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RESEARCH ARTICLE

Impact of Lufenuron 5.4% EC on Major Arthropod Diversity in Cabbage

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ABSTRACT

An experiment was conducted to assess the impact of insecticide, lufenuron 5.4% EC on arthropod diversity in cabbage ecosystem. The two seasons diversity indices revealed 2866 arthropods from 26 families under eight orders in sprayed and unsprayed condition. Diamondback moth, *Plutella xylostella* (Linnaeus), two species of aphids *viz., Myzus persicae* (Sulzer) and *Brevicoryne brassicae* (Linnaeus), cabbage whitefly *Aleyrodes proletella* (Linnaeus) were found to be a major pests of cabbage plants in this region. Minor pests are recorded as follows Cabbage looper, *Trichoplusia ni* (Hubner), Leaf roller, *Sylepta lunalis* (Guenee), Marmalade hoverfly, *Episyrphus balteatus* (de Geer), Painted bug, *Bagrada picta* (Fabricius) and Mealybug, *Coccidohystrix insolita* (Green). Natural enemies, predators of aphid *viz.,* syrphids flies, coccinellid beetles, and spiders were recorded in this cabbage ecosystem. Larval parasitoids *Cotesia plutellae* of cabbage diamondback moth was recorded. Presence of mantids and hymenopterans (braconids) indicated the relative safety of the insecticides in these ecosystems. The biodiversity indices in the sprayed (997) and unsprayed (1869) fields showed higher diversity in unsprayed fields revealing the influence of insecticidal spraying.

Keywords *: Biodiversity, Lufenuron, Pesticides impact, Alpha diversity indices, Cabbage, Arthropods*

Cabbage (*Brassica oleracea* var. *capitata* L.) is an important vegetable of cole crop group and the third major vegetable group primarily grown in the winter season in plains. . In India, cole crops were grown over an area 4,07,000 of hectares with an annual production of 89,71,000 tonnes in 2016-2017 (Annual Report, 2017). Major cabbage growing states in the country are Uttar Pradesh, Orissa, Bihar, West Bengal, Assam, Karnataka, Maharashtra, Madhya Pradesh and Tamil Nadu. There are several insect pests are attack the cabbage. Primary pests are diamondback moth (DBM), *Plutella xylostella* (Linnaeus); cabbage butterfly *Pieris brassicae* L.; cabbage semilooper *Trichoplusia ni* Hubner; head borer *Hellula undalis* Fabricius; Tobacco caterpiller, *Spodoptera litura* (Fabricius), Cabbage aphid, *Brevicorneae brassicae* and green peach aphid *Myzus persicae*. Among these DBM is the most serious pest. These pests are a major constraint in the production of cabbage and for their management. For increasing the market value of this crop, the growers to go for more frequent use of insecticides for better yield. This has resulted in several problems *viz*., pesticide resistance, resurgence, residue problems, inefficiency of natural enemies due to effect of chemicals and environmental pollution. Among, the previous study, most of the literature data on insect pests and natural enemies of cabbage are available. However, not much data is available in literature about arthropod diversity of cabbage crop from Tamil Nadu. Keeping the importance of fauna diversity an experiment was conducted to evaluvate the impact of lufenuron 5.4% EC on arthropods diversisity in cabbage ecosystem.

MATERIAL AND METHODS

Two season studies were conducted to evaluate the arthropod diversity in cabbage ecosystem at Jahirnayakanpalayam (10°59′12″N 76°47′39²E), Coimbatore and Erisibetta (11°26′28″N 76°50¢57²E), Kotagiri and TNAU Farm (11°22′00″N 76°38¢44²E), Najanadu, Horticultural Research Station, Ooty.

Sampling

To develop a package of methods for quantitative sampling of arthropod communities, collections were made using four different methods *viz*., active searching, net sweeping, pitfall trap and rubbish trap.

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Active searching

Active searching was done in the early morning and evening hours. Each quadrat was selected at random and they were actively searched for arthropods. Each site was searched for a total of two hours. Spiders were collected by walking diagonally in the fields and care was taken to capture them without injuring and transferred to polythene bags for further studies. Specimens from a single quadrat at each habitat type were pooled for analysis.

Net sweeping

Sweeping is very effective for the collection of flying and jumping arthropods at the ground level and under storey vegetation. The nets used in systematic sweeping of the ground level were made of thick cotton cloth with a diameter of 30 cm at the mouth and a bag length of 60 cm. For carrying out net sweeps, the plot was divided into 100 quadrats, measuring 10 m x 10 m each. Five such quadrats representing the field were chosen at random and the entire ground level vegetation in the chosen quadrat was covered during the sweeping. Net sweeps were always done between 10 am and 12 noon. The arthropods collected from each quadrat were transferred to polythene bags containing cotton dipped in chloroform.

Pitfall trap

Pitfall trap method was adopted to collect ground dwelling and nocturnal arthropods. Pitfall traps were set out using a plastic container (15 cm height and 10 cm width) buried in to the soil to a depth of 20 cm. Five pitfall traps were placed in each of five randomly chosen 10 m x 10 m quadrats. The traps were set up between 6 AM and 5 PM and specimens were collected the next morning. In order to stop the receptacle from filling with water or leaf litter and to deter some larger predators like mice, the trap was covered with a flat stone supported by four smaller stones. Teepol (2-3 drops) in water was kept in the traps as trapping fluid. The traps were placed at the rate of 25 per plot. The trapping fluid was changed every week. Observations were recorded daily on the number and type of arthropods trapped in each container.

Rubbish trap

Rubbish traps were constructed using chicken wire mesh, stuffed with leaf litter(45 cm length and 15 cm width). Five rubbish traps were placed in each of five randomly chosen quadrats. The traps were placed in the field allowing a week for arthropods to take up residence. Every seven days, these traps were removed and brought to the laboratory to collect the arthropods found inside were collected.

Collection and identification of arthropods

The collection of arthropods for biodiversity analysis was carried out in cabbage field at different stages of the crop growth. Arthropod fauna were collected fortnightly from first fortnight of April to the last fortnight of June using the methods specified earlier. The collected arthropods were sorted out based on taxon. Soft bodied insects and spider species were preserved in 70 per cent ethyl alcohol in glass vials. Other arthropods were card mounted or pinned. The preserved specimens were photographed and identified based on the taxonomic characters. All arthropod species were identified to the lowest possible taxon. Insects were identified with the help of Dr. M. Ganesh Kumar, Professor, Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore and also following Poorani (2002) and Firake *et al.* (2012) after comparing with the specimens available in the Department of Agricultural Entomology, Tamil Nadu Agricultural University.

Alpha diversity indices of arthropods in cabbage ecosystem

The following indices were used to assess and compare the diversity and distribution of arthropods in cabbage ecosystem. Species richness and diversity version ii (Pisces Conservation Ltd., www.irchouse. demon.co.uk) (Henderson, 2003) programmes were used to assess and compare the diversity of arthropods in sprayed and unsprayed cabbage ecosystems.

Alpha diversity indices	Formula	Formula explanation	Author
Species richness			
Fishers alpha	$\alpha x, \frac{\alpha x^2}{2}, \frac{\alpha x^3}{3}, \frac{\alpha x^n}{n}$	Each term gives the number of species predicted to have 1, 2, 3, … n individuals in the sample.	Fisher *et al.,* 1943

Q Statistic	$Q = \frac{1}{2}nR_1 + \sum nr + \frac{\frac{1}{2}nR_2}{\ln\left(\frac{R_2}{R_1}\right)}$	nr - the total number of species with abundance R R_1 and R_2 - 25 per cent and 75per cent quartile of the cumulative species curve nR_1 - the number of individuals in the class where R1 falls nR_2 - the number of individuals in the class where R2 falls	Kempton and Taylor, 1976
Species number			
Margalef's D	$D_{Mg} = \frac{(S-1)}{\ln N}$	S - total number of species recorded N - the total number of individuals summed overall S species	Clifford and Stephenson, 1975
Shannon diversity index	$H' = \sum P_i \ln P_i$	Pi - The proportion of individuals in the i^{th} species H- This program calculates the index using the natural logarithm	Batten, 1976
Brillouin diversity index	$H = \ln N! - \sum_{i=1}^{s} \frac{\ln n_i!}{N}$	N - is the total number of individuals in the sample n_i - is the number of individuals belonging to the i^{th} species and s is the species	Magurran, 1987
Species Dominance indices			
Simpson's index	$D = \sum \frac{[N_i(N_i-1)]}{[N_t(N_t-1)]}$	N_i - is the number of individuals in the i^{th} species N_t- is the total number of individuals in the sample	Simpson, 1949
Berger Parker diversity index	$d = \frac{N_{max}}{N}$	N_{max} - is the number of individuals in the most abundant species N- is the number of individuals in the sample	Berger and Parker, 1970
McIntosh index	$D = \frac{N-U}{N-\sqrt{N}}$ $U = \sqrt{\sum n_i^2}$	N- is the total number of individuals in the sample U - is given by the expression, n_i is the number of individuals belonging to the i^{th} species and the summation is undertaken for over all the species.	McIntosh, 1967
Evenness indices	$E = \frac{H'}{\ln S}$	S – Total number of species in a community H' - prime is the number derived from the Shannon diversity index	
Equitability	$J = \frac{H}{\log S}$	H is the observed Shannon - Weiner index, the maximum value this could take, where S is the total number of the species in the habitat.	Magurran, 1987

RESULTS AND DISCUSSION

Arthropods collected at fortnightly intervals from April to June in sprayed and unsprayed cabbage fields were documented, identified up to the lowest taxonomic level possible and various biodiversity indices were worked out (Fig. 2). The survey yielded from sprayed and unsprayed area was 997, 1869 respectively and a wide array of total 2866 individuals of arthropods from 26 families and eight orders of insects. The class Insecta was the most common followed by Arachnida. Totally, six families of Lepidoptera were collected with the majority of individuals falling under the family Plutellidae and Pyralidae in both sprayed and unsprayed cabbage fields (Table 1).

Based on this primary arthropod data, different sets of alpha diversity indices were calculated. The species number calculated based on the generic level varied between a minimum of 34.50 during the month of April to a maximum of 39.00 during the month of June in unsprayed cabbage field. In sprayed cabbage, the maximum (36.00) was during the month of May and the minimum (29.50) during the month of April. Based on ordinal level and species level analysis, the species richness was not clear in variation from the Fisher's alpha index values. At generic level, the value was the highest in the month of May in sprayed field (9.77).

Table 1. Inventory of major arthropod in cabbage ecosystem

Order	Family	Number of species	
		Sprayed field	Unsprayed field
Araneae	Araneidae	2	7
	Tetragnathidae	4	5
Coleoptera	Chrysomelidae	2	9
	Coccinellidae	27	83
	Meloidae	12	15
Diptera	Syrphidae	67	76
	Tachnidae	40	63
	Tipulidae	4	27
Hemiptera	Aleyrodidae	16	69
	Aphididae	190	377
	Pentatomidae	18	59
	Pseudococcidae	7	35
Hymenoptera	Apidae	40	72
	Braconidae	92	157
	Ichneumonidae	29	45
	Tenthredinidae	22	22
Lepidoptera	Crambidae	26	26
	Lymantriidae	9	9
	Noctuidae	82	82
	Pieridae	36	36
	Plutellidae	186	504
	Pyralidae	27	28
Mantodea	Mantidae	14	16
Orthoptera	Gryllidae	17	17
	Pyrgomorphidae	15	16
	Tettigoniidae	13	14
	Total	997	1869

The highest ordinal and familial level indices were 1.77 in month of June and 7.85 in the month of June in sprayed cabbage and Margelef's D generic level varied between a minimum of 4.84 during the month of April and maximum of 5.90 during the month of May in sprayed cabbage. In unsprayed cabbage, the index value was the highest during the month of May (6.52) and the lowest during the month of April (6.04). Q statistic index represented value based on ordinal level ranged from 1.88 to 2.37 and 1.53 to 1.85 in sprayed and unsprayed cabbage fields, respectively and showed significant variation. On the generic level, the value was maximum in the month of May (5.90) and minimum in the month of April (4.84) in sprayed cabbage. In unsprayed cabbage, the value was the highest in the month of May (17.60) and the lowest in the month of June (14.10). Minimum variation was observed in case of Brillouin diversity index based on ordinal, generic, familial and species level between the sprayed and unsprayed cabbage. The Shannon-Weiner index was calculated based on the four taxonomic levels. The index values based on generic, familial and species levels in sprayed cabbage were lower than unsprayed field (Table 2).

Table 2. Arthropod diversity in sprayed and unsprayed cabbage ecosystem

Alpha diversity			Month	Sprayed field				Unsprayed field			
				Ordinal level	Familial level	Generic level	Species level	Ordinal level	Familial level	Generic level	Species Level
Species richness		Species number	April	7.00	19.00	29.50	32.00	7.50	22.00	34.50	39.00
			May	8.00	23.50	36.00	38.00	8.00	24.50	38.50	43.50
			June	7.50	22.00	31.50	33.50	8.00	26.00	39.00	43.50
Species richness indices		Fishers alpha	April	1.34	5.51	7.63	11.39	1.45	5.86	10.81	9.88
			May	1.70	7.08	9.77	14.32	1.50	6.21	11.50	10.62
			June	1.77	7.85	9.66	15.65	1.46	6.49	11.20	10.26
		Margalef's D	April	1.17	3.50	4.84	5.97	1.18	3.81	6.04	6.10
			May	1.34	4.30	5.90	7.06	1.22	4.09	6.52	6.60
			June	1.35	4.38	5.55	6.79	1.20	4.26	6.48	6.48
		Q Statistic	April	2.05	7.57	4.84	14.48	1.85	7.78	16.62	17.53
			May	1.88	8.05	5.90	14.14	1.53	7.33	17.60	18.97
			June	2.37	7.92	5.55	13.82	1.61	7.37	14.10	17.51
		Brillouin diversity index	April	1.37	2.20	1.94	2.56	1.46	2.32	2.61	2.02
			May	1.54	2.41	2.04	2.76	1.49	2.34	2.63	2.03
			June	1.58	2.40	2.04	2.77	1.55	2.33	2.57	1.99
		Shannon-Weiner index	April	1.44	2.38	2.07	2.83	1.51	2.47	2.83	2.14
			May	1.61	2.60	2.18	3.04	1.53	2.47	2.82	2.13
			June	1.69	2.66	2.23	3.14	1.60	2.45	2.74	2.09
Species dominance indices		Simpson's index	April	3.30	8.10	3.65	11.74	3.70	8.81	11.50	3.64
			May	4.27	9.84	3.73	13.80	3.81	7.40	8.72	3.60
			June	4.93	12.06	3.81	20.56	4.21	7.42	8.31	3.57
		McIntosh index	April	0.48	0.69	0.50	0.74	0.51	0.69	0.72	0.50
			May	0.55	0.73	0.51	0.78	0.52	0.67	0.70	0.49
			June	0.60	0.77	0.52	0.83	0.54	0.66	0.69	0.49
		Berger parker diversity index	April	0.48	0.25	0.50	0.24	0.41	0.25	0.24	0.50
			May	0.55	0.21	0.50	0.19	0.36	0.26	0.26	0.50
			June	0.60	0.16	0.50	0.15	0.34	0.28	0.28	0.50
Evenness indices		Equitability J	April	0.69	0.73	0.55	0.73	0.73	0.76	0.75	0.55
			May	0.78	0.80	0.58	0.79	0.74	0.76	0.75	0.55
			June	0.81	0.82	0.59	0.81	0.77	0.76	0.73	0.54

Comparison of abundance and diversity of arthropods

Measures of diversity are frequently seen as indicators of the well being of any ecosystem. They also serve as a measure of the species diversity in the ecosystem. As complete counts of organisms are impractical, indirect solutions that are practical, rapid and inexpensive are necessary and hence, diversity indices have gained importance. In the present study, the data on the arthropods collected were subjected to alpha or within habitat diversity and beta or between habitat diversity of sprayed and unsprayed cabbage fields. Margelef's D generic level varied between a minimum of 4.84 during the month of April and maximum of 5.90 during the month of May in sprayed cabbage. In unsprayed cabbage, the index value was the highest during the month of May (6.52) and the lowest during the month of April (6.04). Similar results were earlier reported by Stanley (2007) that the overall species richness indicated by Margelef index was 2.60 for sprayed and 2.03 for unsprayed clumps for eight sprays of diafenthiuron at 0.08 per cent.

The maximum number of individuals belonged to family Braconidae, followed by Ichneumonidae, Tenthredinidae and Apidae in both sprayed and unsprayed cabbage. Studies on diversity and abundance of DBM parasitoids in Thailand revealed that *C. plutellae* was dominant during early crop stages as reported by Upanisakorn *et al.* (2011). Diptera was represented by three families with majority of individuals collected falling under Syrphidae followed by

Tachnidae and Tipulidae. Majority of species under Tachinidae belonged to the genus *Exorista*. Under Coleoptera three families were collected with majority of individuals belonging to Coccinellidae. Only 27 individuals of Curculionidae were collected. Spiders were particularly susceptible to organosynthetic insecticides such as carbamates and organophosphates, while fungicides, herbicides, and natural insecticides such as *Bt* had little or no toxicity for spiders as documented by Stark *et al*. (1995).

Fig 2. Arthropod diversity richness in cabbage ecosystem

In current study, alpha diversity was estimated based on species number, Fishers alpha index, Margelef's D index , Q statistic, Brillouin index and Shannon-Weiner index while dominance was based on Simpson's index, McIntosh index and Berger parker index. In both instances, the analysis was subjected to four levels of classification *viz.,* based on order, family, genus and species (Fig 1). The use of higher taxa typically families as proxy for species has been suggested by Williams and Gaston (1994). Hughes (1978) concluded that the taxonomic level of identification is one of the most important factors influencing the value of the Shannon index.

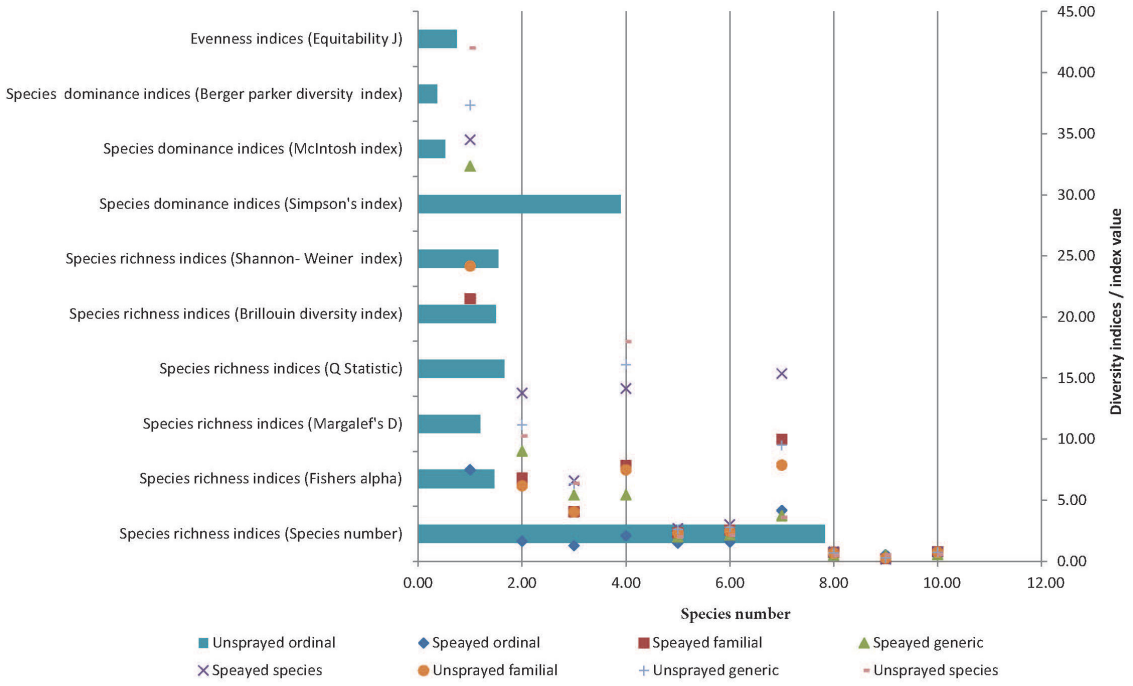

Fig 1. Arthropod diversity in cabbage ecosystem

Biodiversity of arthropod fauna assessed in brassicaceous ecosystems in unsprayed area in Meghalaya region by Firake *et al.* (2012). His study also supported the all species richness indicated by Menhinick index (1.77 and 0.93) and Simpson's index of diversity (0.17 and 0.28) in sprayed and unsprayed fields, respectively. However, survival comes to normal state at 21 days after the next spray (second spray). This was evidenced by the same Simpson's index of 0.26 and 0.20 in the sprayed and unsprayed area, respectively.

The current biodiversity study demonstrated that the chemicals applied in the sprayed area had a negative effect on the arthropod community as a whole. The current findings on the sensitivity of certain taxa to chemical sprays could contribute in the identification of bioindicators for environmental stress due to pesticide usage in the cabbage field. Therefore, the use of the best management practices should be taken into serious consideration in controlling the pests in the agricultural areas to reduce the negative impacts on biodiversity and continuously provide natural ecological services such as biological control.

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