PRELIMINARY SURVEY OF INSECT DIVERSITY AND POPULATION ABUNDANCE DURING FLOWERING AND FRUITING SEASON IN *Mangifera odorata* (KUINI) ORCHARD, SINTOK, KEDAH, MALAYSIA

Nurin Izzati Mohd Zulkifli[1*], Siti Noor Aishikin Abdul Hamid[1], Saiful Zaimi Jamil[1], Zul Helemey Mohamad Sabdin[2], Mohd Shukri Mat Ali[3] & Aimi Athirah Ahmad[4]

[1]Agrobiodiversity and Environment Research Centre,
[2]Horticulture Research Centre,
[3]Industrial Crop Research Centre,
[4]Socio Economic, Market Intelligence and Agribusiness Research Centre,
MARDI Headquaters, Persiaran MARDI-UPM,
43400 Serdang, Selangor
*Corresponding author: *nurin.izzati@mardi.gov.my*

ABSTRACT

A preliminary survey of insect population in Kuini (*Mangifera odorata*) orchard was conducted between February 2016 and May 2016 in MARDI, Sintok, Malaysia. Collection of insects were done using two different methods namely yellow sticky trap (YST) and sweep net. A total of 857 arthropods were collected during flowering season and 1,454 arthropods during fruiting season. Data were analysed using descriptive statistics while mean comparisons were done using t-test. Thysanoptera recorded the highest percentage (31.65%) of total catch during flowering season, while Blattodea and Neuroptera recorded as the lowest with 0.23% respectively. During fruiting season, the highest recorded insect was Diptera (79.92%) while Thysanoptera and Lepidoptera recorded the lowest percentage (0.07%). The Shannon-Weiner diversity index (H'), Simpson Diversity Index (D) and Margalef's Diversity Index (d) were for insects during flowering season were of 3.01, 0.87 and 12.44 respectively. Conversely, H', D and d value for insects during fruiting season were 2.61, 0.83 and 7.28 respectively. Results obtained from this study will be used as baseline for future insect pest and biological control related studies.

Keywords: Insect diversity, insect abundance, kuini, orchard

ABSTRAK

Tinjauan awal populasi artropod di kawasan penanaman Kuini (*Mangifera odorata)* telah dijalankan antara bulan Februari 2016 dan Mei 2016 di MARDI, Sintok, Malaysia. Pengumpulan serangga telah dilakukan dengan menggunakan dua kaedah yang berbeza iaitu perangkap melekit kuning (YST) dan juga jaring perangkap serangga. Sebanyak 857 artropod telah dikumpulkan semasa musim berbunga dan 1,454 serangga semasa musim buah. Data dianalisis menggunakan kaedah statitik deskriptif dan ujian *t*. Thysanoptera mencatatkan peratusan tertinggi (31.65%) daripada jumlah tangkapan semasa musim berbunga, manakala Blattodea dan Neuroptera mencatatkan peratusan terendah masing-masing sebanyak 0.23%.

Pada musim buah, artropod tertinggi yang dicatatkan ialah Diptera (79.92%) dan Thysanoptera dan Lepidoptera mencatatkan peratusan terendah (0.07%). Selain itu, indeks kepelbagaian Shannon-Weiner (H'), Indeks Kepelbagaian Simpson (D) dan Indeks Kepelbagaian Margalef (d) di kira bagi arthropoda semasa musim berbunga dengan nilai 3.01, 0.87 dan 12.44. Sementara itu H ', D dan d untuk artropod pada musim buah masing-masing adalah 2.61, 0.83 dan 7.28. Keputusan yang diperoleh daripada kajian ini akan menjadi garis panduan untuk kajian berkaitan pemantauan kawalan biologi pada masa depan.

Kata kunci: Kepelbagaian, musim berbunga, musim berbuah, serangga

INTRODUCTION

Malaysia has a rich variety of underutilised fruits which are consumed locally and grows wildly in the region of Peninsular Malaysia, Sabah and Sarawak (Khoo et al. 2010). *Mangifera* is a common genus in Malaysia, belongs to the family Anacardiaceae which contains approximately 69 species that bear edible fruit (Kostermans & Bompard 1993). One of these species known as *M. odorata* or locally recognized as kuini is considered as an underutilised fruit (Khoo & Ismail 2008). It is native to Guam, the Philippines, Thailand and Vietnam and cultivated in Malaysia, Indonesia and Singapore. The fruit is an obliquely ellipsoid-oblong, hardly flattened drupe with green to yellowish-green skin. The flesh is orange-yellow in colour, firm and fibrous with a sweet turpentine taste and a strong aroma (Orwa et al. 2009). Apart from the good taste, the kuini fruit also emits a strong odour that attracts variety of insects (Wong & Ong 1993). Kuini has the potential to be commercialized as it contains high levels of nutrients and can be eaten either fresh or processed (Hughes 2009; Rukayah 2001).

Similar to other major fruit crop, kuini also faces a number of pests and diseases issues. As kuini is a species of *Mangifera*, the injury imposed by common pests of *Mangifera* may have profound affecting on kuini as well. Grove et al. (2001) reported that *Thrips acaciae* Thybom, *T. tenellus* Trybom, and *Scirtothrips aurantii* were the most abundant species collected from mango flowers in South Africa and the major damage was noted on newly fruit sets. Research by Aliakbarpour & Rawi (2012) reported that *Thrips hawaiiensis* (Morgan) were the dominant thrips species on mango panicles, whereas *S. dorsalis* were the dominant thrips species in untreated mango orchards in Malaysia. Apart from thrips, the same authors also reported that mango hoppers as major, serious and wide-spread pest throughout the year in south Gujarat. *Idioscopus clypealis* (Lethierry) and *Idioscopus nitidulus* (Walker) remains active and damage each crop stage of mango from emergence of new flush to flowering cum fruit setting stages (Bana et al. 2016). Due to its status as an underutilized crop, the kuini is often neglected in comparison to other major fruits (Padulosi et al. 2002). This also translates to the dearth of information of insects associated with kuini in this country. Hence, it is imperative to evaluate the pest occurrence and abundance as a guide to implement successful pest management programmes in kuini production. This preliminary study was conducted to assess the abundance and diversity of insect population during the flowering and fruit seasons of kuini in Sintok orchard. Data from this study will be utilised as a guideline to assess insect population in kuini orchards and assists farm managers to proper implementation of pest management programmes for kuini.

MATERIALS AND METHODS

Study Area

This study was conducted on a 3.2 ha kuini orchard in MARDI, Sintok, Kedah during flowering (February 2016) and fruiting (May 2016) season respectively. The orchard consists of more than 100 kuini trees with an average age between 9 to 10 years and an average height between 4 to 5 metres.

Insect Collection

Collections of insects were done using two different methods namely yellow sticky trap (YST) and sweep net. Yellow sticky traps are generally used to monitor Homopteran and Dipteran family in agricultural orchard. A yellow plastic sheet (10x10cm) sprayed with insect glue (Neopiece) was then hung on 15 randomly selected kuini tree. Three (3) YST were positioned on each tree with one at the top, middle and lower part of the tree. All YST traps were exposed for 24h. At the time of collection, the traps were covered with a transparent plastic sheet and brought back to the lab for identification purposes. An additional of 15 trees different trees were then randomly selected for sweeping. Standard canvas sweeps net was used. Similarly, the sweeping was also done at three different levels (top, middle, low) which represented as replicate. All contents were then transferred into individual plastic bottles and refrigerated below 0°c for further analysis.

Data analysis

Most of the specimens were identified up to the species level, but in cases where identification was unable to done due to damaged specimens or the discovery of a new species, specimens were only acknowledged to order level. Insect diversity and richness are determined by the Shannon Weiner Index (H') and Simpson Diversity Index (D), Margalef Index (D) and Species Richness (S), referring to the total number of species contain in one area. Comparison between mean was tested by t-test (p=0.05) using Minitab Version 18.

Shannon-Weiner Index (H')

$H' = -\sum (P_i)(\ln P_i)$

where,
$P_i = n_i/N$
n_i = number of individuals for species until i
N = total number of individuals

Value of bigger H' indicates that it is higher in diversity. If H' is equal to 0, there is only one species in the sample and H' is maximum only when all species are represented by the same number of individual (Mcdonald et al. 2010).

Effective Number of Species (ENS)

Effective number of species is calculated according to Lou et al., 2006. This formula is use to convert common diversity indices into true diversities.

$ENS = \exp^{[H']}$

where,
H'= Shannon-Weiner Index

Simpson's Index of Diversity (D)

Simpson's Index of Diversity (D) measures the diversity of a population which considers the number of species present, as well as the relative abundance of each species. The greater value of D, more diverse the ecosystems (Hill 1973).

$$D = 1 - \frac{\sum n(n-1)}{N(N-1)}$$

where,
N = total number of organisms of all species found
n= number of individuals of particular species

Margalef's Diversity Index (d)

Margalef's diversity index (d) is calculated according to formula given by Margalef 1968

$$D = \frac{S-1}{\mathrm{Log}\,N}$$

where,
S = number of species
N = number of individuals

Jaccard Similarity Index

Jaccard Similarity Index compares 2 sets data to see which are shared and which are distinct. It is a measure of similarity for the two sets of data, with a range from 0% to 100%. A higher percentage value indicates that two populations are more similar. Although easier to interpret, this index is extremely sensitive to small samples sizes and may give erroneous results, especially with very small samples or data sets with missing observations (Glen 2016).

$$\text{Jaccard Index} = \frac{\text{(the number of members which are shared between both sets)}}{\text{(total number of members in both sets (shared and un-shared))}} \times 100$$

RESULTS AND DISCUSSION

A total of 857 arthropods was collected during flowering season and further 1,454 arthropods were collected in the respective fruiting season. Thysanoptera recorded the highest percentage (31.65%) of total catch during flowering season, while Blattodea and Neuroptera recorded as the lowest with 0.23% respectively (Fig.1). During fruiting season, the highest recorded arthropod was Diptera (79.92%). Conversely, both Thysanoptera and Lepidoptera recorded the lowest percentage (0.07%) (Fig. 2).

The Shannon-Weiner diversity index (H'), Simpson Index of Diversity (D) and Margalef's Diversity Index (d) for arthropods during flowering season were 3.01, 0.87 and 12.44, respectively. Meanwhile H', D and d for arthropods during fruit season were 2.61, 0.83 and 7.28, respectively (Table 1). T-test showed no significant differences in the abundance of arthropods collected between flowering and fruiting season (p =0.197, p<0.05) (Table 2). Nevertheless, based on the Jaccard Index, similarity between the two seasons were visibly low at 25% (Table 3). The effective number of species (ENS) was also distinguishable with 20 during the flowering season and 13 during the fruiting season. Yaherwandi & Syam (2007) argues that species biodiversity index as one of the most important things in the study of how biodiversity influences the natural community stability. A higher diversity index is often related to better complexity of interaction among species, which subsequently brings more equilibrium to the community and environment (Rahayu et al. 2006).

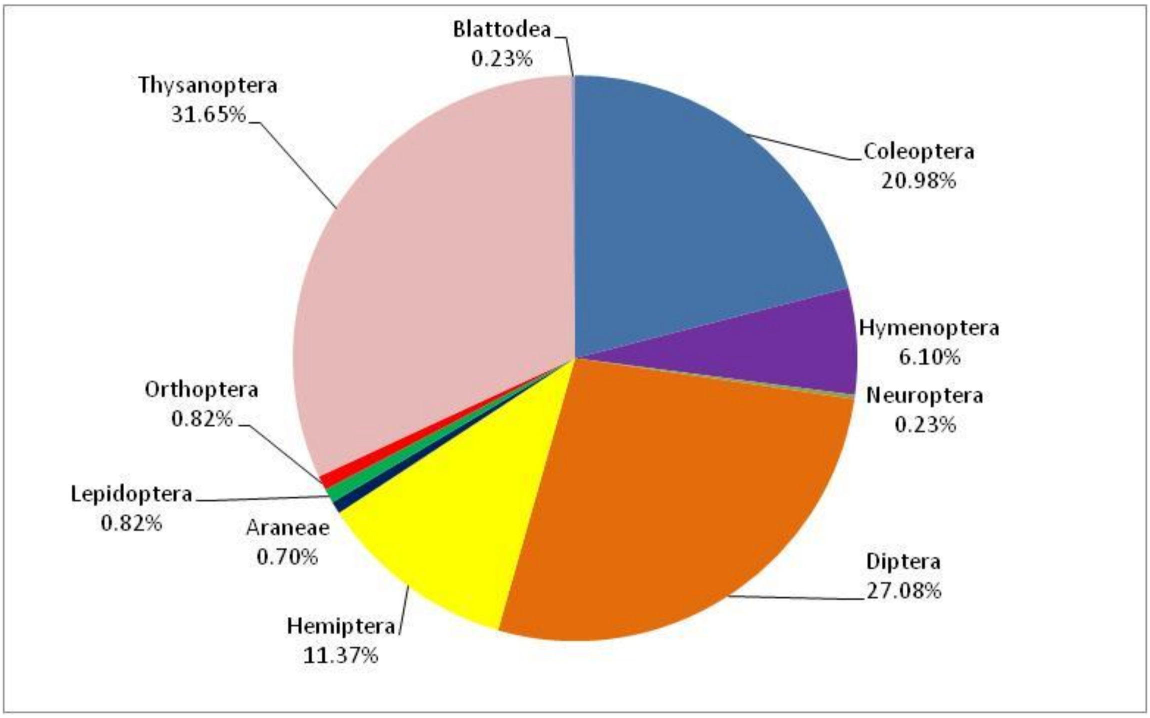

Figure 1. Percentage of insects collected according to order during flowering season

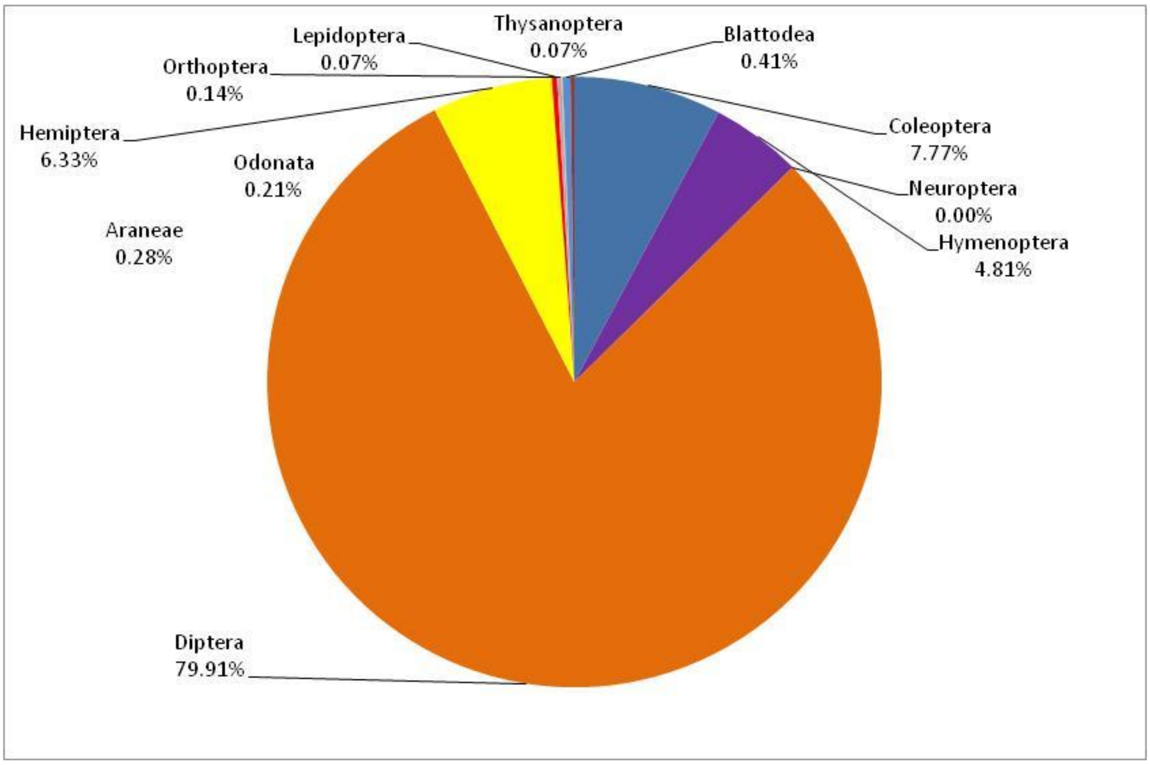

Figure 2. Percentage of insects collected according to order during fruiting season

More species of insects were collected during flowering season (S=82) compared to fruiting season (S=66) (Table 2). This may be due to the availability of rewards provided by the blooming kuini flowers during this season. Finding sugar-rich food sources such as floral nectar, pollen and extra floral nectar (EFN) is essential for the survival of many carnivorous insect species (predator and parasitoid) as they often require plant-provided foods as well, at least during part of their life cycle (Wackers n.d.). Floral nectar is easily detectable by its floral scent and very abundant during flowering season (Raguso 2001 2004). Floral scents attract pollinators to ensure the efficacy of pollen transfer, reduce pollen loss and contribute to the maintenance of reproductive barriers among species (Grant 1994). Other than that, these floral scents might as well advertise availability of reward for insect examples like reliable cue for an appropriate site landing and oviposit for some species of insects (Finch & Collier 2000; Proffit et al. 2011). Moreover, during flowering season, EFN glands which located on leaf laminae, petioles, rachids and bracts of the tree secretes sugar which offer an important supplemental food source for beneficial insects and some pest species (Mizell 2009).

High number of thrips (Thysanoptera) were collected during flowering season (n=270) (Table 2). Thrips is a key pest of *Mangifera* family during flowering season. These insects cause substantial crop losses by feeding on the petals, anthers, pollen, and floral nectarines (Aliakbarpour et al. 2011). Damage is severe when thrips oviposit in the panicles, which then leads to discoloration and reduced vigour of the panicles (Higgins 1992; Pena et al. 2002). Similarly, thrips also feed and oviposit on the pericarp of the fruits, which causes bronzing of the fruit surface, and severe infestations often result in the cracking of the fruit skin (Grove et al. 2000; Nault et al. 2003). However, the number of thrips significantly decreased during fruiting season (n=1). This may be due to the insecticide spraying regime taken by the field operators to prevent and reduce pest population. Aliakbarpour & Che Salmah (2011) argued that correct timing in using insecticides is critical for pest management programs to increase susceptibility of larvae to insecticides. Moreover, thrips fertility is dependent on the consumption of pollen grains from flowers (Pickett et al. 1988; Riley et al. 2010), which is not available during fruiting season.

Result from the study also indicated that Diptera dominated the insect diversity during fruiting season. Number of insects from Agromyzidae, Tephritidae and Drosophilidae was considerably high. Insect pest, *Ophomiya* sp. from Agromyzidae was the highest recorded of total catch (n=557) (Table 2). This species is properly known as leaf miners. Their larvae are exclusively internal plant feeders. Female adult oviposits eggs in leaves, stems and hypocotyls of young seedlings. Emerging maggots mine their way to the root zone where pupation takes place and where feeding becomes concentrated between the woody stem and the epidermal tissue (Ochilo & Nyamasyo 2010). Such feeding intervenes with water and nutrient intake and creates avenues for entry of disease. Nevertheless, the kuini trees in the orchard are old enough to handle the stress of defoliation by these leaf miners, therefore it is considered as minor pest to the crop. Other insect pest sampled during the fruiting season include *Bactrocera* sp. (n=103) or known as Oriental fruit fly. *Bactrocera* sp. is known as major pest with a broad host range of cultivated and wild fruits (Drew & Raghu 2002). They feed primarily on unripe or/and ripe fruit, with many species being regarded as destructive agricultural pests, especially the Mediterranean fruit fly (Tan & Serit 1994).

Several species belonging to Braconidae, Coccinellidae, Apidae, Oxyopidae, Lycosidae and Araneidae were known to beneficial arthropods were found present in both fruiting and flowering season but the number is considerably low (Table 3). These species may act as important biological control agents thus avoiding the need for excessive use of chemical pesticides. In order to increase the number of these beneficial, several studies had been conducted by Fiedler et al. (2008) and Landis et al. (2000) where they exploit and alternate the landscape of orchard with flowering plant to enhance the population of natural enemy and beneficial insects as a part of conservation biological control strategy. Flowering plants are commonly used in designing field or orchard scale to increased natural enemy efficacy because it provides them with resources such as nectar, pollen or alternative prey.

Further study needs to be conducted to determine the major pests that mainly cause the damage and yield loss to kuini and also the pollinators which help during flowering as this study is meant for preliminary purposes to depict to the abundance and richness of insect present in the kuini field. In addition to YST and sweeping, other methods such as scouting and direct observation may possibly help to provide better and reliable result of determining kuini's associated pest and pollinators.

Table 1. Comparison on Species collected (S), Shannon-Weiner Index (H'), Effective Number of Species (ENS), Simpson Index (D) and Margalef Index (d) insects obtained during flowering and fruiting season in kuini orchard

Diversity indices	Flowering season	Fruiting season
Species collected (S)	82	66
Shannon-Weiner Diversity Index (H')	3.01	2.61
Effective Number of Species (ENS)	20	13
Simpson Index of Diversity (D)	0.87	0.83
Margalef Index (d)	12.44	7.28

Table 2. T-test Results comparing abundance of insects collected during Flowering and Fruiting Season

Season	n	Mean	SD	t-cal	df	p
Flowering	82	7.9	22.0	-1.29	146	0.197
Fruiting	66	18.4	69.4			

Table 3. List of species collected in kuini orchard during flowering and fruiting season

Order	Family	Species	Flowering season (n)	Fruiting season (n)
Coleoptera	Coccinellidae	*Scymus* sp.	2	2
		Cryptogonus orbiculus	42	
		Cryptogonus sp.	6	
		Micrapis discolor	29	
		Micrapis afflicta		1
		Halmus chalybeus	1	
		Coccinellidae sp.	1	
	Staphylinidae	*Philonthus* sp.		1
	Chrysomelidae	*Nodina* sp.	34	35
		Colposcelis sp.	1	2
		Monolepta bifasciata	18	8

		Monolepta sp.	8	
		Basilepta sp.	1	7
	Curculionidae	*Hypomeces squamosus*	8	4
	Carabidae	*Carabidae* sp. A	5	4
		Carabidae sp. B	6	
	Cerambycidae	*Cerambycidae* sp.		1
	Anobiidae	*Caenocara* sp.		5
	Anthicidae	*Formicomus* sp.		5
	Dermestidae	*Thorictus* sp.	17	38
Hymenoptera	Formicidae	*Crematogaster* sp.		12
		Oecophylla sp.		1
		Diacamma sp.		1
		Formicidae sp.	2	5
		Camponotus sp.	9	5
		Iridomyrmex sp.	4	2
	Branconidae	*Apanteles* sp.	2	
		Bracon sp.	3	4
		Branconidae sp. A	10	6
		Chelonus sp.	2	
		Microplitis sp.	1	
		Elasmus sp.		3
	Apidae	*Ceratina* sp.	4	
		Heterotrigona itama	2	25
	Ichneumonidae	*Amauromorpha* sp.	2	
		Paraphylax sp.	1	
		Ichneumonidae sp. A	5	3
	Evanidae	*Evania* sp.	1	3
	Chalcididae	*Asaphes vulgaris*	1	
		Brachymeria sp.	1	
	Vesp.idae	*Ropalidia* sp.	1	
	Eulophidae	*Euplectrus* sp.	1	
Diptera	Syrphidae	*Eumerus* sp.	3	
		Eristalis sp.	2	
		Eristalinus arvorum		1
		Paragus sp.	4	
	Dolichopodidae	*Chrysosoma vittatum*	2	98
		Chrysosoma sp.	14	74
	Drosophilidae	*Drosophila lurida*	6	1
		Drosophila sp. A	7	132
		Drosophila sp. B		30
		Bacterocera umbrosa	1	
	Tephritidae	*Bactrocera dorsalis*	5	80
		Bactrocera sp.	7	23

	Agromyzidae	*Chromatomyia* sp.	123	25
		Ophiomyia phaseoli		27
		Ophiomyia sp. A	32	557
	Platystomatidae	*Elassogaster* sp.		2
	Stratiomyidae	*Microchrysa flaviventris*	7	4
	Muscidae	*Musca domestica*	4	2
		Musca sp. A	6	26
		Musca sp. B		1
	Ortalidae	*Ortalidae* sp. A		33
	Tipulidae	*Limonia* sp.	2	
		Tipulidae sp. A		1
	Celyphidae	*Celyphus obtectus*	5	
	Chloropidae	*Gampsocera* sp.		1
	Cullicidiae	*Cullicidiae* sp. A		42
	Anisopodidae	*Anisopodidae* sp. A		1
	Calliphoridae	*Chrysomya megacephala*		1
	Tephritidae	*Sp.haeniscus atilius*	1	
Neuroptera	Chrysopidae	*Chrysopa* sp.	2	
Hemiptera	Cixiidae	*Oliarus* sp.	6	
	Miridae	*Miridae* sp. A	2	
	Alydidae	*Leptocorisa oratorius*	5	
	Cicadellidae	*Krisna* sp.	6	
		Cicadellidae sp. A	14	4
		Idioscopus nitidulus	9	9
		Idioscoupus clypealis		4
		Idioscoupus clavasignakus	5	
		Idioscopus sp.	14	6
		Neodartus acocephaloides	26	
		Neodartus sp. A	1	6
		Doratulina sp.		59
	Tropiduchidae	*Kallitaxila* sp.		1
	Ricaniidae	*Pochazia fuscata*		1
	Membracidae	*Gargara* sp.		1
	Aphidae	*Aphis* sp.	11	1
	Tingidae	*Tingis* sp.	1	
	Lygaeidae	*Geocoris* sp.	1	
Lepidoptera	Gracillariidae	*Acrocercops* sp.	3	
	Pyralidae	*Orthaga incarusalis*	3	
		Pyralidae sp. A	1	
	Lymantridae	*Lymantridae* sp. A		1

Orthoptera	Gryllidae	*Metioche* sp.	5	2
		Oecanthus sp.	2	
Thysanoptera	Thripidae	*Thrip* sp.	270	1
Odonata	Coenagrionidae	*Ishnura* sp.		2
	Libellulidae	*Crocothemis* sp.		1
Blattodea	Ectobiidae	*Blattela germanica*	1	2
	Blattellidae	*Megamareta* sp.	1	4
Araneae		*Lycosa* sp.	1	1
		Oxyopes javanus	1	3
		Oxyopidae sp.	1	
		Laufeia sp.	2	
		Thomisidae sp.	1	
Jaccuard Similarity Index			25%	

CONCLUSION

The study revealed a total of 857 arthropods which were collected during flowering season and 1,454 arthropods during fruit season. Thysanoptera recorded the highest percentage (31.65%) as key pest of kuini during flowering season while Diptera (79.92%) was recorded highest during fruit season. The diversity of insect was generally lower in the fruiting season than the flowering season. Inferring from the study, the following recommendations were made: Method such as scouting and direct observation may give more reliable result of determining kuini's pest. A year-round study including off season data is necessary to elucidate the insect observed in the orchard to formulate appropriate strategies for their control, if necessary.

ACKNOWLEDGMENTS

The authors would like to thank many people had been involved directly and indirectly in this study. Special thanks to Azman Rejab, Zulidzham Mohd Sani, Jayprakash Pertabrai Keshavla, Hidayah Yahya, Che Ammar Abqari and Shahidan Suhaimi for their continuous support, professional guidance, encouragement and patience throughout this study. This study was supported by MARDI & Malaysian Government for Grant P-RS407.

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