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Unveiling the Insect Spectrum of Carrot (*Daucus carota* L.) in Eastern Dry Zone of Karnataka

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***Abstract*:** The study investigates the insect fauna associated with carrot crops in the Eastern Dry Zone of Karnataka, India. Roving surveys conducted across Kolar, Chikkaballapur and Bengaluru Rural districts resulted in documenting a total of 39 insect species across four orders and 12 families, where Hemiptera order being the most diverse and order Diptera being most abundant. Major pests identified include leafminer, *Liriomyza trifolii*, carrot fly, *Melanagromyza* sp., mirid bug, *Taylorilygus apicalis*, Lygaeid bug, *Nysius* sp., leafhoppers, *Balclutha* spp. and *Hishimonus phycitis* which cause substantial damage on carrots. All these insects are being newly recorded on carrot in India. *Liriomyza trifolii* and *Melanagromyza* sp. were the most economically significant pests causing 42.33% damage to foliage and 20.77% to taproots respectively. Species diversity indices revealed Kolar as the most diverse district, followed by Bengaluru Rural and Chikkaballapur.

***Keywords*:** Carrot, Insect fauna, *Liriomyza trifolii, Melanagromyza* sp.

Carrot (*Daucus carota* L.) is one of the ten leading vegetables grown globally, about 1.2 million hectares of land are currently used for carrot cultivation in the world with an estimated economic value of nearly $14 billion (Bolton et al., 2020). Originating from Afghanistan and Persia, carrots belong to the Apiaceae family. China holds the top position globally as the leading producer of carrots and turnips, producing 21.3 million tonnes. India, occupies the 14th position, covering a total area of 0.122 million hectares, with production of 2.3 million metric tonnes. Predominantly carrot is a temperate climate plant but, it is also cultivated in tropical and subtropical regions, especially at high elevations with assured irrigation.

Carrots being a high value vegetable crop have attracted many growers in different parts of Karnataka and neighbouring states. Like other vegetable crops, carrots have also been infested by many insect pests. Insect pests damaging carrot include carrot rust fly, *Psila rosae* (F.), aster leafhopper, *Macrosteles quadrilineatus* (Fobes), flea beetle, *Systena blanda* (Melsheimer), carrot weevil, *Listronotus oregonensis* (LeConte), aphid, *Myzus persicae* (Sulzer) and cutworm, *Agrotis* sp. from United States of America. Collier (2017) reported several species of aphid viz., *Cavariella aegopodi* (Scopoli), *C. pastinacae* (Linnaeus), *C. theobaldi* (Gillete and Bragg), *Myzus persicae* (Sulzer) and turnip moth, *Agrotis segetum* (Denis and Schiffermuller) as major pests of carrot from England. Bhat and Ahangar (2018) recorded four insects on carrot which includes carrot aphid, *Cavariella aegopodii* (Scopoli), *Semiaphis heraclei* (Takahashi); semilooper, *Thysanoplusia orichalcea* (Fabricius) and thrips, *Aeolothrips meridionalis* Bagnall from Jammu and Kashmir, India. The current study was aimed to investigate the insect fauna on carrot crop, their distribution, abundance, diversity and its potential on carrots in the Eastern dry zone of Karnataka.

MATERIAL AND METHODS

Roving surveys were conducted in major carrot growing districts of Karnataka *viz*., Kolar, Chikkaballapur and Bengaluru Rural during December 2021-22 to December 2022-23 to document the insect fauna of carrots. Fields were visited at fortnightly intervals, with each field being sampled twice for observations, and unsprayed fields were selected for the study. In total, 30 fields were surveyed during the study period, with samples taken from carrot crops at various developmental stages. Since the duration of carrot crops is 85-90 days, the entire crop period was divided into five developmental stages: stage I (1-25 days), stage II (26-40 days), stage III (41-60 days), stage IV (61-75 days), and stage V (76-90 days) (Wang et al., 2016). Samplings for insect fauna were made in the field by sweep netting on carrot foliage by adapting the zig-zag sampling method. Insects along with the foliage were immediately collected using polythene bags. Ten samples were collected in 0.4 ha area and each sample was a composite of five sweeps. Insect abundance recorded by sweep netting was expressed as an average number of adults per sample. Simultaneously, the abundance of aphids and lepidopteran caterpillars on the leaf

was recorded by counting the total number of aphids and caterpillars on ten randomly selected plants in each quadrant. A total of ten quadrats were observed and abundance was expressed as the mean number of insects per plant.

Pestiferous and beneficial insects associated with carrots in different surveyed locations were collected and brought to the laboratory, and the immature stages were reared till the adult stage. The adult insects were preserved for taxonomic identification. Soft-bodied insects were preserved in 70% ethanol. The insect faunal abundance and species diversity were worked out by using different indices such as Margalef's index of richness (MI), Shannon-Wiener Diversity index (H), Simpson's index (D), Pielou's evenness index (J) and Berger-Parker index of dominance (d). Engelmann's scale of dominance was used to evaluate the dominance structure of the ecosystem. Based on relative abundance, the dominance structure was categorized into five scales as follows: eudominant (>31.7%), dominant (10.1–31.6%), subdominant (3.2-10%), recedent (1.1-3.1%) and subrecedent (<1%).

RESULTS AND DISCUSSION

The 39 insect species belonging to four orders and 12 families were found associated with carrot crops in three major carrot-growing districts of Karnataka (Table 1). Order Hemiptera was the most diverse with 33 species documented, followed by Diptera with four species, and one species each from Coleoptera and Lepidoptera. Family Cicadellidae (Hemiptera) was the most speciose representing 14 species, followed by Delphacidae (eight species), Miridae (five species), Agromyzidae (two species), Pentatomidae and Tephritidae with two species each. Noctuidae, Coreidae, Lygaeidae, Geocoridae, Chrysomelidae and Aphididae with one species each. This is a maiden attempt in India to document the insects associated with carrots. Consequently, a thorough examination of the nature of damage inflicted by major insect pests on carrots has been meticulously documented and discussed herein.

During the initial stages of crop growth, the presence of leafhoppers and planthoppers leads to the complete yellowing of foliage (Fig. 1a and 1b), consequently impeding plant growth. Among the Cicadellidae family, *Balclutha* spp. emerged as the dominant leafhoppers, followed by *Hishimous phycitis* (Distant) and *Empoasca* sp. All four species were consistently observed across all surveyed locations. In a study conducted in Michigan, USA (Stillson and Szendrei 2020), researchers investigated leafhoppers in carrot crops and identified a total of 23 taxa. Among these, *Balclutha* sp. and *Empoasca fabae* (Harris) were noted as two of the eight most prevalent leafhopper taxa, which is in accordance with this study. Among the Delphacidae family *Toya* sp1.was the sole predominantly observed planthopper. Wilson and O'Brien (1987) in the Australo-Pacific regions, also recognized *Toya dryope* (Kirkaldy) and *Sogatella kolophon* (Kirkaldy) as pestiferous planthoppers affecting carrots.

Of the five recorded species of Miridae, *Taylorilygus apicalis* (Fieber) was the most prevalent phytophagous mirid bug followed by *Campylomma livida* Reuter and *Halticus minutus* Reuter. The feeding damage by mirid bugs resulted in production of pale whitish circular punctures on the lower surface of carrot leaves, which further results in yellowing of the leaves. *Dortus primaries* Distant and *Nesidocoris tenuis* Reuter are non-pestiferous insects that are general predators of soft-bodied insects and zoophytophagous predators respectively (Sanchez and Lacasa 2008). In India, both *T. apicalis* and *C. livida* are recorded as an important emerging mirids on cotton and sunflower (Rajesh et al., 2020 and Sahana et al., 2023).

Carrots encountered infestation from two agromyzid pests, among which the leafminer, *Liriomyza trifolii* (Burgess), holds substantial importance as a primary defoliator. This pest is known for causing unique serpentine feeding galleries on carrot foliage (Fig. 1c), and a severe infestation can lead to the yellowing and eventual drying of leaves. The attack of leaf miners typically initiates on cotyledon leaves and persists throughout the crop's growth until harvest. Although the initial damage by the leafminer is observed mainly on the lower leaves, if left unchecked, it can extend to infest the entire foliage, leading to a direct impact on the carrot yield. *L. trifolii* was also recorded on carrots in Florida and Brazil (Fernandes et al 2016), but not documented on carrot crops in India.

The carrot fly, *Melanagromyza* sp., is a newly identified pest seen affecting carrots in India (Raghunandan and Manjunatha 2023). The maggot of the carrot fly directly feeds the taproot, creating tunnels in a spherical pattern (Fig. 1d). This ultimately leads to the cracking of carrots, posing a direct impact on both the development and overall quality of the carrot crop. Leaf miners and carrot flies stand out as the main perpetrators responsible for carrot damage, with leaf miners affecting the foliage and carrot flies primarily targeting the taproots. These pests have become the most economically significant threats to carrot cultivation in the Eastern Dry Zone of Karnataka. The defoliation of carrots is also attributed to two other pests, namely the flea beetle, *Monolepta signata* Chevrolat and the semilooper, *Thysanoplisia orichalcea* (F.). *S. blanda* is a globally recognized flea beetle affecting carrots (Nunez and Haviland 2014) but has not been reported in India.

Table 1. Insect faunal distribution on carrot in Karnataka

Order	Family	Scientific name	Abundance			Mean	Relative abundance (%)
			Kolar	Chikkaballapur	Bengaluru rural		
Hemiptera	Cicadellidae	*Hishimonus phycitis* (Distant)	0.18	0.20	0.20	0.19	2.51
		Cicadulina bipunctata (Malichar)	0.02	0	0.02	0.01	0.17
		Balclutha sp1.	0.75	0.77	0.87	0.79	10.35
		Balclutha sp2.	0.15	0.62	0.41	0.39	5.11
		Nirvana pallida Malichar	0.09	0	0.05	0.04	0.60
		Maistes pruthi (Metcalf)	0.01	0.07	0	0.02	0.34
		Kolla ceylonica (Melichar)	0.03	0	0.01	0.01	0.17
		Empoasca sp.	0.05	0.02	0.15	0.07	0.95
		Exitianus indicus (Distant)	0.03	0	0	0.01	0.12
		Austroagallia nitobei (Matsumura)	0.03	0	0.02	0.01	0.21
		Thomsonia arcuata (Signorat)	0.03	0	0	0.01	0.12
		Nephotettix virescens (Distant)	0.04	0	0.02	0.02	0.25
		Balcluta rubrostriata (Malichar)	0	0.15	0.06	0.07	0.90
		Seriana sp.	0.02	0	0	0.006	0.08
	Delphacidae	*Toya* sp.1.	0.05	0.05	0.07	0.05	0.73
		Cemus sp.	0.02	0	0	0.006	0.08
		Perkinsiella sinensis Kirkaldy	0.02	0	0	0.006	0.08
		Coronacella sinhalana (Kirkaldy)	0.05	0	0	0.01	0.21
		Toya sp.2.	0.02	0	0.05	0.02	0.30
		Sordia sp.	0.02	0.2	0	0.07	0.95
Hemiptera	Delphacidae	*Sogatella kolophon* (Kirkaldy)	0.05	0	0.05	0.03	0.43
		Tagosodes pusanus (Distant)	0.03	0	0	0.01	0.12
	Miridae	*Taylorilygus apicalis* (Fieber)	0.37	0.1	0.5	0.32	4.20
		Halticus minutus Reuter	0	0	0.07	0.02	0.30
		Dortus primaries Distant*	0.12	0	0.11	0.07	0.99
		*Campylomma livida*Reuter	0.04	0.12	0.02	0.06	0.77
		Nesidocoris tenius Reuter*	0.05	0.1	0.03	0.06	0.77
	Coreidae	*Cletus* sp.	0.04	0	0	0.01	0.17
	Lygaeidae	*Nysius* sp.	0.37	0.97	0.03	0.45	5.93
	Geocoridae	*Geocoris* sp.	0.04	0.02	0.03	0.03	0.38
	Pentatomidae	*Nezara viridula* (L.)	0.09	0.07	0.16	0.10	1.38
		Menida sp.	0.03	0	0	0.01	0.12
	Aphididae	*Aphis sp.*	0.10	0.06	0.02	0.06	0.77
Diptera	Tephritidae	*Sphenella* sp.	0.08	0.12	0	0.06	0.86
		Scadella sp.	0.04	0	0.02	0.02	0.25
	Agromyzidae	*Melanagromyza* sp.	0.14	0.27	0.36	0.25	3.33
		Liriomyza trifolii(Burgess)	1.55	8.00	2.67	4.07	52.9
Coleoptera	Chrysomelidae	*Monolepta signata*Chevrolat	0.12	0.05	0.11	0.09	1.21
Lepidoptera	Noctuidae	*Thysanoplusia orichalcea*(F.)	0.02	0.08	0.05	0.05	0.64

*Beneficial insects

Table 2. Diversity of insect fauna of carrot in Eastern Dry Zone of Karnataka

Locality	Number of species (S)	Total number of individuals (N)	Margalef's index of richness (MI)	Shannon's Wiener Diversity index (H)	Simpson's index (1-D)	Pielou's evenness index (J)	Berger parker index of dominance (P_{max})
Kolar	37	856	5.33	2.69	0.86	0.39	0.69
Chikkaballapur	20	484	3.07	1.45	0.54	0.21	0.33
Bengaluru rural	27	473	4.22	2.12	0.75	0.30	0.54

Table 3. Succession of major insect pests of carrot with crop developmental stages

Insect pests	Developmental stage of crop (Days)				
	I (0-25)	II (26-40)	III (41-60)	IV (61-75)	V (76-90)
	Germination	Taproot initiation	Taproot development	Pre-maturity	Maturity
L. trifolii	———	———	———	———	———
Balclutha spp.	———	———	———	———	———
Nysius sp.				———	———
T. apicalis		———	———	———	
Melanagromyza sp.		———	———	———	———
H. phycitis	———	———	———		

*The duration of occurrence of each insect pest on the crop is shown by horizontal lines.

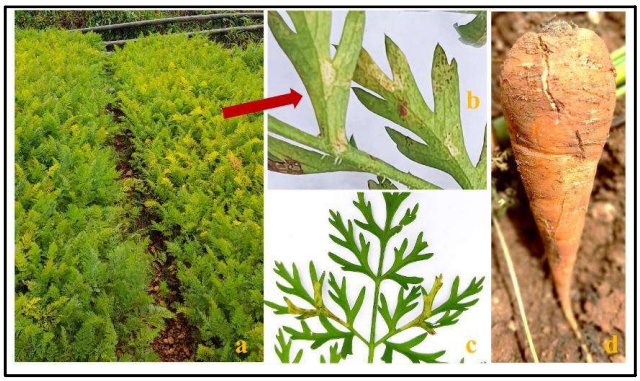

Fig. 1. Symptoms of damage caused; a and b: sucking insects on foliage; c: leaf miner; d: carrot fly

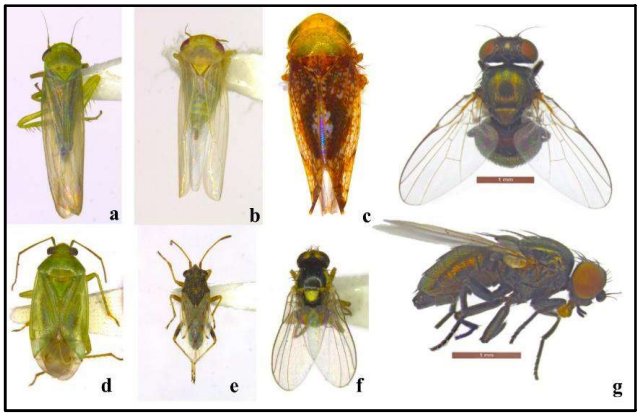

Fig. 2. a: *Balcluthas*p1; b: *Balclutha* sp 2; c: *Hishimonus phycitis*; d: *Taylorilygus apicalis*; e: *Nysius* sp; f: *Liriomyza trifolii*; g: *Melanagromyza* sp.

Considering population densities, relative abundance and nature of damage the following insect species namely *L. trifolii*, *Balclutha* spp., *Nysius* sp., *T. apicalis*, *Melanagromyza* sp. and *H. phycitis* (Table 1, Fig. 2) were considered as major pests on carrots. The progression of major insect pests on carrots was carefully observed and recorded throughout all stages of crop development (Table 3). The richness index was maximum from Kolar, followed by Bengaluru Rural and was minimum for Chikkaballapur (Table 2). The Shannon's Wiener Diversity index and Simpson's index followed a similar trend. Engelmann's classification was used to know the species dominance structure (Dalal and Gupta 2016). Out of 39 insect species recorded in the entire eastern dry zone of Karnataka only one species was found to be eudominant (*L. trifolii*), one species was dominant (*Balclutha* sp1.), four species were subdominant (*Nysius* sp., *Balclutha* sp2., *T. apicalis* and *Melanagromyza* sp.), three species were recedent (*H. phycitis*, *N. viridula* and *M. signata*) and all other 30 insect species recorded were subrecedent.

CONCLUSION

The study provides the first comprehensive documentation of insect pest diversity and abundance associated with carrots in India highlighting the urgent need for targeted pest management strategies, especially in the Eastern Dry Zone of Karnataka, to mitigate the impact of these pests on carrot crops and improve yield quality and

quantity. The study also contributes new host records of several insect species on carrots, marking a significant addition to the entomological literature in India.

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