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Diversity, relative abundance and temporal spread of insects associated with Roselle (*Hibiscus sabdariffa* L.) at Makurdi, Nigeria

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ABSTRACT

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Roselle, *Hibiscus sabdariffa* L., is cultivated extensively for food and income generation in Africa, but research on biotic constraints to its production has been scanty. A 48-plot (5m×5m wide each) field experiment laid in randomized complete block design was used to document the relative abundance (% RA), diversity, richness, and temporal spread of insect species infesting the crop at Makurdi, Nigeria. The insects were collected from all parts of early- and late-sown green-calyx (*H. sabdariffa* var. *sabdariffa*) and red-calyx (*H. sabdariffa* var. *altissima*) Roselle shoots. About 101 species (81 herbivores, 18 predators, 1 parasitoid, and 1 pollinator) in 45 families and 8 orders were collected. Shannon's diversity index (2.1-2.4) and Margalef's richness index (8.3-10.0) indicate a rich diversity of species on the crop. However, evenness of species, measured by Buzas and Gibson's index, was low (0.1-0.41). The orders Coleoptera and Hemiptera accounted for 72.0% of the collection. Nineteen species were moderately (≥1 RA<5%) to highly abundant (RA≥10%) on the crop and among them *Monolepta thompsoni* Allard and *Nisotra sjostedti* Jac. were ubiquitous causing extensive leaf perforation all through the entire crop growth period. At the reproductive stage of growth, *Dysdercus volkeri* Fab., *Oxycarenus hyalinipennis* Costa and *Earias* sp. were the dominant insects causing fruit and seed damage. The frequency of occurrence and densities of *M. thompsoni* Allard, *N. sjostedti* Jac., *D. volkeri* Fab., *O. hyalinipennis* Costa and *Earias* sp. as well as their extensive damage, indicate that they are the key field pests of Roselle at Makurdi.

Keywords: Roselle, Insect species, Green-calyx, Red-calyx, Diversity, Richness, Temporal spread

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INTRODUCTION

Roselle (*Hibiscus sabdariffa* L.) is a multipurpose vegetable crop in the family Malvaceae. The leaves, calyces, seeds, and seed oil are regularly used as food, food condiment and colorant; as phytomedicine for treatment of diverse ailments; or as raw materials in pharmaceutical, cosmetic and paint industries (Alarcon-Aguilar et al 2007, El-Sheri and Sarwal 2007, Halimatul et al 2007, Alarcon-Alonso et al 2012, Ansari et al 2013, Olaniran et al 2013). Its cut flowers and decorative red stalks and fruits are thriving export commodities (Alegbejo et al 2003, Grubben et al 2004). A variety (*H. sabdariffa var. altissima*) is an important fibre crop serving as a substitute to jute in paper industry (McClintock and Tahir 2004).

The crop is herbaceous, dicotyledonous, woody-based subshrub, annual/ biennial in nature, and widely adapted to a variety of tropical and sub-tropical climatic conditions (El Naim et al 2012, Kone et al 2018). It is believed to be native to Africa (Boulanger et al 1984, Gomez-Leyva et al 2008, Ankrah et al 2018). According to Sameer and Ali (2018), roselle plant could grow as tall as 2-2.5m with three- to five-lobed leaves of about 8-15cm length arranged alternately on the stems. The flowers could be yellow or red of about 8-10cm in diameter having a stout fleshy calyx (1-2cm wide) at the base and could enlarge to 3-3.5cm as the fruit matures. *H. sabdariffa* var. *sabdariffa* and *H. sabdariffa* var. *altissima* are the two major types of Roselle cultivated in Africa (Ankrah et al 2018). In Nigeria, the cultivation of Roselle straddles the diverse agro-ecological zones, and it is largely peasantry, polycultural, and purposively for food and income generation.

In spite of the crop's economic prospect, research on the biotic and environmental constraints to its production is limited. Insect pest infestation and damage have been identified as one of the major factors militating against the cultivation of roselle (Olaniran et al 2013). At different phenological stages, the plant is reported to be attacked by insect pests, and their dominance per plant in relation to other arthropods could be as high as 82.44% (Olaniran et al 2013, Abdel-Moniem and Abd El-Wahab 2006). According to Simon et al (2018) the impact of insect pest infestation at vegetative and reproductive growth stages of Roselle could result in about 87.5% reduction in fresh calyx yield of the crop if synthetic control measures are not employed. Fasunwon and Banjo (2010) also identified *Podagrica* species as an important insect pest attacking both lamina of the foliage and matured leaves of the crop family. The insect was also implicated in the transmission of mosaic virus resulting in 20-50% yield reduction (Fajinmi and Fajinmi 2006). Roselle serves as habitat, oviposition or feeding site for different insect species on it; species richness and diversity and the pest status of the insects infesting the crop vary from one location to another. Documentations of insects associated with the crop in Nigeria are decades old (Daramola 1984, Dike 1992) and they emanated from a limited production area.

For the purpose of pest management, detection of new insect species, determination of the rate of species extinction and anthropogenic alteration of natural habitats, it is important to know the insect species, their relative abundance, diversity and richness on cultivated Roselle in a particular agroecology (Sisk et al 1994, Mirab-balou et al 2017). These insect-related variables were assessed in this pioneering study at Makurdi, Benue State, in the Nigerian Southern Guinea savanna using green- and red-calyx Roselle crops.

MATERIALS AND METHODS

A 48-plot field experiment laid in randomized complete block design at the Agronomy Research Farm of Federal University of Agriculture, Makurdi (Latitude 07°45'-07°50'N, Longitude 08°45'-08°50'E) was used for enumeration and collection of insects on green-calyx (*H. sabdariffa* var. *altissima*) and red-calyx (*H. sabdariffa* var. sabdariffa) Roselle planted early (June–September) and late (August–December) in 2016 cropping season. Each plot was 5m long and 5m wide; adjacent plots and replications were separated by 1m and 2m furrow, respectively. Plant stands were made comparable by thinning and replacing missing stands. Weeds were controlled manually and 100kg of NPK (15-15-15) fertilizer was applied. Rainfall (cm) and Temperature (°C) data were obtained from NIMET (Nigerian Meteorological Agency) substation at the Tactical Air Command, Nigerian Air Force, Makurdi, Nigeria.

Weekly visual enumerations of insects were made between 0700 and 1000 hours on plants enclosed by 1m×1m quadrat in rows 2 and 4 of each plot from 3 weeks after planting (WAP) to harvest (15WAP); the parts of the plant infested was noted before the insects were collected. The insects were killed in acetate jar and taken to the laboratory for sorting. At 50% flowering and 50% podding, five flowers and five pods were picked at random in rows 2 and 4 of each plot and opened to document number and species of insects found. Immature stages collected were reared to adult on appropriate food resource. Adult insects were identified at the Insect Museum of Ahmadu Bello University, Zaria, Nigeria.

The relative abundance of each species of insect was computed as:

$$RA\,(\%) = Ni/N \times 100/1$$

Where: Ni=Number of individuals of a given species, and N=Total number of individuals of all species.

The species were categorized as:

Highly abundant	$Ar \geq 10\%$
Abundant	$\geq 5\% Ar < 10\%$
Moderately abundant	$\geq 1\%$ Ar $< 5\%$, and
Scarce	Ar<1% (Zaime and Gautier 1989).

The frequency of occurrence of the insect species was computed as:

$$C = Pi/P \times 100/1$$

Where: Pi=Number of occurrence of a particular species, and P=Total number of insects.

The species were classified as:

Ubiquist C	100%
Constant	$50\% \geq C < 100\%$
Common	$25\% \geq C < 50\%$
By-catch	$5\% \geq C < 25\%$
Rare	C<5% (Dajoz 2000).

Species diversity was determined using Shannon's index:

$$H'=\Sigma^{s}_{i=1}n_i/N x \ln n_i/N$$

Where: n_i=Number of individuals of the i^{th} species in the sample; N=Total number of all individuals in the assemblage; S=Number of species in the assemblage.

Species richness was determined using Margalef's index:

$$R=(S-1)/\ln(n)$$

Where: S=Number of species; n=Number of individuals; ln=Natural logarithm

Buzas and Gibson's Evenness:

$$(E)=e^{H}/S$$

Where: e=Natural logarithm base; H'=Shannon index; S=Number of species was used to determine species evenness. All indices were calculated using version 2.12 of the Paleontological Statistics Tool (Hammer et al 2001).

RESULTS

Of the 15,930 and 7,427 insects collected from the early and late crops, respectively, 102 species belong to 45 families and 8 orders were identified. Collection from the green-type (13,376) exceeded that from the red-type Roselle by 3,395 insects. Eighty-one (81) of the species were phytophagous (Table 1) and 20 species were beneficial insects (Table 2). Coleopterous (especially Chrysomelidae and Lagriidae) and hemipterous (especially Pyrrhocoridae) insects constituted a high proportion (72.0%) of the collections (Figure 1). Five species (*Monolepta thompsoni* Allard, *Nisotra sjostedti* Jac., *Lagria villosa* F., *Oxycarenus hyalinipennis* Costa and *Dysdercus volkeri* F.) were highly abundant; three species (*Asbecesta cyanipennis* Har., *Carpophilus fumatus* Boh., and *Earias* sp.) were abundant. Meanwhile, eleven species (*Monolepta goldingi* Bryant, *Trichispa sericea* Guérin-Méneville, 1844, *Bemisia tabaci* Genn., *Aphis gossypii* Glover, *Empoasca* sp., *Acrida bicolor* Thunb., *Aiolopus thalassinus* Fab., *Polistes spilophorus* Schlett, *Cheilomenes sulphurea* Oliv., *Exochomus flavipes* Thunb. and *Pheidole* sp.) were moderately abundant. Among the three categories of abundant species, *M. thompsoni*, and *N. sjostedti,* were largely ubiquists (having 100% occurrence), while the other insect species with frequency of occurrence ranging from >50% to <100% were categorized as constant species. Table 3 shows a rich diversity of insects associated with Roselle at Makurdi going by Margalef's and Shannon's indices, respectively; however, Buzas and Gibson's evenness index was low indicating that only a few species dominated the ecosystem. Insect diversity and richness tended to be more on the green-calyx Roselle than on the red-calyx, and more in the early- than in the late-sown crops.

Table 1. Insect pests associated with early- and late-sown Roselle at Makurdi in 2016 cropping season

Order	Family	Species	Relative abundance (%)			
			Early-sown		Late-sown	
			Green-calyx	Red-calyx	Green-calyx	Red-calyx
Coleoptera	Anthribidae	*Araecerus* sp.	0.11	0.00	0.00	0.00
	Aphodiidae	*Rhyssemus carinatipennis* Per.	0.02	0.03	0.07	0.06
	Buprestidae	*Sternocera* sp.	0.70	0.47	0.23	0.13
		Sphenoptera sp.	0.00	0.00	0.05	0.06
	Carabidae	*Drypta ruficollis* Dej.	0.01	0.03	0.00	0.00
	Chrysomelidae	*Asbecesta cyanipennis* Har.	3.90	3.32	0.39	0.71
		A. transversa Allard	0.15	0.23	0.16	0.13
		Aspidomorpha quinquefasciata Fab.	0.02	0.03	0.00	0.00
		Aulacophora africana Weise	0.07	0.12	0.12	0.16
		Lema sp.	0.28	0.01	0.07	0.03
		Luperodes quaternus Fairm	0.00	0.03	0.12	0.00
		Monolepta goldingi Bryant	1.66	1.54	0.19	0.13
		M. nigeriae Bryant	0.71	0.68	0.12	0.13
		M. thompsoni Allard	27.52	27.84	17.68	20.19
		Nisotra sjostedti Jac.	23.77	24.95	14.60	13.68
		Trichispa sericea Guer.	0.99	0.96	0.81	1.09
	Coccinellidae	*Epilachna chrysomelina* Fab.	0.00	0.00	0.05	0.00
		E. hirta Thunb.	0.00	0.00	0.00	0.03
		E. similis Thunb.	0.21	0.38	0.02	0.00
	Curculionidae	*Alcidodes arcuatus* Boh.	0.00	0.01	0.00	0.00
		A. senex Sahl.	0.41	0.22	0.21	0.23
		Apion sp.	0.07	0.03	0.00	0.00
		Baris sp.	0.06	0.04	0.00	0.00
		Cylas puncticollis Boh.	0.03	0.04	0.00	0.03
		Diacoderus sp.	0.13	0.09	0.00	0.00
		Siderodactylus sagittarius Sch.	0.15	0.06	0.46	0.74
	Elateridae	*Cardiophorus hoploderus* Cand.	0.01	0.03	0.21	0.13
	Hydrophilidae	*Allocotocerus* sp.	0.08	0.01	0.00	0.00
	Lagriidae	*Lagria villosa* Fab.	11.41	11.01	0.46	0.19
	Meloidae	*Coryna* sp.	0.00	0.01	0.00	0.00
		Mylabris vestita Reiche.	0.01	0.03	0.74	0.87
	Nitidulidae.	*Carpophilus fumatus* Boh.	4.27	2.72	0.02	0.06
	Scarabaeidae	*Pachnoda* sp.	0.13	0.19	0.02	0.03
Dermaptera	Forficulidae	*Diaperasticus erythrocephalus* Oliv.	0.01	0.00	0.35	0.16
Hemiptera	Aleyrodidea	*Bemisia tabaci* Genn.	0.65	1.08	0.07	0.10
	Alydidae	*Stenocoris elegans* Blote.	0.18	0.12	0.07	0.26
		Tenosius sp.	0.01	0.00	0.00	0.00
	Aphididae	*Aphis gossypii* Glover	0.33	0.29	0.60	1.38
		Myzus persicae Sulz.	0.34	0.55	0.00	0.03
	Cicadellidae	*Empoasca* sp.	1.08	1.37	0.23	0.23
	Coreidae	*Anoplocnemis curvipes* Fab.	0.02	0.04	0.35	0.06

Table 1 continued

Order	Family	Species	Relative Abundance (%)			
			Early-sown		Late-sown	
			Green-calyx	Red-calyx	Green-calyx	Red-calyx
Hemiptera	Coreidae	*Clavigralla tomentosicollis* Stal.	0.22	0.00	0.00	0.00
		Cletus sp.	0.00	0.00	0.00	0.10
		C. albopunctatus Villier.	0.01	0.00	0.07	0.03
		C. notatus Thunb.	0.04	0.06	0.05	0.13
		Mirperus jaculus Thunb	0.01	0.00	0.05	0.71
	Lygaeidae	*Lygaeus rivularis* Germ.	0.07	0.09	0.00	0.00
		Oxycarenus hyalinipennis Costa	0.19	0.22	23.14	9.66
	Machaerotidae	*Enderleinia bispina* Schmidt	0.06	0.06	0.00	0.00
	Miridae	*Eurystylus* sp.	0.00	0.00	0.23	0.10
		Megacoelum scutellare Popp.	0.03	0.00	0.02	0.03
	Pentatomidae	*Agonoscelis* sp.	0.03	0.00	0.00	0.00
		A. erosa Westw.	0.00	0.01	0.00	0.00
		A. versicolor Fab.	0.02	0.03	0.00	0.00
		Aspavia hastator Fab.	0.02	0.03	0.00	0.00
		A. armigera Fab.	0.01	0.00	0.02	0.00
		Carbula pedalis Berg.	0.11	0.01	0.02	0.03
		Nezara viridula Linn.	0.02	0.01	0.05	0.00
	Pseudococcidae	*Planococcoides* sp.	0.02	0.01	0.00	0.00
		Pseudococcus sp.	0.00	0.00	0.05	0.00
	Pyrrhocoridae	*Dysdercus volkeri* Fab.	14.63	15.07	27.77	35.74
		Scantius clavimanus Fab.	0.02	0.00	0.07	0.06
	Scutelleridae	*Hotea* sp.	0.03	0.03	0.00	0.00
Lepidoptera	Arctiidae	*Diacrisia* sp.	0.00	0.00	0.02	0.00
		Metarctia sp.	0.03	0.01	0.00	0.00
	Crambidae	*Cirrhochrista* sp.	0.02	0.01	0.00	0.00
		Palpita sp.	0.01	0.00	0.00	0.00
		Papyda sp.	0.01	0.00	0.00	0.00
	Erebidae	*Euproctis* sp.	0.00	0.00	0.25	0.26
	Nolidae	*Earias* sp.	0.17	0.13	4.63	5.96
		Hypodeva barbata Holland	0.00	0.00	0.05	0.06
		Negeta sp.	0.00	0.00	0.02	0.00
		Westermannia sp.	0.00	0.00	0.02	0.00
		W. agrapha Hamps.	0.00	0.00	0.02	0.00
	Nymphalidae	*Precis orythya* Linn.	0.00	0.00	0.46	0.00
		P. sophia Fab.	0.00	0.00	0.00	0.48
Orthoptera	Acrididae	*Acrida bicolor* Thunb.	0.43	0.67	0.12	0.16
		Aiolopus thalassinus Fab.	0.74	0.80	0.30	0.61
	Pyrgomorphidae	*Zonocerus variegatus* Linn.	0.02	0.01	0.00	0.10
	Tettigoniidae	*Phaneroptera* sp.	0.04	0.04	0.37	0.35

Table 2. Beneficial insects associated with early- and late-sown Roselle at Makurdi in 2016 cropping season

Order	Family	Species	Nature of Insect	Relative Abundance (%)			
				Early-sown		Late-sown	
				Green-calyx	Red-calyx	Green-calyx	Red-calyx
Coleoptera	Carabidae	*Orthogonius* sp.	Predator	0.03	0.03	0.00	0.00
	Coccinellidae	*Cheilomenes sulphurea* Oliv.	Predator	0.49	0.45	0.58	0.55
		C. vicina Muls.	Predator	0.10	0.12	0.00	0.00
		Chilocorini sp.	Predator	0.04	0.09	0.00	0.13
		Exochomus flavipes Thunb.	Predator	0.49	0.51	0.14	0.06
	Staphylinidae.	*Paederus sabaeus* Er.	Predator	0.01	0.00	0.00	0.00
	Tenebrionidae	*Eutochia pulla* Er.	Predator	0.02	0.00	0.02	0.03
Hemiptera	Pentatomidae	*Macrorhaphis* sp.	Predator	0.01	0.03	0.00	0.00
	Reduviidae	*Cosmolestes* sp.	Predator	0.00	0.00	0.00	0.06
		Peprius nodulipes Signoret	Predator	0.04	0.01	0.00	0.03
		Rhynocoris sp.	Predator	0.01	0.01	0.02	0.03
		Tinna sp.	Predator	0.00	0.00	0.00	0.10
Hymenoptera	Apidae	*Eucera* sp.	Pollinator	0.00	0.01	0.07	0.00
	Braconidae	*Iphiaulax* sp.	Parasitoid	0.29	0.25	0.19	0.42
	Formicidae	*Camponotus sericeus* Fab.	Predator	0.17	0.17	0.62	1.00
		Pheidole sp.	Predator	0.36	0.36	0.16	0.42
	Vespidae	*Polistes spilophorus* Schlett.	Predator	1.00	1.57	1.30	0.64
Mantodea	Mantidae	*Sphodromantis* sp.	Predator	0.01	0.04	0.00	0.00
	Hymenopodidae	*Pseudoharpax virescens* Serv.	Predator	0.28	0.33	0.19	0.13
Odonata	Libellulidae	*Pantala flavescens* Fab.	Predator	0.00	0.00	0.12	0.19

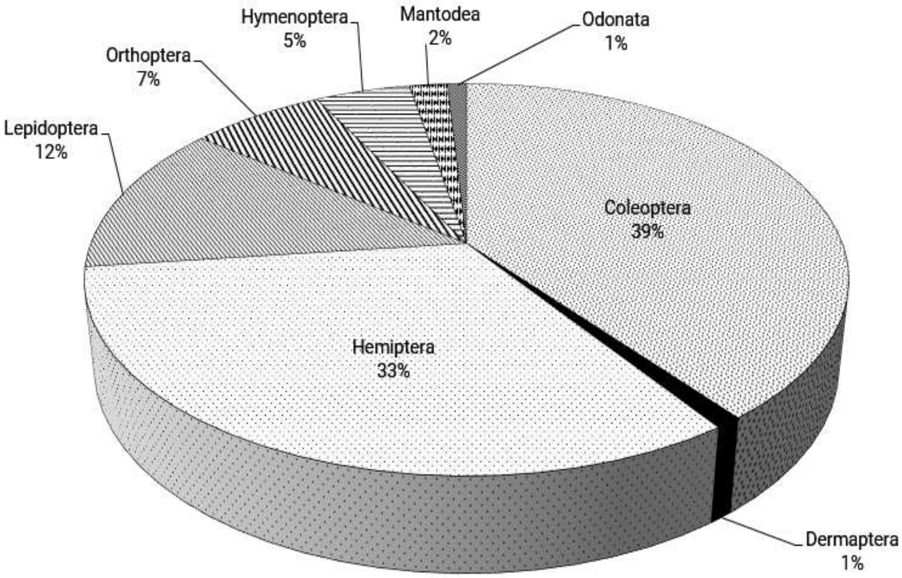

Figure 1. Relative abundance of insects orders associated with Roselle at Makurdi in 2016 cropping season

Table 3: Insect species diversity and richness on Roselle at Makurdi in 2016 cropping season

Parameter	Early-sown		Late-sown		Combined		Combined	
	Green-calyx	Red-calyx	Green-Calyx	Red-calyx	Green-calyx	Red-calyx	Early-sown	Late-sown
No. of species collected	82	71	64	63	96	89	88	72
No. of individuals collected	9055	6875	4321	3106	13376	9981	15930	7427
Shannon-Wiener's Diversity index	2.27	2.23	2.16	2.11	2.4	2.35	2.26	2.16
Buzas and Gibson's Evenness index	0.12	0.13	0.13	0.14	0.11	0.12	0.11	0.12
Margalef's Richness index	8.89	7.92	7.71	7.53	10	9.56	8.99	8.3

All parts of the plants' shoot were colonized by insect pests (Table 4). Defoliators were preponderantly adult coleopterous insects among which *M. thomsoni*, *N. sjostedti*, *A. cyanipennis* and *L. villosa* were the abundant species (Figures 2 and 3). They were most abundant at the vegetative growth stage. At reproductive growth stage, both adult and immature stages of insects fed on the crop, the dominant species being *D. volkeri*, *O. hyalinipennis* and *Earias* sp. (Table 4). The number of insect species collected fluctuated during crop growth, but it increased phenomenally attaining a peak at 11 and 13 weeks after planting in the early- and the late-crop, respectively (Figures 4 and 5). Furthermore, Figures 6 and 7 show temporal spread of the insect species on Roselle. While infestation by *M. thompsoni* and *N. sjostedti* straddled the entire growth period in both cropping seasons, *Earias* sp., *C. fumatus*, *L. villosa*, *A. gossypii, O. hyalinipennis*, *D. volkeri* were limited to the reproductive growth stage of the crop. However, *Empoasca* sp. *B. tabaci* occurred only at the vegetative stage in the late-sown crops.

Table 4. Relative abundance, stage of insects, and the plant parts colonized on early- and late-sown Roselle at Makurdi in 2016 cropping season

Species	Status	Stage	Plant part attacked	Relative abundance*	
				Early-sown	Late-sown
Asbecesta cyanipennis Har.	Pest	Adult	Leaf	MA	S
Monolepta goldingi Bryant	Pest	Adult	Leaf	MA	S
M. thompsoni Allard	Pest	Adult	Leaf	HA	HA
Nisotra sjostedti Jac.	Pest	Adult	Leaf	HA	HA
Trichispa sericea Guer	Pest	Adult	Leaf	S	MA
Lagria villosa Fab.	Pest	Adult	Leaf	HA	S
Carpophilus fumatus Boh.	Pest	Adult	Flower	MA	S
Bemisia tabaci Genn.	Pest	Adult	Leaf/Stem	MA	S
Empoasca sp.	Pest	Adult	Leaf	MA	S
Oxycarenus hyalinipennis Costa	Pest	Adult	Flower/Seeds	S	HA
Dysdercus volkeri Fab.	Pest	Adult /Nymph	Flower/Fruit	HA	HA
Aphis gossypii Glover	Pest	Adult /Nymph	Flower	S	MA
Earias sp.	Pest	Larva/Adult	Flower/Fruit	S	MA

*S=Scarce specie (<1% of total collection); MA=moderately abundant species (.≥1% but <5% of total collection); HA=Highly abundant species (≥10% of the total collection)

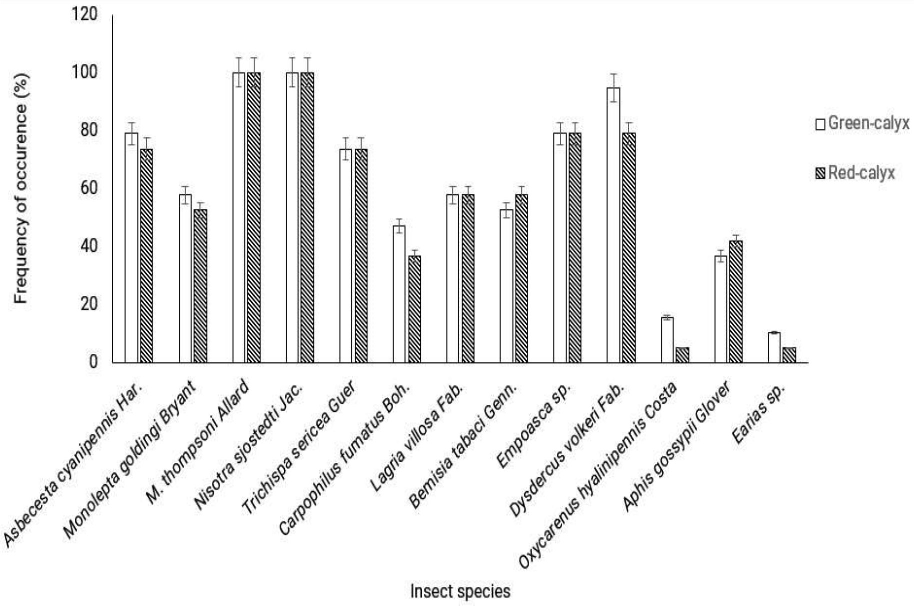

Figure 2. Frequency of insect occurrence on early-sown Roselle at Makurdi in 2016 cropping

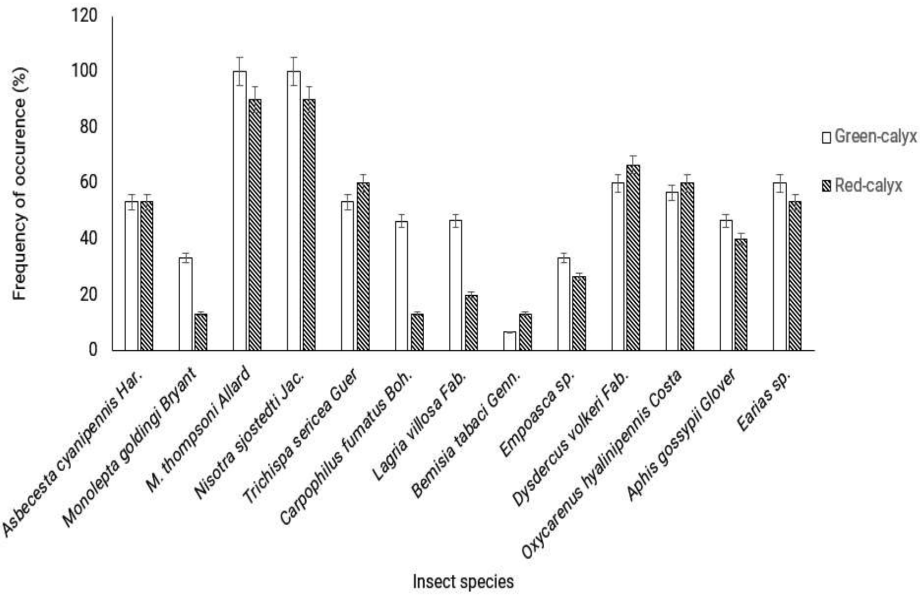

Figure 3. Frequency of insect occurrence on late-sown Roselle at Makurdi in 2016 cropping

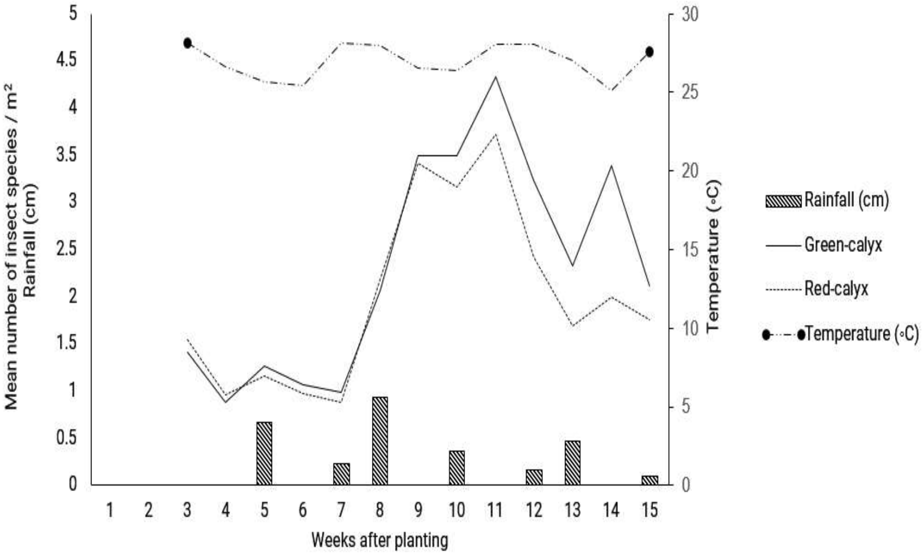

Figure 4. Weekly fluctuation in incidence of insect species infesting early-sown (June-September 2016) Roselle at Makurdi as influenced by rainfall and temperature of Makurdi, Nigeria (1-6 WAP=Vegetative stage; 7-15 WAP=Reproductive stage)

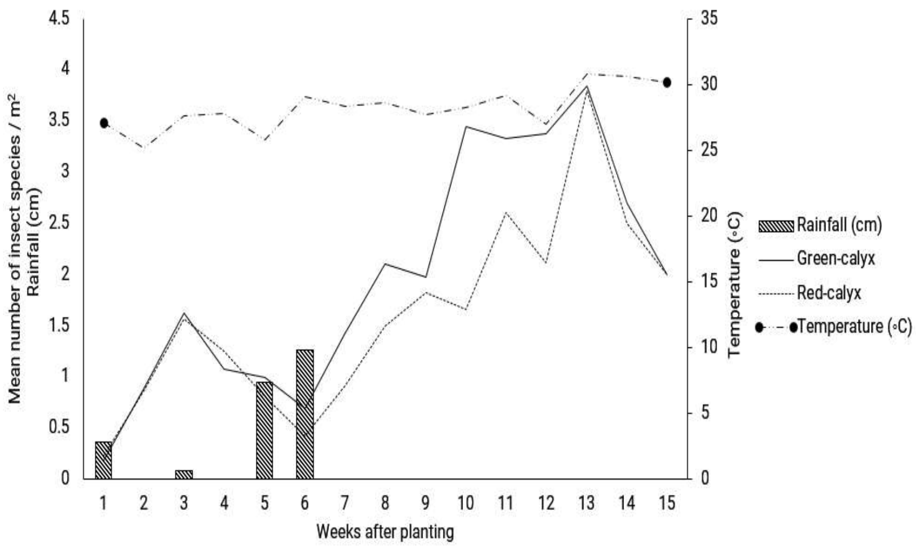

Figure 5. Weekly fluctuation in incidence of insect species infesting late-sown (August- December 2016) Roselle as influenced by rainfall and temperature of Makurdi, Nigeria (1-6 WAP=Vegetative stage; 7-15 WAP=Reproductive stage)

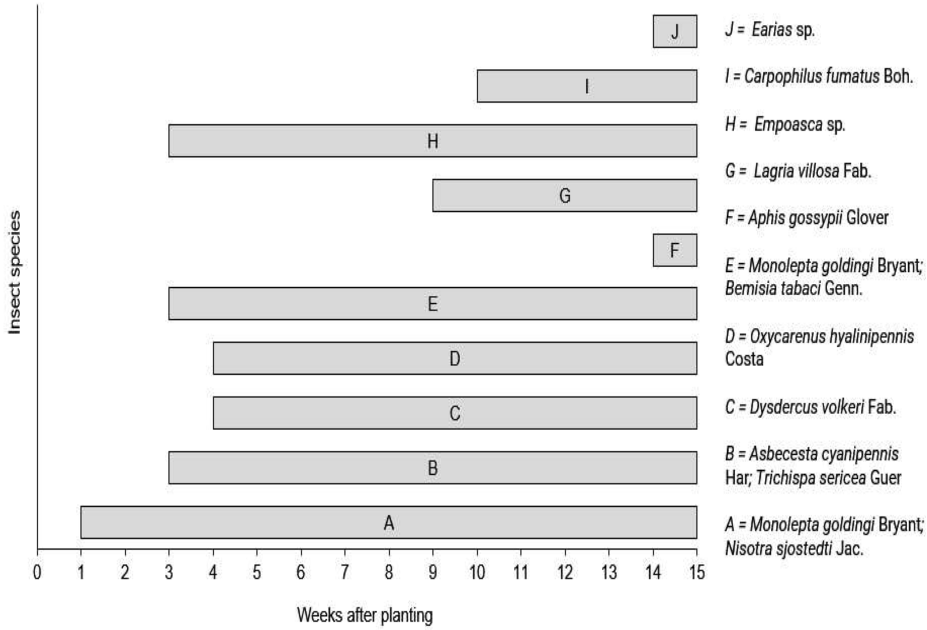

Figure 6. Temporal spread of insect species infesting early-sown Roselle at Makurdi in 2016 cropping season

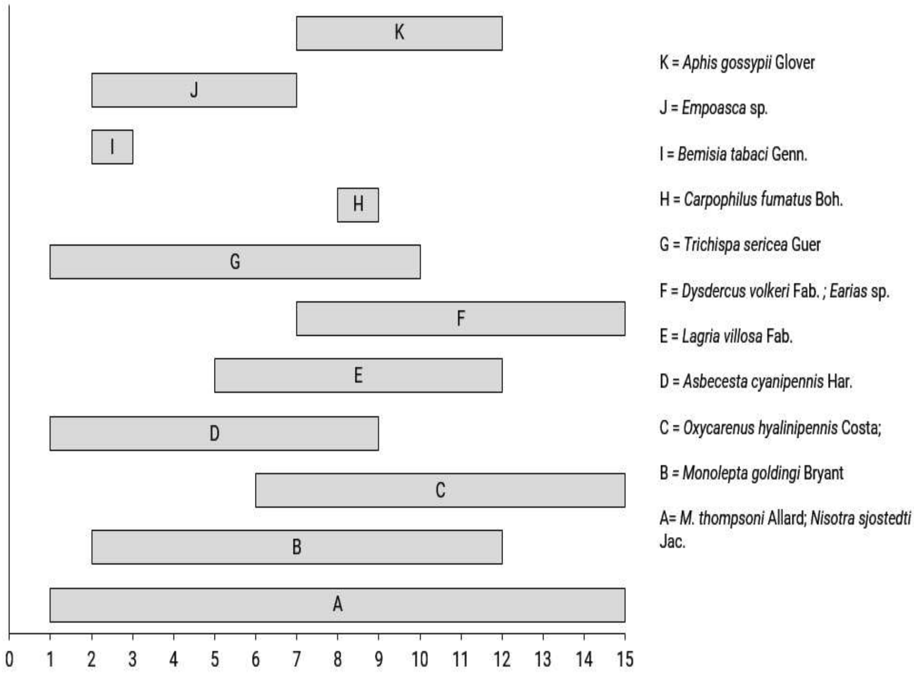

Figure 7. Temporal spread of insect species infesting late-sown Roselle at Makurdi in 2016 cropping season
(1-6 WAP=Vegetative stage; 7-15 WAP=Reproductive stage)

DISCUSSION

Daramola (1984) observed 30 species of insects in 15 families and 4 orders infesting Roselle in farmers' fields in Southwestern Nigeria. In a study at Samaru, Dike (1992) recorded 11 species in 9 families and 3 orders. At Ogbomoso, Olaniran et al (2013) listed 5 insect pest species in 5 families and 4 orders. A far greater species diversity and richness have been documented in this paper. Nevertheless, many species reported elsewhere were not found at Makurdi. These include: *Alcidodes grassirostris* Thoms., *Cheilomenes lunata* F., *Chrysolagria cuprina* Thoms., *C. nairobana* Borch., *Cryptocephalus obesus* Suffr., *Diplognata gagates* F., *Lobotrachelus incalidus* Boh., *Lycus semiamplexus* Murr., *Nematocerus acerbus* Fst., *Podagrica uniforma* Jac., *Pseudagrilus sophorae* F., *Silidius bennensis* Pic., *Stictoleis maculata* F., *Syagrus calcaratus* F. [Coleoptera]; *Clavigralla gibbosa* Spin., *Deraeocoris martini* Puton, *Drylocoris* sp., *Dysdercus superstitiosus* F., *Locris maculata* F., *Lygaeus festivus* Thunb., *Mirperus torridus* Wstw., *Nagusta* sp., *Oxycarenus gossypinus* Dist., *Rhinocoris bicolor* F., (Hemiptera); *Amascta flavicosta* Ham. (Lepidoptera) (Daramola 1984, Dike 1992, Olaniran et al 2013). However, *Cylas puncticollis* Boh. (a known key insect pest of sweet potato, *Ipomoea batatas*) was observed on both green- and red-calyx Roselle plants in the study. This corroborates the findings of Malgwi and Onu (2013) who reported an instance of the insect feeding (nibbling and cutting holes or punctures) on various plant parts including young flowers, buds, and the soft apical growing points of five Malvaceae crop types (including Roselle) at Zaria, Nigeria.

M. thompsoni and *N. sjosstedti*, the frequently occurring and abundant coleopterous species, whose infestation straddled crop growth period, are classifiable as major pests at Makurdi given the extensive leaf perforation noticed particularly at the seedling and vegetative stage and the consequential adverse impact on plant vigour, growth, and yield (Ewete 1978, Clementine et al 2009). In Southwestern Nigeria, Daramola (1984) identified *Chrysolagria cuprina* Thoms., *C. nairobana* Borch, *Podagrica uniforma* Jac. and *Syagrus calcaratus* F. as the major seedling and foliage pests. In the present study, the dominant insects at the reproductive stage were *D. volkeri*, *Earias* sp. and *O. hyalinipennis*. This finding is consistent with the reports by Daramola (1984), Ewete and Osisanya (1984), Ottai et al (2004) and Abdel-Moniem et al (2011). *Earias* larvae perforated the fruits consuming its content and creating portals of entry for secondary invaders. Piercing and sucking of maturing seeds of Roselle by both *D. volkeri* and *O. hyalinipennis* culminated in seed weight loss and poor germination as reported by (Odhiambo 1957) on cotton in Uganda. The occurrence of piercing and sucking insects like *Empoasca* sp. and *B. tabaci* at the vegetative stage was not unexpected as these insects have been reported to cause significant damage to leaves and stems of roselle (Abdel-Moniem and El-Wahab 2006, El-Zoghby 2017).

Of the 20 beneficial insects documented, 18 were predatory species with *P. spilophorus* and *E. flavipes* as the dominant species in both the early- and late-sown crops. Abdel-Moniem and Abd El-Wahab (2006) had previously identified *Polistes* sp. as a dominant predator in Roselle fields in Egypt. The coccinelid beetles, *C. sulphurea* and *C. vicina* have been reported to prey upon aphids in Southwestern Nigeria (Daramola 1984). The impact of the predators and the only parasitoid found in this study (*Iphiaulax* sp.) was not determined. However, the ratio of beneficial insect to pest species was very low (1:4.1). This suggests a low impact level of natural biological control on the pest population in the location. If the aim is to promote biological insect pest control, repeated releases (augmentation) and implementation of measures that enhance the abundance or activity of the natural enemies, including manipulation of the crop microclimate (conservation), are needed to achieve an adequate level of insect pest control in the area.

CONCLUSION

Monolepta thompsoni Allard, *Nisotra sjostedti* Jac, *Lagria villosa* F., *Oxycarenus hyalinipennis* Costa and *Dysdercus volkeri* F. were the abundant phytophagous insect species. Natural enemies occurred at extremely low frequency and density, *P. spilophorus* was the dominant beneficial species encountered during this study.

It is suggested that feasibility of economically controlling the key field pests using resistant varieties, cultural techniques, physical barriers, semiochemical based technologies and, as a last resort, the use of selective chemicals which conserve beneficial insects in Roselle fields should be evaluated.

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