Leaf	Larva
Lepidoptera	Pyralidae	*Syngamia floridalis* Zeller **, ***	Minor	Leaf	Larva
Orthoptera	Acrididae	*Catantops spissus* Walker *	Minor	Leaf	Adult
Orthoptera	Acrididae	*Cyrtacanthacris aeruginosa unicolor* Uvarov ***	Minor	Leaf	Adult
Orthoptera	Acrididae	*Stenocrobylus festivus* Karsch **	Minor	Leaf	Adult
Orthoptera	Acrididae	*Zonocerus variegates* Linnaeus	Minor	Leaf	Adult and Nymph

**Insect not found on leafy amaranth*
***Insect not found on grain amaranth*
****Insect not found on ornamental amaranth*

Table 4. List of predators observed on *Amaranthus* spp

Order	Family	Species	Pest attacked
Coleoptera	Coccinellidae	*Cheilomenes lunata lunata* Fabricius **, ***	Aphids predator
Diptera	Calliphoridae	*Stomorhina apta* Curran ***	Other insects
Heteroptera	Reduviidae	*Rhynocoris bicolor* Fabricius	Bugs predator
Heteroptera	Reduviidae	*Rhynocoris albopilosus* Sign	Bugs predator
Heteroptera	Reduviidae	*Rhynocoris Carmelita* Stal	Bugs predator
Heteroptera	Reduviidae	*Rhynocoris rapax* Stal	Bugs predator
Heteroptera	Reduviidae	*Rhynocoris tropicus* Herrich-Schaffer	Bugs predator
Heteroptera	Reduviidae	*Hediocoris tibialis* Stal	Bugs predator
Heteroptera	Reduviidae	*Peirates* spp	Bugs predator
Heteroptera	Reduviidae	*Cosmolestes pictus* Klug	Bugs predator
Heteroptera	Reduviidae	*Pisilus tipuliformis* Fabricius	Bugs predator
Heteroptera	Reduviidae	*Vestula lineaticeps* Sign ***	Bugs predator
Heteroptera	Reduviidae	*Nagusta* spp	Bugs predator
Heteroptera	Reduviidae	*Harpagocoris katangae* Schouteden *	Bugs predator
Hymenoptera	Ichneumonidae	*Phorotrophus* spp ***	Parasitoid of coleopteran larvae
Hymenoptera	Ichneumonidae	*Phorotrophus mameti* Benoit	Parasitoid of coleopteran larvae
Hymenoptera	Ichneumonidae	*Larpelites* spp	Parasitoid of larva and pupa of coleoptera and lepidoptera
Hymenoptera	Ichneumonidae	*Charops* spp	Parasitoid of *Acraea terpsichore* Linnaeus larva

**Predator not found on leafy amaranth*
***Predator not found on grain amaranth*
****Predator not found on ornamental amaranth*

Table 5. Percent composition of insect observed on *Amaranthus* spp. by order and family

Order	Members of order in total observation (%)			Family	Members of family within an order (%)		
	Grain amaranth	Leafy amaranth	Ornamental amaranth		Grain amaranth	Leafy amaranth	Ornamental amaranth
Coleoptera	40.30	36.84	47.17	Carabidae	3.70	7.14	4.00
				Chrysomelidae	18.52	17.86	16.00
				Curculionidae	40.74	39.29	40.00
				Elateridae	0	0	4.00
				Lagriidae	18.52	17.86	20.00
				Lycidae	7.41	7.14	0
				Scarabaeidae	3.70	0	4.00
				Tenebrionidae	7.41	10.71	12.00
Dermaptera	0	1.32	0	Chelisochidae	0	100	0
Dictyoptera	2.99	2.64	1.89	Blattellidae	100	66.67	0
				Perisphaeridae	0	33.33	100
Hemiptera	17.91	14.47	16.98	Coreidae	25	27.27	33.33
				Lygaeidae	8.33	9.09	0
				Pentatomidae	58.33	54.55	66.67
				Plataspidae	0	9.09	0
				Pyrrhocoridae	8.33	0	0
Homoptera	4.48	7.89	5.66	Cercopidae	100	66.67	66.67
				Dictyopharidae	0	16.67	33.33
				Flatidae	0	16.67	0
Lepidoptera	29.85	31.58	22.64	Arctidae	5	4.17	0
				Lymantridae	0	4.17	8.33
				Noctuidae	30	29.17	16.66
				Nymphalidae	10	8.34	8.33
				Pyralidae	55	54.17	66.67
Orthoptera	4.48	3.95	5.66	Acrididae	100	100	100
Predator							
Coleoptera	0	5.88	0	Coccinelidae	0	100	0
Diptera	5.88	5.88	0	Calliphoridae	100	100	0
Heteroptera	64.71	70.59	78.57	Reduvidae	100	100	100
Hymenoptera	23.53	23.53	21.43	Ichneumonidae	100	100	100

4. DISCUSSION

The increase in the diversity of insect pests associated with indigenous leafy amaranths more than those of the underutilized grain and ornamental amaranths which majority were just introduced into the Country for the first time could be that the insects have adapted to the leafy amaranths due to its readily availability all through the seasons as a result of continuous production over the years. The coleopterans were generally the most abundant leaf and stem feeders of *Amaranthus* spp. The adults of the 6 major curculionids bored leaf petioles, stem and inflorescence while their larvae galled stem and predisposed the plant to leaf wilting, death of branches, lodging of stem and entrance for secondary fungal attack and or death of plant. The adult amaranth weevil feeds on leaves, but the larval stage is more damaging because they bore into the central tissue of roots and occasionally stems, causing rotting and potentially lodging [12]. Banjo [13] reported that dissection of *A. cruentus* (L.) stems revealed that developing larvae of *Gasteroclisus rhomboidalis* Boh. usually mine upwards and downwards within the pith of the stem thus leaving all discarded materials as scum at both ends of the larval chamber. Although the lagrids and chrysomelids were more abundant on the 3 amaranth types there were minor leaf eaters. The two coreid bugs: *Cletomorpha unifasciata Blote* and *Cletus fuscescens Walker* and a pentatomid bug: *Aspavia armigera* Fabricius were the major pests that fed on the inflorescence by sucking the embryo of the grain thereby causing reduction in seed viability. They were also listed by Akinlosotu [14] as major leaf and seed feeders of *Amaranthus hybridus* (L.) and *Amaranthus viridis* (L.). Oke and Ofuya [15] reported that *C. fuscescens* population fluctuated relative to over-all phenological stage of grain amaranth with the peak of its population coinciding with the milky seed stage of grain amaranth. Putnam et al. [12] reported that the insect most likely to affect yields in Minnesota, USA, is the tarnished plant bug: *Lygus* spp a sucking insect which often reaches high populations in the seed head during the critical seed filling stage. Olson and Wilson [16] reported that damage to grain amaranth occurs when the tarnished plant bug feeds on the meristematic tissue, developing floral buds, immature blossoms and the developing embryos. Feeding by the tarnished plant bug results in localized wilting and tissue necrosis, abscission of fruiting forms, morphological deformation of fruits and seed and altered vegetative growth [17]. Kauffman and Reider [18] noted that tarnished plant bug severely decreased grain amaranth yields in Pennsylvania, USA by piercing the immature seeds and sucking out the juices. Igbinosa et al. [19] reported that in addition to sucking juice from the rice plant, pentatomid and mirid bugs inject toxic substances into the plant that cause necrosis and may lead to secondary fungal attack. The three major pyralids encountered: *Hymenia recurvalis* Fabricius, *Psara bipunctalis* Fabricius and *Psara palpalis* Hampson, scraped the epidermal tissues of leaves and webbing of leaves causing reduction in the marketability of the leaves.

The reduviids which were the most predominant predators were found preying on other insects especially the heteropteran bugs. This is in agreement with the report of Alam [20] that assassin bugs (Reduviidae) suck the blood of other insects or animals of a wide range of groups, and are important as part of the total mortality factors acting on the phytophagous insects.

5. CONCLUSION

This study has revealed that common insect pests fed differentially on the developmental stages of grain, leafy and ornamental amaranth. This therefore indicates that the introduced underutilized grain amaranths accessions especially could be cultivated alongside the indigenous leafy amaranth with the application of the same pest control methods.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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