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Within-plant distribution of predators on chilli

(Taburan pemangsa pada pokok cili)

N. Maisin*, S. T. S. Hassan*, M. Y. Hussein** and A. S. Sajap***

Key words: chilli, predator, sampling, within-plant distribution, Coccinellidae, aphid

Abstrak

Bentuk taburan intra-pokok bagi pemangsa Coccinellidae (kumbang kura-kura), Formicidae (semut) dan Araneae (labah-labah) pada pokok cili telah diteliti sepanjang satu musim penanaman untuk merumus unit pensampelan pemangsa pada pokok cili. Secara am, pemangsa banyak tertumpu pada buku batang utama 0 (batang utama 0 ialah bahagian atas pucuk) hingga kelima dan ke atas kerana adanya sumber makanan di tempat itu. Apabila pertumbuhan pokok cili meningkat, lebih banyak pemangsa bertaburan di bawah terminal, dan bentuk taburan pemangsa berubah selari dengan perubahan taburan mangsa, musuh semula jadi dan morfologi pokok akibat penuaan dan serangan perosak. Secara umum, di kawasan yang terdapat banyak semut, bilangan pemangsa yang lain rendah. Kajian ini mencadangkan zon pertama (buku batang utama 0 hingga yang kelima) dipilih sebagai unit pensampelan optimum untuk pemangsa pada pokok cili. Secara keseluruhannya, kadar populasi bagi setiap pokok sepanjang musim ialah 65% bagi Formicidae, 78% bagi Coccinellidae dan 78% bagi Araneae.

Abstract

The within-plant distribution patterns of the predators Coccinellidae (ladybird beetles), Formicidae (ants) and Araneae (spiders) on chilli were traced throughout a crop growing season to formulate the predator sampling unit on chilli plants. The predators were more abundant from main-stem node 0 (main-stem 0 is the uppermost terminal bud) through node 5, due partly to the availability of food sources. As the plant grew, more predators spread out downwards, and their distribution patterns changed parallel to changes in distribution patterns of the prey, their natural enemies and changes in plant morphology due to aging and pest damage. Generally in areas where ants were in abundance, the numbers of other predators were small. Overall this study suggests the selection of zone one (main-stem nodes 0 to 5) as the optimum sampling unit for predators on chilli plants, where the general population proportion per plant for the growing season were 65% for Formicidae, 78% for Coccinellidae and 78% for Araneae.

Introduction

Natural enemies, especially predators, are known to regulate population of pest species in agro-ecosystems (Kenmore et al. 1984; Way and Heong 1994). Information on their (predators) within-plant and between-plant distribution is essential in developing ecologically-based pest management

*Department of Biology, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia
**Department of Plant Protection, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia
***Department of Forest Management, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia
Authors' full names: Navies Maisin, Syed Tajuddin Syed Hassan, Mohd Yusof Hussein and Ahmad Said Sajap

strategy, especially in the formulation of monitoring and surveillance schemes. The within-plant distribution of arthropods (pests and predators) on crop ecosystems other than chilli, except for a preliminary report (Hassan, Hussein et al. 1992), has been well studied (Wilson and Gutierrez 1980; Wilson et al. 1982; Pickett et al. 1988; Vehrs et al. 1992). According to these studies, arthropods were more abundant in the terminal uppermost third of the crop plant. Consequently, this information can be used in formulating population sampling and commercial monitoring strategies (Wilson et al. 1989). However, Hassan, Hussein et al. (1992) and Vehrs et al. (1992) found that for *Aphis gossypii* Glover (Homoptera: Aphididae), the insect was abundant in the terminal region only at the early stage of plant growth, but was more abundant further away from the plant terminal as the plant grows. The within-plant distribution of predators on chilli is largely unknown.

Consequently, this study aims to define the main-stem nodal distribution of predators on chilli plants at various growth stages, and to propose the optimum sampling unit for the sampling of predators. The predators are Coccinellidae (*Menochilus sexmaculatus* Fabr., *Coccinella transversalis* F. and *Coelophora bisellata* Muls.), Formicidae (*Solenopsis* sp. and unidentified species) and Araneae (Oxyopidae, Araneidae and Salticidae).

Materials and methods

The study was conducted in an experimental farm (Ladang 2) of Universiti Putra Malaysia (UPM), Serdang, Selangor, Malaysia (3° 02' N, 101° 42' E, 31 m above sea level). The chilli plants (cultivar Kulai) were planted in a 200 m^2 area in five adjoining plots. Each plot had 108 chilli plants grown at 0.45 m x 0.60 m rows. Predator monitoring commenced when the plants were 20 cm tall.

The predators (adults and juveniles) were visually counted and grouped according to main-stem nodal locations. From each plot, 20 plants were randomly selected twice weekly and examined thoroughly at 0800, 1100, 1400 and 1700 h. Those located on leaves, branches and internodes were designated as belonging to the nearest main-stem node. The main-stem nodes were numbered commencing from the main terminal portion, where the terminal bud was numbered 0 and first unfolded leaf below as number 1 and so on. This study was conducted for a 3-month chilli crop season (August to October) in 1992. No insecticide was applied on the crop during the entire cropping season.

The pooled adult and juvenile predators data were subjected to the exploratory data analysis and distribution fitting of residuals (STATGRAPHIC 1988). Due to highly non-random and non-normal distribution of residuals (even after transformation), the Kruskal-Wallis analysis of variance by rank (STATGRAPHIC 1988) was then conducted to determine the significance of main-stem node location as a main effect influencing the distribution of each predatory species. A non-parametric multiple comparison test by Dunn (Zar 1984) was used to compare predator numbers between the main-stem nodes. Three (for Formicidae) and four zones (for Coccinellidae and Araneae) comprised the total main-stem nodes throughout the entire growth of the plant. Generally, zone grouping was made based on those having almost similar number of predators. For all arthropods, zones 1 and 2 consisted of main-stem node 0 through 5, and 6 through 8 respectively. In Formicidae, zone 3 demarcated main-stem nodes 9 through 12, and zone 4 main-stem nodes 13 through 20. In Coccinellidae and Araneae, main-stem nodes 9 through 20 comprised zone 3. In each zone, the proportion of predators to the total number of predators per plant was calculated. The data were not demarcated according to times of sampling since exploratory data examination indicated no significant difference in pattern of distribution comparing the various times.

Results

For each taxonomic grouping of predator, the number of predators was significantly affected by the location of main-stem nodes *(Table 1)*. Predators were more abundant in certain zones of the chilli plant relative to the others *(Table 2)*. The within-plant distribution of predators throughout the entire study shows that the upper zone (main-stem nodes 0 to 5) generally contained a greater proportion of predators *(Figure 1* to *Figure 3)*.

During the first 3 weeks of plant growth, all three predators were present in large numbers per plant within the terminal zone, i.e. zone 1 (main-stem nodes 0 to 5) of the chilli plant *(Figure 1* to *Figure 3)*. During the fourth week, ants were more abundant within main-stem nodes 3, 4 and 5, whereas spiders and coccinellids were absent within these main-stem nodes.

The spatial distribution pattern of the ants from the fourth to 10th weeks remained similar. However, the distribution pattern of ants changed after the 10th week and no preferential single zone location could be detected. Their numbers decreased and they were found at almost all main-stem nodes *(Figure 1)*.

For the coccinellids, their distribution pattern began to change only in the eighth week. They began to spread out almost throughout the entire plant, though the largest proportion was still within the terminal zone, i.e. zone 1 *(Figure 2)*. The distribution pattern of the spiders began to change at seventh week through 12th week. The most favoured region was still the main-stem terminal zone but they became more dispersed even at the lower levels of main-stem nodes 3 to 5 *(Figure 3)*.

Discussion

The status of ants as predators is debatable. The ants *Solenopsis geminata* (Fabricius) had been reported as predators of paddy

Table 1. The χ^2 values and significant levels of main-stem node location of the predator category in determining the number of predators (n = 100) (Kruskal-Wallis one-way analysis of variance)

Predator	df	χ^2 computed	Significant level
Formicidae	99	973	p <0.01
Coccinellidae	99	673	p <0.01
Araneae	99	866	p <0.01

Pooled data of the entire chilli crop season of 1992

Table 2. Proportion of total population of each predator category, within the plant main-stem node zones (n = 100)

Predator	Zone (main-stem node)	Proportion (SE)
Formicidae	1 (0–5)	0.65 ± 0.03
	2 (6–8)	0.24 ± 0.02
	3 (9–12)	0.10 ± 0.01
	4 (13–20)	0.01 ± 0.01
Coccinellidae	1 (0–5)	0.78 ± 0.04
	2 (6–8)	0.20 ± 0.03
	3 (9–20)	0.02 ± 0.01
Araneae	1 (0–5)	0.78 ± 0.03
	2 (6–8)	0.20 ± 0.03
	3 (9–20)	0.02 ± 0.01

Pooled data of the entire chilli crop season of 1992

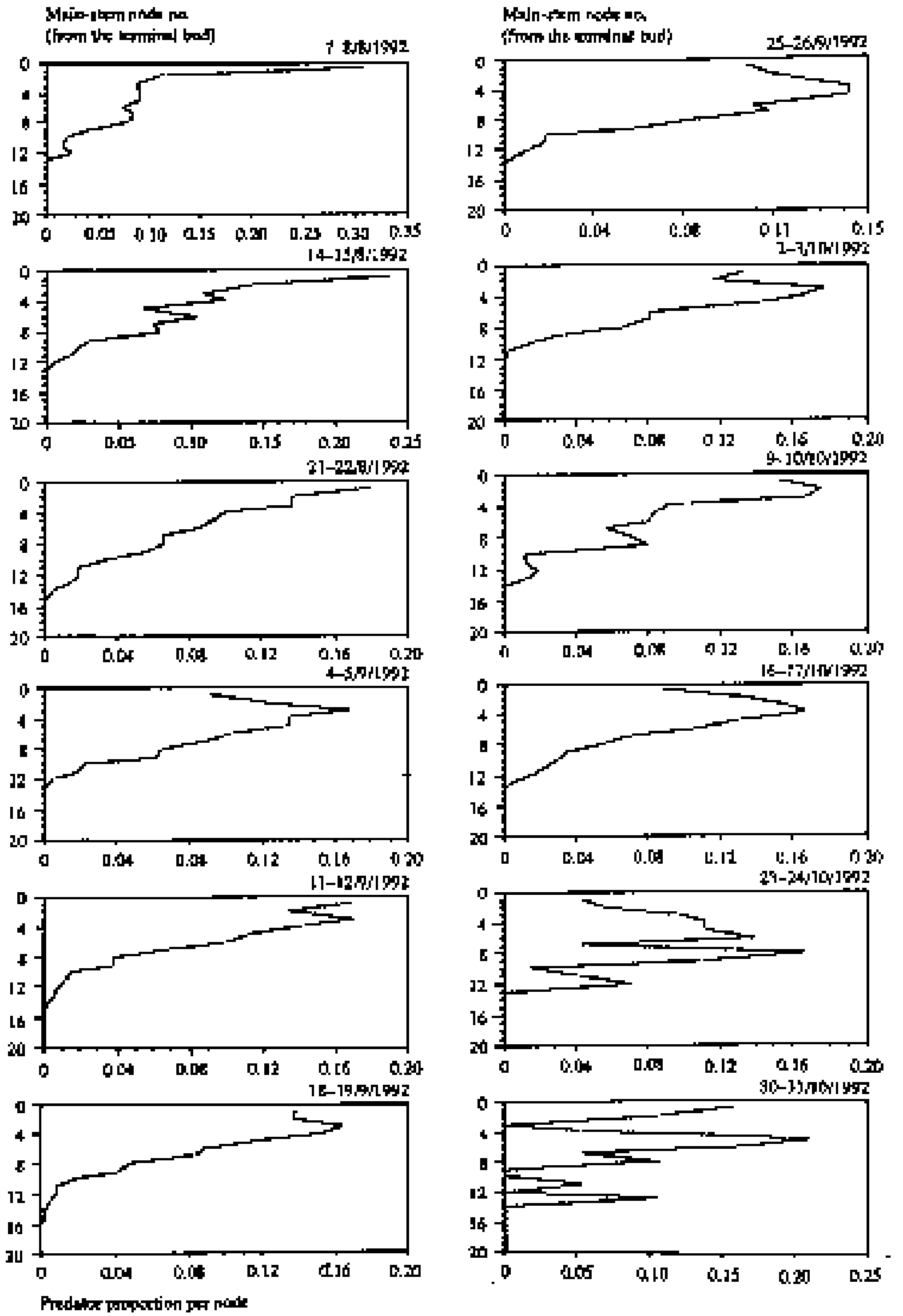

Figure 1. The within-plant distribution pattern of ants on chilli plant

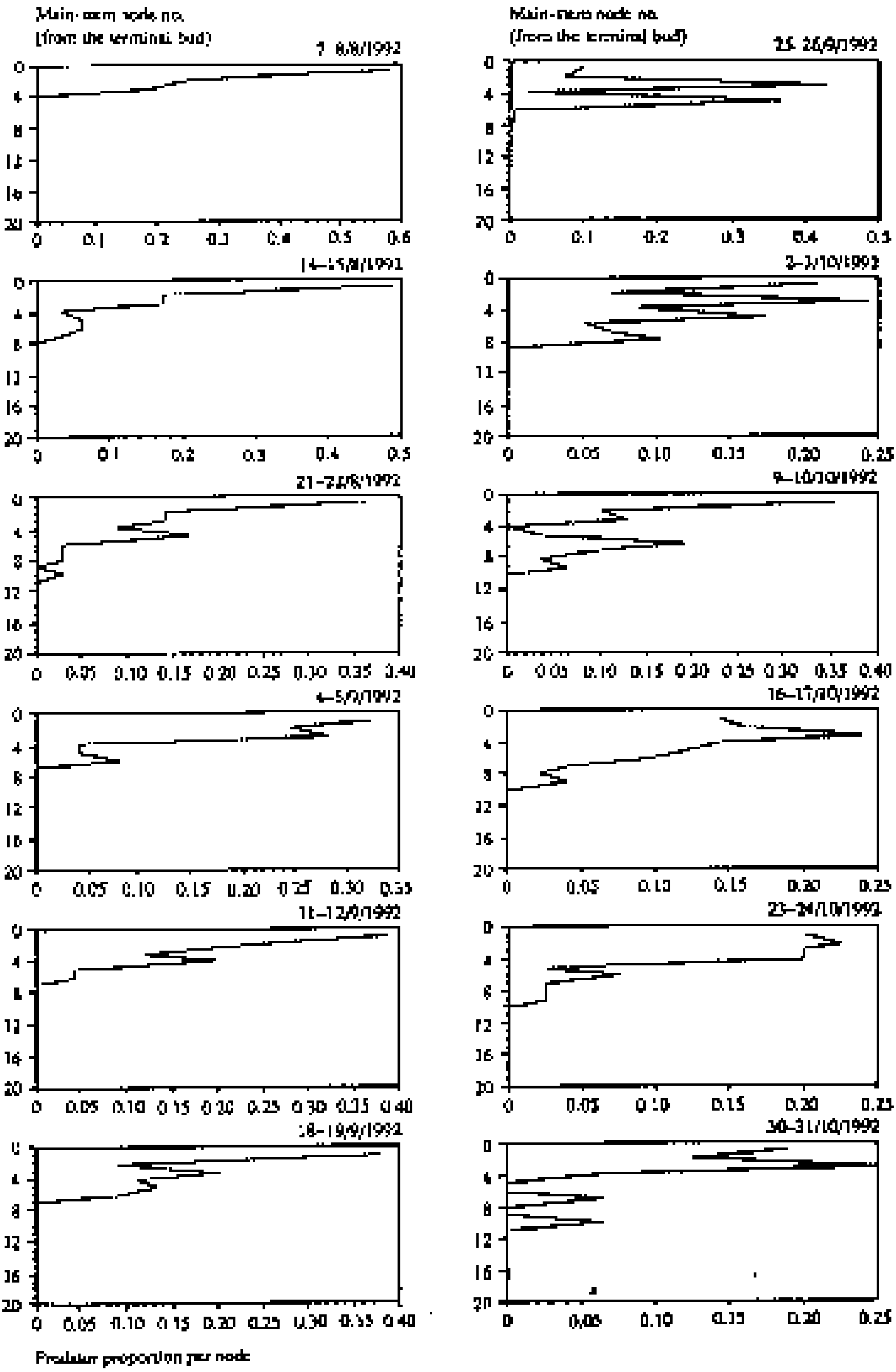

Figure 2. The within-plant distribution pattern of coccinellids on chilli plant

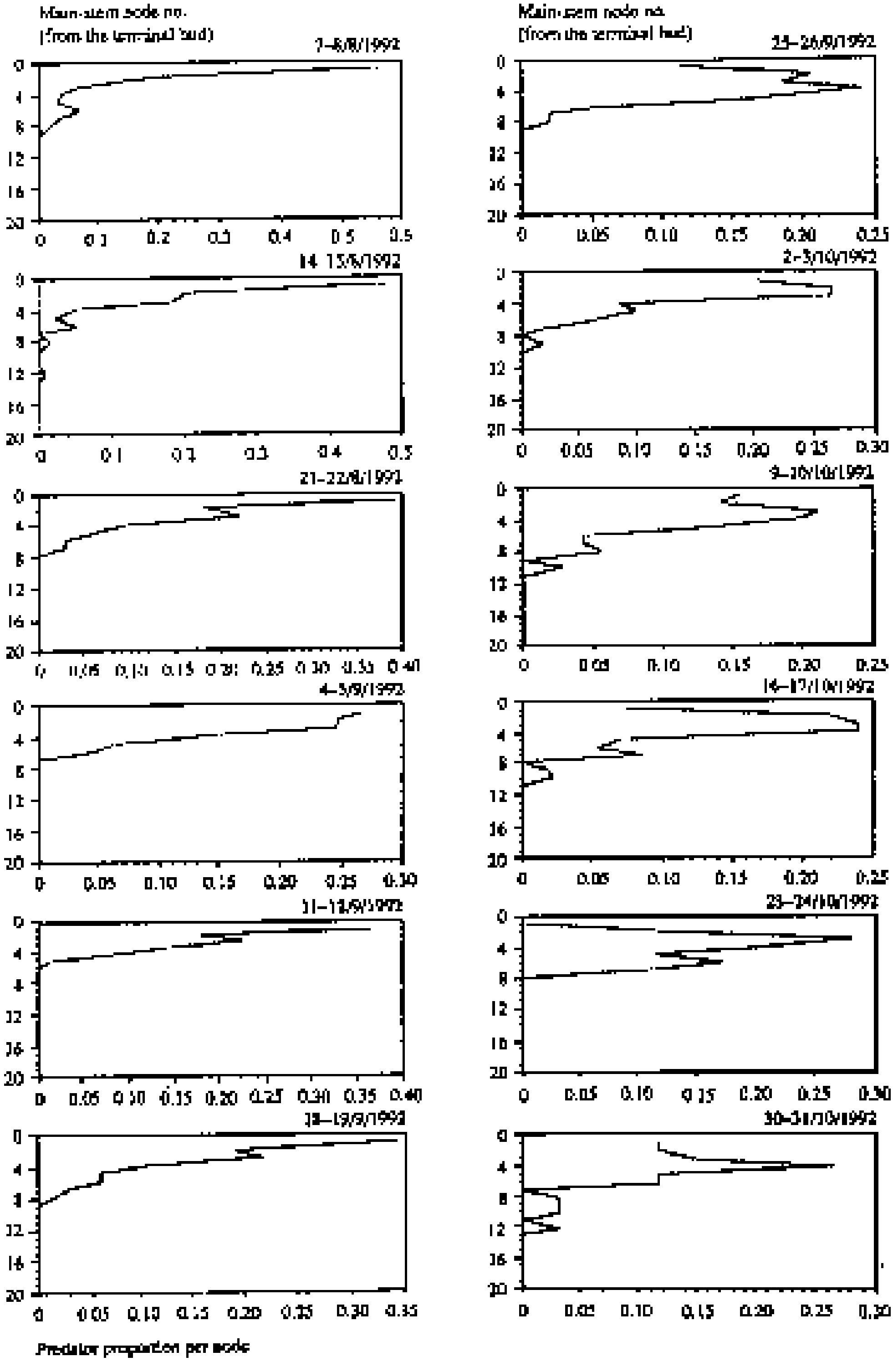

Figure 3. The within-plant distribution pattern of spiders on chilli plant

pests in the Philippines (Shepard et al. 1987). In China, ants had been used to control homopteran pests since 300 AD or earlier (Buckley 1987). Observable incidents of chilli leaf damage by leaf feeding insects were very low during this study. This could be due to the large numbers of ants attending the chilli plants and driving off any potential herbivores, and/or an interactive effect due to behavioral or physical component such as warding-off by the ants and chemical component such as semiochemicals.

This study found that generally all predators were more abundant in the upper main-stem nodes of the plants. In the first 3 weeks of chilli growth, the ants were more numerous in the terminal most region (main-stems node 0 to 3) than the other regions. It is interesting to note that on bigger plants, ants were more abundant below the terminal most part (main-stems 3, 4 and 5) starting soon after establishment of the seedlings.

According to Pickett et al. (1988), the within-plant distribution of the predatory thrips, *Franklinella occidentalis* (Pergade) (Thysanoptera: Thripidae), is broad and largely overlaps that of spider mites (*Tetranychus* spp.), a prey of the thrips in early season cotton. Similarly, this study has shown that ant distribution overlaps with that of *A. gossypii* largely due to the ants having symbiotic relationship with the aphids. Hassan, Hussein et al. (1992) found that the main-stem nodal locations of the *A. gossypii* in early stage of chilli growth were nearer to the terminal bud. However, when the plant grew, the nodal locations of infestation were further away from the terminal bud. Such changes in distributional pattern were followed closely by the ants, as recorded in this study

Notwithstanding the changing distributional pattern in ants, the within-plant distribution of coccinellids and spiders did not change in time corresponding with that of *A. gossypii* (Hassan, Hussein et al. 1992; Vehrs et al. 1992). This could be due to the influence of plant morphology and the ants. Grevstad and Klepetka (1992) showed that plant morphology can impede or facilitate movement of a predator, causing the predator to fall or otherwise making prey difficult to reach. On the chilli plant, developing leaves on terminal region facilitate the coccinellids movement, hence increase foraging success. In contrast, developed leaves on the lower region which are usually flatter, prevent the coccinellids from reaching aphids located at the centre of the underside of the leaves.

Other factors that influence the distribution pattern of the coccinellids and spiders are the presence and activity of the ants. Fritz (1982) reported that ant attendance significantly reduced the number of other predators on branches with treehoppers, *Vanduzea arquata* Say (Homoptera: Membracidae), compared with branches lacking both ants and treehoppers. Tills and Wood (1982) found that coccinellid larval numbers were smallest in aphid colonies with high ant attendance levels. Bristow (1984) reported results of his predator exclusion experiments as strongly indicating the protective role of ants in increasing homopteran colony survivorship. Our study further verified the role of ants attending to aphids on the plants and possibly preventing establishment of population of other herbivores on the chilli plant. Conversely, the presence of ants may repel other beneficials or natural enemies of the pestly aphids.

Age of plants too seems to affect the within-plant distribution pattern of the coccinellids and spiders. During the late season, the terminal-most part of the chilli plant shrivelled and the leaves fell because of the aging process and damage by the pests and/or virus. This situation changed the microclimate at the terminal part that was directly exposed to radiation from the sun forcing the pests and predators to move below the terminal-most area. As such, at the end of the studies, most of the predators were found more abundant further away from the terminal-most area.

The within-plant distribution patterns of arthropod on crops are important in many ways. Wilson et al. (1982) and Terry et al. (1987) in similar studies on cotton and soybean crops succeeded in reducing sampling cost by only considering the terminal part of the plant. Hassan, Jamaluddin et al. (1992) in a study on chilli crops suggested studying the within-plant distribution of the aphids through vertical zonation of the plant. In the study reported here, the number of aphids per plant can be calculated and extrapolated to the entire area of agro-ecosystem if necessary. Since almost up to 80% of the predators were found in zone one, therefore, we suggest that zone one be chosen as the sampling unit for visual sampling for predators on chilli plants. However, since this study was designated as a preliminary investigation to determine the optimum sampling unit, another study is needed to elaborately investigate quantitative aspects such as distribution parameters and optimum sample sizes.

In summary, it can be concluded that the predators (ants, coccinellids and spiders) were most abundant at the upper part of the chilli plants (main-stem nodes 0 to 5). However, this distribution pattern changed in tandem with the distribution pattern of the prey and plant aging. As the plant grew in time, its volume increased corresponding with the expanding architecture and canopy, hence also accounting for the increase in distribution of the arthropods throughout almost the entire plant. There are indications that ants seem to influence the within-plant distribution of the coccinellids and spiders perhaps through their more aggresive warding-off behavior. Consequently, it is possible to postulate that the distribution of ants through time may modify sampling reliabilities of affected arthropods. Zone one of the chilli plants is hereby suggested to be chosen as the optimum sampling unit for predators on chilli plants. In commercial chilli farms, monitoring and surveillance of populations of these major predatory arthropods can expedite and economize making decision on management of pest species, especially aphids, through immediate information on population status of the relevant predators.

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