CHAPTER – VIII

DISCUSSION

Although the mustard aphid, *Lipaphis erysimi* has been exemplified as an oligophagous pest capable of infesting plant species that belongs to Cruciferae, in recent years, it has been recognised as one of the ‘National Pests’ in view of its increasing problem on mustard/rapeseed and other cruciferous crops (Jayaraj, 1995). Considering its economic importance, a comparative assessment has been made in the present work by studying its breeding potential, growth and survival rate on four cruciferous plant species, since it is immensely important to know the above biological parameters of a pest on its plant hosts in a given agro-ecosystem before executing any control measures.

Biology of *Lipaphis erysimi*:

An attempt on its biology on rapeseed, local mustard, cabbage and knol-khol revealed that the aphid could complete its nympha1 development in 10 to 14 days (Table 1). The minimum and maximum period of its growth were recorded on rapeseed M-27 and cabbage respectively especially when they were reared during winter season during which the laboratory temperature ranged from 12 to 20°C. Goel & Singh (1993) observed the nymphal duration of 9 days on mustard which was found to be less than the present observation. This variation might be due to the effect of temperature and difference in plant varieties.
In general, the developmental period, fecundity and longevity of the aphid decreased with increasing temperature. For instance, Tripathi et al. (1986) noticed a nymphal duration of 4 to 6 days when reared on *B. juncea* var. *toria* at 27°C. Similarly, in the present study also the duration of nymphal development and adult longevity were significantly less at 25°C in comparison to that at 20°C (Table 5). Besides their survival rate, variation in reproductive rate of *L. erysimi* was also observed at different seasons in spite of rearing them on the same plant host. *Lipaphis erysimi* laid more nymphs in winter and significantly less number of individuals during spring and autumn (Table 5). Such differences being the resultant effect of variation in their reproductive period which in turn varies with different season. For example, the reproductive period of *L. erysimi* was found to be 12 days in winter, 7 and 6 days during spring and autumn and only 3 days in summer, consequently its fecundity rate indicated a diminishing trend proportionately from winter to summer (Table 5 & 6). It is well known that season or climatic effect has a profound role in determining the survival and reproductive rate of aphids (Dixon, 1985).

Although aphids by and large prefer to colonize at low temperature range by producing even sexual forms in winter (Raychaudhuri, 1980; Goel & Singh, 1993), species such as *A. gossypii*, *A. craccivora* and *M. persicae* also maintain appreciable density during other seasons in spite of the temperature being little high (Lal & Verma, 1986; Hijam & Singh, 1989; Raj, 1989). But in the present case, the study revealed that during summer *L. erysimi* maintained negligible population on its alternate weed host *C. arvensis* (Cruciferae), yet, the low temperature during winter appeared to be more conducive for nymphal development, reproduction and colony maintenance of *L. erysimi*. 
A comparative approach on the fecundity rate of *I. erysimi* on four crucifer hosts showed variation in its reproductive potential, even though they were reared simultaneously on each host during the winter season. The results exhibited that the average number of nymphs laid by *I. erysimi* was 56.4, 52, 40.4 and 36.8 per female when reared on the hosts—rapeseed, local mustard, cabbage and knol khol respectively. Such variation in fecundity reflected the suitability of the plant host for aphid colonization, i.e., the host on which high fecundity being noticed as most suitable/susceptible and with minimum fecundity as least preferred host (Table 1). Earlier studies relating to reproductive potential of *I. erysimi* showed 32.5 nymphs on *B. juncea* var. *tortia* (Srivastava, 1980) and 28 to 31 nymphs on cabbage during March (Roy & Pande, 1991). However, observations of the present work were comparable with that of Rana et al. (1994), who also noticed the nymphal output in the range of 47 to 51 per female on rapeseed and mustard crops.

The data pertaining to the life table prepared for *L. erysimi* on each plant host mentioned above also revealed that *B. juncea* cv. M-27 was an ideal host among the four crucifers, in terms of reproductive rate of the aphid (*Rₐ*), generation time (*T*) and the time required for doubling of aphid population (*DT*) (Table 4). Earlier studies on life table statistics of *I. erysimi* carried out by Phadke (1982) and Goel & Singh (1994) on few species of *Brassica* showed that their results on *Rₐ*, *DT*, *T* and *rₘ* i.e. intrinsic rate of growth were found to be comparatively less than the data obtained in the present work especially with reference to rapeseed and mustard plants (Table 4). These variations could be due to the difference in plant cultivars.
While comparing the life table analyses of \emph{L. erysimi} with that of other aphids such as \emph{Aphis fabae}, \emph{Acyrthosiphum pisum} (Frazer, 1972), \emph{Brevicoryne brassicae} (Verma & Makhmoor, 1988), \emph{Aphis gossypii} (Singh et al., 1993) in terms of $r_m$, DT, T and $R_a$, the present study clearly indicated that \emph{L. erysimi} could establish its colony little faster than other species mentioned above. Further, comparative assessment on the biology of \emph{L. erysimi} on four plant species also revealed that the rapeseed M-27 was found to be favourable host for the population build up of \emph{L. erysimi} under the agro-climatic conditions of Manipur and the preference of plant hosts in terms of suitability for colony formation being in the sequence of \emph{B. juncea cv. M-27} $>$ \emph{B. juncea var. rugosa} $>$ \emph{B. oleracea var. gongylodes} $>$ \emph{B. oleracea var. capitata}.

Population dynamics:

The primary objective of estimating the abundance of an insect population is to determine the pest status and activity of the insect in a given agro-ecosystem. Since the damage caused by an insect is generally considered as a function of the population density of that species, for assessing the infestation level and to appraise the extent of damage, it is imperative to monitor the pest population periodically (David & Kumaraswami, 1988). Further, informations pertaining to pests that infest the crop year after year are rather important from the view point of pest control programme (Pradhan, 1991). Considering these aspects in the context of present work, it becomes essential to know the above said factors in detail because \emph{Lipaphis erysimi} is a seasonal pest of cruciferous crops, inflicting damage every year especially under the climatic conditions of Manipur.
Seasonal occurrence of *L. erysimi*:

Regular sampling of the aphid density on four crucifer species over a period of 3 cropping seasons (1993-1996) revealed that the incidence of *L. erysimi* commenced from November and continued till February or March (Fig. 3-7). Since most of the crucifers grow during these months, aphids maintain their density continuously. Similar observation were also made by Bakhetia et al. (1986) and Phadke (1986) on the seasonal occurrence of *L. erysimi* on different species of *Brassica*. But the striking feature noted in this study was that the peak period of their abundance on each crop has been found variable. For instance, the density of *L. erysimi* was maximum on *Brassica juncea* in December, while that of cabbage and knol khol being January and February respectively (Table 8). Though, these plants harbour *L. erysimi* from November to March, during rest of the periods other hosts provide shelter to this aphid species. The present observation revealed that with the onset of spring aphids shifted their host to late variety of cauliflower and some populations were maintained on the local variety of mustard *B. juncea* var. *rugosa*. Later, during summer negligible individuals of *L. erysimi* were observed on weed host *Cardamine hirsuta* and in autumn they maintained their colony on the mid variety of cabbage and cauliflower. Subsequently, during winter they began to infest the crucifer crops and thereby the cycle continued (Fig. 10). Although, under natural condition they occur throughout the year with the availability of different varieties/species of crucifers, they exhibit more density only during winter months. This aspect is being supported by the seasonal biology of mustard aphid carried out in the present work (Table 5 & 6), which suggests that cold climate is conducive for reproduction and population build up of *L. erysimi*. Sinha et al. (1990) and Rajendran & Phadke (1992) were also of the view that winter is the suitable season for this aphid to strengthen its colony on mustard crops.
Density of *L. erysimi*:

While considering the numerical density of this aphid on different crucifers, the study revealed that mustard and rapeseed could harbour comparatively more individuals than non mustard crops like cabbage and knol-khol (Fig. 3-7). It means that *L. erysimi* prefers *Brassica juncea* for breeding and colonization in comparison to *Brassica oleracea*. This observation gains further support from the data on comparative biology of the aphid, wherein more fecundity (50-56 nymphs) on mustard and rapeseed plants and proportionately less fecundity (36-40 nymphs) on cabbage and knol-khol have been recorded (Table 1). Since, breeding potential of an insect species projects the population size of that species (Southwood, 1966), the number of nymphs laid by *L. erysimi* is also expected to give an idea on the density of this aphid in the above mentioned plant hosts. While viewing this aspect in terms of feeding, breeding and their density, it appears that the common name 'mustard aphid' is very much relevant to *L. erysimi*.

The population distribution of aphids on the leaves of different strata showed significant variation with dense population at lower strata, less density at middle level foliage and negligible number of aphids at the apical level. Though biochemical analysis indicating differences between the leaves of different strata has not been attempted in this work, still, based on the available informations relating to other hosts, it may be interpreted that such dense distribution of aphids on lower level leaves may possibly be due to the presence of more nitrogenous material on the leaves that are approaching senescence, which in turn enhance the reproductive rate of the aphid (Dixon, 1986; Banerjee & Raychaudhuri, 1987).
Morph composition:

Studies pertaining to morph composition of *L. erysimi* showed the presence of three different morphs such as nymphs, alates and apterous forms. Among them, nymphs outnumbered the apterous and alate adults (Fig. 8). This pattern of morph composition appeared to coincide with that of other aphid species in general (Ghosh & Mitra, 1983; Debaraj, 1993; Singh, 1993). However, out of the four crops, the nymphal density was found to be significantly more on the rapeseed M-27 in comparison to other plant species. Since the abundance of nymphs being an index of fecundity rate, significantly high proportion of nymphs on *B. juncea* cv. M-27 reflects the suitability of that plant for aphid colonization than that of other crucifers.

Aerial activity of aphid:

Among the ploymorphic forms, the alate adults i.e. winged aphids are responsible for immigration, dispersal and emigration. Studies on the trap catches of aphids are useful clues to predict the appearance of aphids and colony establishment on the plant host. For the collection of air borne aphids, yellow pan water trap is generally used because this method is simple, economic and efficient. Moreover, it is also known that winged aphids are attracted to yellow colour. This was demonstrated by several workers in different aphid species (Ghosh & Raychaudhuri, 1983; Rajendran & Gulab, 1990; Debaraj & Singh, 1996).

Observations on the trap catches revealed that the aphids began to appear from the first week of November and attained peak population during December after which the population declined gradually (Fig. 5). It showed that the occurrence of mustard aphid
was only during specific period and during the off season they might inhabit other hosts. Similar result was also observed by Hughes (1963) on cabbage aphid, who also reported that the aphid was restricted to a particular period of the year since its host plants are not perennial. The present observation revealed that the peak population of alate was found coincided with the maximum abundance of aphid on the crop. Similar observation was recorded in case of cabbage and green peach aphids (Bahana & Karuhize, 1986; Lal & Verma, 1986). Analysis of the data revealed that the number of alates trapped was negatively correlated with temperature, relative humidity and rainfall which being same with that observed by Ghosh (1975), Debaraj (1993) and Singh (1993).

**Impact of abiotic factors on aphid density:**

Aphids being a soft bodied insect, are vulnerable to abiotic factors (Dixon, 1985). Among these factors, effects of temperature, relative humidity and rainfall on the density of *L. erysimi* were taken up in the present study. The correlations of these factors with aphid density showed a negative relation with temperature and rainfall and a weak positive correlation with humidity (Table 7). Chandra & Khushwaha (1986) also observed a negative relation between temperature and populations of *L. erysimi* and positive relation with relative humidity under the agro-climatic conditions of Udaipur. Phadke (1986) reported that low temperature had a profound influence on the incidence of mustard aphid. The present result also showed that low temperature during December and January with the range of 10 to 15°C favoured the multiplication of aphid as a result the population attained maximum abundance during these months. However, Bakhetia & Sidhu (1983) have computed 22.6 to 25°C as optimum temperature for the growth of
mustard aphid, which was found to be little on the higher range than the present data. But while considering the result obtained from the comparative biology of *L. erysimi*, the study suggests that low temperature of 10 to 15°C appears to be ideal for aphid's growth and breeding.

In addition to temperature, relative humidity and rainfall also affected the populations of *L. erysimi*. The field data of the current work showed that the maximum abundance of aphid was recorded in December during which the relative humidity ranged from 60 to 75% with no rainfall. Bakhetia & Sidhu (1983) reported that 53 to 90% as the favourable relative humidity for the population maintenance of *L. erysimi* whereas Bakhetia *et al.* (1986) and Sinha *et al.* (1990) observed that 55 to 77% RH as ideal range, which being in conformity with present result. Although RH indicated a weak positive relation with aphid abundance, the data on rainfall showed a non-significant negative correlation (Table 7). Earlier studies highlighted that populations of *L. erysimi* were affected by the intensity of rain (Roy, 1975), but in the present work there appeared to be no instances of destabilising the aphid density with the effect of rain. However, the negative correlation obtained in the analysis asserts that rainfall and temperature on the higher range indirectly restrict the population size of *L. erysimi* on crucifers especially during November to March.

**Role of natural enemies:**

Predators and parasitoids are the two important groups which help to keep the pest population within the range of economic threshold level (Atwal *et al.*, 1971.
Dhiman et al., 1987; Shenhar & Brar, 1995). The crucifer crops are also endowed with an array of such natural enemies in order to protect them from invading insect pests (Atwal et al., 1971; Chandra & Khushwaha, 1987). With particular reference to the mustard aphid, a number of aphidophagous insects (Agarwala et al., 1989; Chitra et al., 1997) and also few hymenopteran parasitoids have been reported from the mustard crops, of which the primary parasitoid *A. rapae* could alone bring about the parasitism of *L. erysimi* to the extent of 41 to 63% under the field conditions (Dhiman & Kumar, 1986). However, its parasitic activities were found to be less than 5% in Manipur during the period of present work.

On the other hand, 7 species of syrphids, 3 species of coccinellids and a neuropteran predator were observed in the aphid colonies of crucifers during this study. The density of these predators showed significant positive relation with the abundance of aphids in all the four crops (Table 7) reflecting appreciable chances for biocontrol of *L. erysimi* through these aphidophagous insects. Agarwala et al. (1987) also found the association of 4 coccinellids and 9 syrphid species with *L. erysimi* on mustard crop in Tripura, indicating the predominance of syrphids over the rest which also being evident in the present work. However, Gautam (1989) is of the view that although syrphid’s composition and density are more in mustard, the role of coccinellids cannot be ruled out and the ratio of syrphids and coccinellids may vary with plant system.
Seasonal occurrence and voracity of predators:

The occurrence of all the predators did not show any sequential pattern over time but most of them overlapped with one or another species. Some species were observed during the specific period and some other occurred throughout the cropping period. For example, *E. balteatus*, *L. scutellaris* and *C. transversalis* were noticed in the field along with the aphid for a longer period while *P. serratus* and *Sphaerophoria* sp. occurred only for a specific period from December to January (Fig. 13).

Biotic interactions among the predators of *L. erysimi* showed a wide variation in terms of consumption. It ranged from 67 to 774 aphids/predator in different species. Among the syrphids, the highest feeding rate was exhibited in *B. serarius* and the minimum was observed in *P. serratus* (Table 11). *E. balteatus* and *L. scutellaris* did not show much variation between them. The instar-wise consumption also showed significant variation which increased with age/instar of the larvae. Of all the 11 species the present result revealed that *B. serarius* and *M. confrater* were more efficient than the rest because they consumed 774 and 641 individuals of *L. erysimi* over a period of 13 and 16 days respectively (Table 9). Though the voracity varies with varied predators, it also depends on the prey species too. For instance, *M. confrater* devoured as much as 300 individuals of *Cervaphis quercus* (Shantibala et al., 1994) while Agarwala & Saha (1986) observed the consumption of *M. confrater* as 886 individuals of *Aphis gossypii*. The present study showed that the same predator consumed 641 individuals of *L. erysimi* which was found to be different than the results of other workers. It proved variation in consumption rate due to aphid species. In some cases the feeding rate is influenced by the temperature and
other rearing conditions (Veeravel & Bhaskaran, 1996), prey preference (Agarwala & Saha, 1986). However, in Paragus serratus, the larval voracity per predator was found to be 160 aphids when fed on T. auranntii (Radhakrishnan & Muraleedharan, 1993) which was at par with the present result.

Yet, another aspect of prey-predator interaction discussed herein is the relation between body size of predator and their feeding potential. The result showed that the feeding rate was significantly correlated with length and width of predator indicating that bigger the body size higher the consumption rate and vice versa (Table 11). For instance, the feeding rate of B. serarins was appreciably high as a result body size (length and width) also comparatively bigger than other predatory species. On the other hand, the minimum length and width was observed in M. timidus which showed less voracity. This revealed that the feeding efficiencies of predators were directly proportional to their body size indicating the dependence of predator on prey for their growth and development. This result corroborates the findings of Shantibala et al. (1994), who reported a significant positive relation between body size and prey consumption rate with reference to oak aphid and its associated predators. Agarwala et al. (1989) also observed similar relation between syrphid and cruciferous aphids. Similar to body size, the pupal weight of syrphids were also found to be directly proportional to their prey consumption (Fig. 11) and correlations of this kind were also known from tea aphids and syrphids (Radhakrishnan & Muraleedharan, 1993).
**Tritrophic relations:**

Studies on the mustard aphid, syrphid and mustard plant throw light on the occurrence of tritrophic interactions among them, therein each one is benefitted at the expense of the other. This triangle network having the feature of interdependence is schematically represented in Fig. 15, which highlights three important biological phenomena such as pollination, predation and plant parasitism. Adult syrphids pollinate the mustard flower while their larvae feed on the aphids by virtue of their predatory habit. Aphids basically being a group of plant parasites, derive food from mustard plant and breed enormously in order to withstand the pressure of predation. Thus one can come across the Tritrophic interdependent associations among the mustard plant – aphid and syrphid predators.

While analysing this interaction it is not only their interdependence but intricacies existing in their association have also been seen to some extent. Basically it appeared to be the master plan of the plant to attract aphids and syrphids for definite functions, of which pollination by syrphids seems to be the primary objective. Syrphids invariably visit the plant only when there is aphid infestation. The mustard plant attracts aphid (*L. erysimi*) by its by-product Sinigrin. It is well known that this plant metabolites plays crucial role in cruciferous plant selection by mustard aphid (Klingauf et al., 1972; Nautl & Styer, 1972). On host selection, aphids multiply and produce large colonies on young leaves and tender shoots of the plant. This facilitates syrphids to oviposit eggs on the aphid infested plant and derive floral resources (Pollen and nectar) from mustard flowers (Agarwala et al., 1988). The latter event eventually leads to pollen transfer from one
Fig. 15 - Tritrophic relations among the plant host-prey and predator
flower to another. Since, syrphids lay eggs in the midst of an aphid colony, the emerging syrphid larvae are rest assured of getting food in their vicinity. The predation by syrphid larvae limits the population build up of aphids and save the plant from severe infestation Thus, each one is benefitted in the tritrophic level.

Impact of aphid feeding on the plant host:

It is well known that aphids are phloem feeders. When aphids pierce the tissue and suck the sap from phloem cells, changes occur in the foliage. These changes are morphological, anatomical and biochemical in nature. Morphological changes like yellowing, curling, twisting of foliage, drying up and stunted growth of the plant are common features as a result of aphid infestation. The intensity of such symptom would vary according to aphid’s density and feeding pressure. Amzad & Peters (1990) and Singh & Verma (1990) also reported similar morphological changes in mustard as a result of L. erysimi feeding. The above mentioned symptoms were also observed in plants like cabbage, tea, prunus, ornamental plants, etc. (Bahana & Karuhize, 1986, Medda et al. 1986; Mani & Krishnamoorthy, 1989; Sood & Kakar, 1989; Muraleedharan, 1992), wherein they reported that due to aphid feeding, the vitality of the plant was reduced and consequently the plants exhibited retarded growth. In sycamore plant, the size of the leaf and length of the twig were reduced due to aphid attack (Dixon, 1973).

In case of anatomical changes, the leaf sections of B. juncea var rugosa showed the presence of stylet sheath in between the cells (Plate 10 d). It indicated that the penetration of rostrum is intercellular. Dixon (1973) is of the opinion that most of the
aphid species insert their stylet in between the cells. The rostrum penetration is assisted further by secretion of saliva which passes down the salivary duct in the maxillary stylet and is exuded from the tip of the stylet bundle. The enzyme pectinase present in the aphid's saliva helps in breaking down the bonding between the cells (Dixon, 1973).

In the shoots of B. juncea cv. M-27, the penetration of its sucking apparatus was found to be through inter and intracellular space of cortex region. This might possibly be due to the presence of thickly packed parenchymatous cells in cortex. The intracellular penetration of stylet was also evident in some cases. As for example, *Myzus persicae* and * Macrosiphum euphorbiae* insert their rostrum into the potato leaf through intracellular region (Pollard, 1973). The penetration depth is marked clearly in the infested leaf (Plate 11 c) by the formation of stylet sheath which perhaps be due to the resultant effect of deposition of certain chemical substances. Dixon (1973) stated that the stylet sheath is a protein substance of insect origin secreted from the salivary gland.

Comparative analysis between the length of rostrum and depth of phloem showed that the rostrum length was significantly more than the depth of phloem. It indicated that the aphid could easily puncture the plant tissue and insert its rostrum upto the phloem and suck the cell sap from it. The present result was in conformity with the finding of Gill & Rataul (1990), who compared the proboscis length of 6 aphid species and depth of phloem of their respective plant species in the context of virus transmitting efficiency of the aphids.
The change in the level of primary as well as secondary metabolites of the host leaf are bound to occur as a result of feeding, especially when the aphids pierce and suck the cell sap. As a consequence, the plant system is triggered to withstand the feeding pressure of the herbivore, which eventually leads to synthesis of plant products (Ananthakrishnan, 1993). Such kind of changes have been noticed in the aphid infested leafsheaths of *B. juncea*. For instance, the quantity of the plant metabolites like carbohydrate, protein, lipid and nitrogen components were found to be more in aphid infested foliage when compared to normal leaves (Table 13). Similar result of increase in carbohydrate content was also noticed in aphid induced leaf galls (Chakrabarti & Chakrabarti, 1990). The increase in carbohydrate level is possibly due to some changes in metabolism and transport of the produce to the site of infestation. But Dixon (1973) showed that chlorophyll content in the infested leaf was more than that of normal leaf and hence more carbon fixation through photosynthesis resulting in higher level of carbohydrate in the aphid infested leaf.

This trend of enhanced level of primary metabolites appear to be a common phenomenon especially in cases where the feeding injury is caused by sucking pests (Ananthakrishnan, 1993). One of the views on higher level of protein accumulation is that it promotes tissue repair function of the insect fed-necrotised area (Raman & Ananthakrishnan, 1983). But Chandraguru et al. (1987) is of the opinion that the trigger in elevating the level of primary metabolites could be considered as a consequence of insects activating the growth potential of leaves through the formation of adaptive tissues, thereby enabling the plant to cope with the herbivore’s pressure on feeding.
In addition to the primary metabolites, the increase in total phenol was also noticed in aphid fed foliage (Table 13). Accumulation of phenolic compounds in infested leaf could be either in response to feeding stress or even as a function of phenological event (Abrahamson et al., 1991). However, higher levels of phenol in the foliage suggest a direct relationship with herbivore stress as a defense response. The term "defense" implies tissue responses by elevating the levels of phenols which is considered detrimental to feeding. In addition to that, phenols play pivotal role in wound healing and in regulation of plant growth hormones (Janzen, 1977). The observations recorded in the present investigation also suggest a similar relation, indicating the fact that the plant *B. juncea* var. *rugosa* also exhibits defense mechanism and wound healing against aphid infestation by enhancing phenol level.

Further, while comparing the phenol content of the three plant hosts examined in this work, the oilseed *B. juncea* cv. M-27 showed lowest range in comparison to *B. juncea* var. *rugosa* and *C. hirsuta* (Table 14). While correlating the aphid’s performance with that of phenol content of the hosts, appreciably high fecundity rate and less duration in nymphal development of *I. erysimi* were observed on the rapeseed *B. juncea* cv. M-27, while *C. hirsuta* indicated less fecundity and little delayed nymphal development (Table 14). This correlation has also revealed the fact that low phenol content of the plant promotes insect growth and colonization and vice versa.

The rate of increase in population of an insect also depends upon the nutritional composition of the plant host, since the latter influences the feeding behaviour of the
phytophagous insects to a significant level (House, 1969; Ananthakrishnan, 1992), which in turn determines the fecundity and colonization capacity of the insect (Dixon 1966, van Emden & Bashford, 1969; Banerjee & Raychaudhuri, 1987). This aspect has been studied in the present work wherein the performance of the aphid *L. erysimi* was correlated with the quantity of plant primary metabolites present in three crucifer plant species. Analysis of the result showed the presence of higher level of carbohydrate, protein, lipid and nitrogen in *B. juncea* cv. M-27, followed by *B. juncea* var. *rugosa* and *C. hirsuta* (Table 14). The performance of the aphid in terms of nymphal development and fecundity rate was also found to be better on rapeseed M-27 followed by *B. juncea* var. *rugosa* and *C. hirsuta* reflecting that higher levels of plant metabolites enhance the fecundity rate of *L. erysimi* and promote faster growth of their nymphs.

The above observation was in agreement with that of Sachan & Sachan (1991) who observed a significant positive correlation between *L. erysimi* population and sugar content of *Brassica* cultivars indicating that higher amount of sugar is needed to promote better survival of the aphid. Equally important component being the nitrogen content of the plant, since it also modulates the flush growth of the plant which are target sites for aphid attack (van Emden & Bashford, 1969). The relations between nitrogen content of the foliage and reproductive performance of the aphids have been highlighted by a number of workers (Dixon, 1966; Banerjee & Raychaudhuri, 1987; Dhari et al., 1995) and they observed that the quantity of nitrogen in the foliage could play an important role in colony maintenance of aphids. Greater the availability of carbohydrate and nitrogen and thereby narrow range of C/N ratio of the plant result in increased egg output and quick
development of insects (Ananthakrishnan, 1992). Such situation being evident in the present system wherein *B. juncea* cv. M-27 exhibited appreciable level of primary metabolites and less content of phenol with proportionately narrow range of C/N ratio in comparison to other crucifers examined. These factors perhaps paved the way for promoting faster growth of nymphs and also significantly higher fecundity rate of *L. erysimi* on *B. juncea* M-27 than the rest of the *Brassica* species. On the basis of which, it can be considered that the rapeseed *B. juncea* M-27 as the primary plant host of *L. erysimi* among the cruciferous plants studied.

**Chemical control of *L. erysimi***:

Despite the fact that many methods are available for the field control of insect pests, only chemical control is considered as a method for quick relief from insect pests and hence it is widely employed in spite of many side effects. However, it would be ideal to use those pesticides which are comparatively good in combating the pest problem but at the same time cause less/minimum disturbance to ecosystem and environment. Keeping these points in mind, efficacy of compounds such as endosulfan, phosalone and the neem product bioneem were field tested against *Lipaphis erysimi* on the rapeseed cv. M-27 under the agro-climatic conditions of Manipur. The results of the field trial showed that the percentage efficacy and seed yield of all the three chemical treatments were found to be significantly better than untreated control. The chemical insecticides – phosalone and endosulfan gave an average of 72.8% and 63% control of aphids respectively, whereas bioneem could reduce the density of *L. erysimi* only to the extent of 51.5%.
The efficacy of these chemicals against aphids has been studied by a number of workers but their results revealed some variation between them. For instance, Kotwal & Singh (1994) reported that the effectiveness of endosulfan (0.07%) began to diminish after 5th day of spray and Yadav et al. (1988) indicated its efficacy to the extent of 80% and the effect lasted for about 15 days after application. But the present study showed 63% reduction of *L. erysimi* in endosulfan (0.05%) treated plots and its effect lasted for nearly 12 days (DAS). While comparing the efficacy of endosulfan, phosalone (0.05%) yielded appreciably better effect in the field control of *L. erysimi*. This observation made in this work being corroborated by that of Kotwal & Singh (1994), who also noticed significantly higher efficacy of phosalone than endosulfan. But, in case of bioneem, the percentage control of aphid was only 51.5% and this being significantly lower than that obtained with synthetic pesticides. In other words, unlike endosulfan and phosalone, the plant product bioneem was not so effective in reducing the density of *L. erysimi*.

Neem has insect repellent and antifeedant properties, besides suppressing the growth and development of insects (Subrahmanyan, 1990). The adverse effect on population growth has also been observed among aphids as a result of application of neem products (Schmutterer, 1990). As for instance, Pandey et al. (1987) tested the effect of certain plant extracts against mustard aphid and observed that the treatment with *Azadirachta indica* gave a reduction of 60% aphids than other plant extracts. Similar result was also obtained by Mani et al. (1990) who reported cent percent mortality of *L. erysimi* at a concentration of 1.5% neem oil. Likewise, the pea aphid also responded to the extent of decreasing their density to a level of 61% after 72 hours of treatment with
neem product. These results are in a way comparable with that of present work wherein 51% reduction of aphid population being evident with the application of bioneem at a concentration of 0.3%. In the light of the above background, it can also be viewed that by increasing the concentration of bioneem little more than 0.3%, there is scope for getting higher efficiency of aphid’s control using this neem product. However, data on the field trials showed that single spray would be enough to control aphid problem on B. juncea cv. M-27 during each season, especially under the agro-climatic conditions of Manipur. On the other hand, more than one spray had been used in other areas for the field control of L. erysimi (Sharma & Adlakha, 1986; Awchar et al., 1995; Dingra et al., 1995).

Besides chemical control of the pest, impact of insecticides on the density of the predator was also recorded during the period of observation and it revealed no significant difference on predator density before and after spray of insecticides in the respective treatments (Fig. 14). But the abundance of predators on chemical insecticide treated plots showed a marginal reduction than the plots treated with bioneem. Similar result was also obtained by Sharma & Adlakha (1981; 1986) who reported that endosulfan and phosalone were comparatively safe to the Coccinellid, C. septempunctata. In other species like M. sexmaculatus, Dingra et al. (1995) observed that endosulfan, lindane and methyl demeton were less toxic to the predator.

It was not only the predator, even the density of parasitoid also appeared to be unaffected in the plots treated with monocrotophos. For instance, Awchar et al. (1995)
showed that monocrotophos was safer to *D. rapae*. While comparing the above reports with the present work, it can be considered that endosulfan, phosalone and bioneem are quite ideal for the control of *L. erysimi*, since they did not affect much on the density of aphidophagous insects and this in turn paves way for biocontrol of the mustard aphid.
SUMMARY

1. Basic bio-ecological aspects such as duration of nymphal development, longevity, fecundity rate during different seasons, age specific life table, seasonal incidence, population dynamics in relation to density dependent and independent factors and natural enemy complex of *Lipaphis erysimi* have been studied under the valley climatic conditions of Manipur on four Cruciferous plants namely:

   (a) *Brassica juncea* var. *rugosa*
   
   (b) *Brassica juncea* cv. M-27
   
   (c) *Brassica oleracea* var. *capitata*
   
   (d) *Brassica oleracea* var. *gongylodes*

2. The results obtained from the basic biological studies enabled to construct age specific life table for *L. erysimi* on each host separately. The important parameters like reproductive rate (*R₀*), generation time (*T*), population doubling time (*DT*) and intrinsic rate of increase (*rₙ*) were calculated. Among the four hosts, *R₀* and *rₙ* values of the aphid were found to be high on rapeseed and minimum on cabbage whereas values of *T* and *DT* were less on rapeseed and more on cabbage plant (Table 3). In general, for the population build up of any pest, the insect should exhibit high *R₀* and *rₙ* as well as low *T* and *DT*. In the present study, *L. erysimi* showed the above trend when reared on the rapeseed plant.

3. Based on the performance of *L. erysimi* in terms of its survival capacity and reproductive potential, the suitability of plant hosts can be considered in the following sequence i.e. *B. juncea* cv. M-27 as highly suitable, followed by *B. juncea* var. *rugosa*, *B. oleracea* var. *gongylodes* and *B. oleracea* var. *capitata*. 
The data on the seasonal biology of *L. erysimi* on *B. juncea var. rugosa* during autumn, winter and spring seasons revealed that nymphal duration, longevity and fecundity were significantly more during winter, while the data did not show much difference in autumn and spring (Table 5), reflecting the fact that low temperature being more favourable for colony maintenance.

Similarly, comparison of biology of the mustard aphid by rearing them on a weed host *Cardamine hirsuta* during summer and winter season indicated that winter season was more conducive for the development and breeding of *L. erysimi* (Table 6).

The seasonal incidence of *L. erysimi* on these four crops studied over a period of 3 cropping seasons (1993-1996) showed that aphid infestation commenced in November and continued till February/March. The population trend of the aphid was found to be almost same in all the three crop seasons.

Though mustard aphid maintained appreciable population during November to March, screening of other crucifer varieties/hosts revealed that different crucifers at different seasons support the colony maintenance of aphid throughout the year (Fig. 10).

The data on morph composition of *L. erysimi* exhibited the presence of 3 morphs i.e. nymphs, apterous and alates, of which nymphs outnumbered the density of alate and apterous form in all the four crops (Fig. 8). The populations of the alates were monitored using yellow pan water trap to predict their arrival and initial stage of infestation.

The density of aphid varied in different host plants. For example, the maximum aphid population encountered in each host was 380 on *B. juncea var. rugosa*, 80 on *B. juncea* cv. M-27, 50 and 28 individuals/unit sample on cabbage and knol-khol. Though *B. juncea var. rugosa* was found to harbour maximum population but in terms of unit area.
the population was dense on the rapeseed M-27. The aphid’s peak period of occurrence was found to be during December for the mustard and rapeseed crops, January and February for cabbage and knol-khol respectively.

10. The colonization pattern of aphid on different strata of the plant revealed that lower leaf could harbour maximum aphid, followed by middle and upper leaves in case of mustard, cabbage and knol-khol, while the aphid density was significantly more on young shoots of rapeseed as compared to its foliage.

11. Analysis of aphid density with that of biotic and abiotic factors showed significant positive correlation between aphids and aphidophagous insects (biotic factors) in terms of their density, whereas negative correlation was evident between aphid population and abiotic factors like temperature, humidity and rainfall.

12. During the study, natural enemies comprising of 7 species of syrphids, 3 species of coccinellids and a neuropteron predator were noticed in the aphid colonies of L. erysimi, besides sporadic incidence (< 5%) of the parasitoid Diaeretiella rapae. The field observation indicated that by and large syrphids were dominant in terms of density and species composition besides their voracity and hence they could play an important role in the population regulation of aphids under natural conditions.

13. The impact of aphid feeding exhibited distinct morphological, anatomical and biochemical changes in the plant foliage/shoot. Notable among them were presence of stylet sheath, rostrum penetration through inter and intracellular region, vascular bundle disorganisation and presence of more quantity of carbohydrate, lipid, protein, nitrogen and phenol in the aphid infested foliage (Plate 10d & 11c) (Table 13).
14. The host suitability of the aphid was also studied by comparing the levels of certain plant metabolites and performance of the aphid. On the basis of which, the study highlighted that the rapeseed was more suitable for the population maintenance of *I. erysimi* in comparison to other crucifer hosts perhaps due to the presence of more quantity of protein, lipid, carbohydrate, narrow range of C/N and phenol in *B. juncea* cv. M-27 (Table 14).

15. Experiments for the control of aphids under field conditions using the insecticides indicated that phosalone was better than endosulfan and bioneem and their mean efficacy being 72.8%, 63% and 51.5% respectively. The increase of crop yield also followed the same pattern with maximum in phosalone treated plots and less in bioneem and least in control plots.
BIBLIOGRAPHY


*Watson, T.I. (1964). Influence of host plant conditions on population increase of
Tetranychus telgrius (L.) (Acarina : Tetranyidiidae) Hilgardia, 35(11) : 273-322

antifeedant effects of Azadirachtin in aphids In Aphid plant interactions :
Populations to molecules (ed. D.C. Peters, J.A. Webster and C.G. Chlouber)
Proc. of the International Symposium, Oklahoma, U.S.A. : 305

Yadav, L.S. and Kalra, V.K. (1990). Incidence of Lipaphis erysimi (Kaltenbach) on
mustard in the south western region of Haryana J. Aphidology, 4(1&2) : 65-66

red morphs of green peach aphid, Myzus persicae (Sulzer) on mustard crop J
Aphidol., 5(1&2) : 115-117.

Yadav, P.R., Yadav, L.S and Dashad, S.S. (1988). Comparative efficacy of some
insecticides against the aphid, Lipaphis erysimi Kalt. on cabbage crop Indian J
Ent., 50(1) : 61-68.

Yakhontov, V.V. (1966). Coccinellidae and syrphidae as predators of aphids in
Uzbekistan. In Ecology of aphidophagous insects (eds. I. Hodek) Dr W Junk
Publisher, Prague : 267-269.

Zaman, Muhammad. (1990). Evaluation of foliar insecticides against the mustard aphid
on rape in Peshwar (Pakistan). Indian J. Ent., 52(4) : 565-569.

black sticky traps compared with collection from bean leaves and water pan traps
J. econ. Ent., 60 : 242-244.

* Original not referred.
Appendix
IMPACT OF PREDATORS ON THE FIELD POPULATION OF LIPAPHIS Erysimi (KALT.) INFESTING MUSTARD

L. Chitra Devi, T. K. Singh & R. Varatharajan
Aphid Research Laboratory, Department of Life Sciences, Manipur University, Canchipur, Imphal - 795 003, India

Abstract: The role of predators in regulating the field population of the mustard aphid, Lipaphis erysimi (Kalt.) was studied for two crop seasons (1993-95). Seven species of syrphids and three species of coccinellids were found predating the mustard aphid. Among them, Epius phryses helicatus (De G.) (Syrphidae) and Coccinella septempunctata Linn. (Coccinellidae) were dominant throughout the crop season. The density of predators showed a positive correlation with population density of L. erysimi indicating density dependent response. Their role in biological control of aphid is discussed.

Key words: Predator, aphid, Syrphidae, Coccinellidae, Lipaphis erysimi, biocontrol.

INTRODUCTION

Lipaphis erysimi (Kalt.) is a well known pest of mustard. In Manipur, a local variety of mustard Brassica juncea var rugosa (Roxb.) (only foliage is used for human consumption) has been found infested by L. erysimi. While studying the infestation level of the aphid on the above mustard cultivar, presence of several predators were observed on it. Though the role of predators in regulating the aphid population is evident in general, the present communication highlights the species composition of the predators and its influence on the numerical abundance of the aphid L. erysimi infesting B. juncea var. rugosa.

MATERIAL & METHODS

The population of the aphid L. erysimi as well as its predators were observed continuously for two successive crop seasons (1993-95). Sampling was done once a week by random selection of 10 plants each having ca. 12 spirally arranged leaves and examining the first, sixth and twelfth leaf (3 leaves; from the apex of each plant representing upper, middle and lower strata, respectively up to its vegetative phase. Later on, with the onset of reproductive phase of the crop, observations were taken
from the apical 5 cm length of the inflorescence until harvesting. The data were analysed statistically and presented here.

RESULTS & DISCUSSION

The incidence of *L. erysimi* began from the first week of November and continued up to February. The nymphs outnumbered apterous and alate adults. Both vegetative and reproductive phases of the crop were infested by the aphid showing two distinct peaks, one in December and the other during last week of January or first week of February (Figure). Proportionately high infestation was observed during vegetative phase (435 aphids/3 leaves) of the crop than reproductive stage (250 aphids/3 leaves). This is perhaps due to more number of foliage during the vegetative growth in addition.

**Figure.** Seasonal abundance of *L. erysimi* and its predators during two successive years (1993-94 and 1994-95) in Manipur, India.
comparatively bigger size of the leaf (mean = 62.5 cm²) would also be accountable for more colony formation during vegetative phase, while the foliage became dry and withered during reproductive phase, as a consequence the aphid colony being restricted to the inflorescence or twigs only.

*L. erysimi* was preyed by syrphids (Diptera) and coccinellids (Coleoptera). Syrphids surpassed the coccinellids both in population strength and species composition. The data revealed the occurrence of an average number of 0.15 syrphids and 0.05 coccinellids per aphid infested foliage and the numerical abundance of the syrphids was significantly (P<0.05) more than that of coccinellids.

Seven species of syrphids *viz.* *Epusyrphus baleatus* (De G.), *Ischnochalon scutellaris* (Fabr.), *Metasyrphus contrater* (Weid.), *Paragus paragus seratus* Fabr., *Betasyrphus serarius* (Weid.), *Sphaerophoria indiana* (Bigot) and *Sphaerophoria* sp. and three species of coccinellids *viz.* *Coccinella septempunctata* Linn., *C. transversalis* Fabr. and *Mecochilus sexmaculatus* (Fabr.) were found predating on the aphid.

The seasonal abundance of predators synchronised with the incidence of the aphid and is prey density dependent (Figure). The maximum abundance of syrphids and coccinellids was observed during December and February, respectively in both the crop seasons. After December the populations of both the prey and the predators declined owing to a shift in colony formation from leaf to inflorescence of the same plant. Again, the population gradually increased and attained a small peak during the first week of February, 1994 and last week of January, 1995 respectively.

The population concentration of aphid on different stages of leaf showed significant variation (F = 13.42. P < 0.001). For instance, the leaves at the lower level had more population (126.4 ± 30.2 SD aphid/leaf) than at middle level (66.6 ± 21.3 SD aphid/leaf), whereas very low population of the aphid was observed on the foliage of the upper level (17.6 ± 5.0 SD aphid/leaf). The reason for higher density of aphids on the leaves of lower stratum could be due to the presence of more nutritious material on the senescent foliage (Dixon, 1986) which in turn increases the reproductive potential of the aphid (Banerjee & Raychaudhuri, 1987).

The correlation between the density of predators yielded a significant positive correlation coefficient (r = 0.80. P < 0.05). However, no significant correlation coefficients were obtained between temperature and aphid density (r = -0.40) and between rainfall and aphid density (r = -0.23). Similar relationship were also recorded for the other aphid species (Chandra & Kushwaha, 1986, 1987).

From the seasonal occurrence of the aphids and its predators and their relationship, it becomes evident that predators played an important role in regulating the pest population. Awasthi et al. (1971) reported that a combination of factors (biotic and abiotic) regulate the aphid population in the field. Shennama & Brier (1995) reported that coccinellids were able to reduce the population of *L. erysimi* below the economic threshold. Similarly, in the present study, it was also evident that only the
predators check the aphid population. It could be attributed to the influence of synchronised occurrence of an array of predatory species along with the aphid.

REFERENCES


(Received on: October 28, 1996; Accepted on: April 14, 1997)
Succession of aphids and their relation with syrphid predators of knol-khol

L. Chitra Devi and T.K. Singh

Aphid Research Laboratory, Department of Life Sciences, Manipur University, Canchipur, Imphal - 795 003 (India)

ABSTRACT

Three species of aphids viz., Myzus persicae Sulzer, Lipaphis erysimi (Kalt.) and Brevicoryne brassicae Linn. appeared in succession on knol-khol. Five species of syrphid predators viz. Ephyraea balteata De Geer, Ichneumon scutellaris Fabr., Sphaerophoria iniana Big., Metasyrphus confusus Weld, and Metasyrphus serarius Weld were found associated with these aphids. A significant positive correlation existed between the populations of syrphid predators and M. persicae.

Three species of aphids viz. Myzus persicae Sulzer, Lipaphis erysimi (Kalt.) and Brevicoryne brassicae Linn. were found infesting on knol-khol in Manipur. While monitoring the populations of these aphids on knol-khol, presence of syrphid larvae were noticed along with the aphids. Since information pertaining to aphids and their relation with syrphid predators on knol-khol is limited, an attempt was made to find out the succession of aphids and their relationship with predators on knol-khol.

MATERIAL AND METHODS

The incidence of aphids along with predators was assessed simultaneously for two successive crop seasons (1993-94 and 1994-95) of knol-khol. At each sampling ten replicates of three leaves one each from young, medium and mature leaves of the plant were randomly examined at seven days interval and the density of aphids was recorded. Besides, data on abiotic factors viz. temperature, relative humidity and rainfall were also recorded. The data on the numerical abundance of insects were computed along with the abiotic factors in order to find out the influence of these factors on the stability of insect population.

RESULTS AND DISCUSSION

The infestation of aphids on knol-khol began from November and continued till harvesting in March. Three species of aphids viz., M. persicae, L. erysimi and B. brassicae were found to infest this crop in succession. In both the crop seasons viz., 1993-94 and 1994-95, M. persicae initiated colony formation during November-December followed by L. erysimi and B. brassicae respectively (Figs 1 and 2). However, the numerical abundance and the period of maximum infestation were different. The
population build up of *M. persicae* began from November and attained its maximum during the last week of January in both the years, after which the population gradually declined.

After 2-3 weeks of *M. persicae* infestation, *L. erysimi* appeared on the crop. Its population build up was quick and maximum number was recorded during February in both the years. The cabbage aphid, *B. brassicae* infestation started from last week of December in both the years. A maximum of 154 individuals per sample was observed in February and the population showed a trend almost similar to *M. persicae* and *L. erysimi*. 

*Shashpa*, 4 (2): 127-130 (September, 1997)
succession of aphids on knol-khol

Fig. 2. Seasonal abundance of aphids and syrphid predators on knol-khol (1994-95)

erysmi (Figs. 1 and 2). The period of maximum infestation of L. erysimi, B. brassicae and M. persicae on cabbage and cauliflower were also reported during January and February by Atwal et al. (1971), Debraj et al. (1994) and Lal and Verma (1986). However, Roy and Pande (1991) recorded the highest number of L. erysimi on cabbage in the 2nd half of January.

The sequential sampling also showed the presence of five species of syrphid predators viz., Episyphus baleatus De Geer, Ischioidon scutellaris Fabr., Sphaerophoria indiana Big., Metasyphus confrrator Weid. and Betasyphus servatus Weid.
Table 1. Correlation between aphids and related factors

<table>
<thead>
<tr>
<th>Aphid</th>
<th>Syrphid predators</th>
<th>Temperature</th>
<th>Relative humidity</th>
<th>Rainfall</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>M. persicae</em></td>
<td>0.46*</td>
<td>-0.28</td>
<td>0.04</td>
<td>-0.11</td>
</tr>
<tr>
<td><em>B. brassicae</em></td>
<td>0.44</td>
<td>-0.30</td>
<td>0.17</td>
<td>0.07</td>
</tr>
<tr>
<td><em>L. erysimi</em></td>
<td>0.12</td>
<td>-0.11</td>
<td>-0.02</td>
<td>0.29</td>
</tr>
</tbody>
</table>

* Significant at 5%

Comparative study of the above five species of syrphid predators revealed that *E. balteatus* was more dominant than the others in terms of density and frequency of occurrence in the aphid colonies on knol-khol. Syrphids have been rated as one of the most efficient bio-control agents of aphids (Kotwal et al., 1984).

The correlation analysis between the aphids and predator/abiotic factors showed a significant positive correlation between predator and *M. persicae* only (Table 1) and is in agreement with the finding of Singh et al. (1994) in cabbage and Chandra and Kushwaha (1987) on cauliflower. This reflects the dependence of the predator on the prey for its survival (Figs. 1 and 2).

REFERENCES


*Shashpa*, 4 (2) : 127-130 (September 1997)
PREY - PREDATOR RELATIONS OF LIPAPHIS ERYSIMI (KALT.) (HOMOPTERA : APHIDIDAE) AND APHIDOPHAGOUS SYRPHIDS ON MUSTARD

L. CHITRA DEVI, R. VARATHARAJAN AND T. K. SINGH

DEPARTMENT OF LIFE SCIENCES. MANIPUR UNIVERSITY, CANCHIPUR, IN'PHAL - 795003, INDIA.

Prey - predator ratio, prey consumption rate, numerical density and occurrence pattern of important aphidophagous syrphids (Epiusyphus baleatus De Geer and Ischiodon scutellaris Fabr.) have been studied in relation to the prey species Lipaphis erysimi on a local variety of mustard plant.

INTRODUCTION

Lipaphis erysimi (Kalt.) commonly known as mustard aphid is an important pest of cruciferous crops (Rai, 1976; Ghosh & Mitra, 1983; Bakhetia et al., 1986). While monitoring the populations of mustard aphid on a local variety of mustard, presence of syrphid larvae were noticed along with aphids, preying upon L. erysimi. Since syrphids have been rated as one of the efficient biocontrol agents of aphids (Kotwal et al., 1984; Singh & Mishra, 1988; Radhakrishnan & Muraleedharan, 1993), an attempt has been made in this study to assess the biotic interactions with special reference to the syrphids Epiusyphus baleatus De Geer and Ischiodon scutellaris Fabr. in terms of prey feeding capacity, frequency of occurrence and seasonal incidence of predators in relation to the density of the prey L. erysimi.

MATERIALS AND METHODS

The incidence of both the prey and predatory species was monitored simultaneously for two successive crop seasons i.e., during 1993 - 94 & 1994 - 95 on a local variety of mustard (Hanguam Lamta Chabi) whose broad leaves being used as an important vegetable in Manipur. The field density of the aphid was monitored by random selection of ten plants and examining three leaves, one each of young, mature and senescent leaves per plant at weekly interval. This mustard plant has Ca 12 leaves arranged in the form of spiral phyllotaxy irrespective of stages of growth. For the purpose of insect sampling, the 1st, 6th and 12th leaf from the apex were examined for assessing aphid density and they being considered here as young, mature and senescent leaves, respectively. This sampling method was followed upto the vegetative phase and subsequently with the onset of reproductive phase, observations were taken from the apical 5 cm length of the inflorescence till the fruit setting stage. The field data on the density of the insects were also correlated with field temperature, humidity and rainfall.

The feeding efficiency of the predatory species was assessed by rearing individuals of E. baleatus and I. scutellaris from their neonate stage separately on plastic petridishes (9 cm x 9 cm) with five replications each. In each culture adequate number of aphids were provided and the consumption rate was noted at every 24 hours cycle.

RESULTS AND DISCUSSION

Density of prey - predator on Mustard

The infestation of L. erysimi on mustard began in November and continued till February with the maximum density of 435 aphids /3 leaves during December (Fig. 1). The seasonal occurrence of syrphid predators also synchronised with the aphid host and their population trend showed similar fluctuation with L. erysimi. The population of both the prey and predator declined gradually after December owing to a shift in colony formation from leaf to inflorescence of the same plant. Unlike its broad leaves, the inflorescence could not harbour dense populations of the aphid. Nevertheless, a
maximum of 250 individuals was observed per sampling unit during January end (Fig. 1). The population distribution of both aphid and syrphids showed significant difference on young, mature and senescent leaves (Table I). For instance the senescent leaves had maximum density of aphids, followed by mature leaves, while that of young leaf exhibited less abundance of aphids. Similarly, the syrphids also followed the same pattern of distribution. Such variation on the insect density on different leaf stages could be attributed to the change in the level of nutritional status and other chemical substances of the host leaf (Amanthakrishnan, 1993).

Fig. 1. Seasonal abundance of *L. erysimi* and syrphid predators on Mustard

The sequential sampling also showed the presence of predators *viz.* *Euphyrhus balleatus, Ischiodon scutellaris* and *Metasyrphus confrater*. Among them the larvae of *E. balleatus* were predominant in proportion in the aphid colonies, followed by *I. scutellaris* and *M. confrater*. The predator - prey ratio under the field condition ranged from 1:34 to 1:518 during different months (Fig. 1). The correlation analysis between prey and predators indicated a significant positive relation whereas temperature and rainfall showed negative correlation with aphid densities (Table II).
INTERACTION OF SYRPHIDS IN THE DENSITY OF MUSTARD APHIDS

Table I: Number of aphids and syrphids at different stages of mustard leaf.

<table>
<thead>
<tr>
<th>Stages of the leaf</th>
<th>Mean no. of aphid/leaf*</th>
<th>Mean no. of syrphids / leaf*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young</td>
<td>17.6a</td>
<td>10.5a</td>
</tr>
<tr>
<td>Mature</td>
<td>66.6b</td>
<td>40.7a</td>
</tr>
<tr>
<td>Senescent</td>
<td>126.4c</td>
<td>127.0b</td>
</tr>
<tr>
<td>C. D. at 5%</td>
<td>45.13</td>
<td>43.38</td>
</tr>
</tbody>
</table>

Same letters followed by the figures in a vertical column are not significantly different at 5% level (ANOVA); N. S. = Not significant; * = Mean of 8 replications.

Table II: Correlation between L. erysimi and related factors.

<table>
<thead>
<tr>
<th>Aphid host</th>
<th>Syrphid Predators</th>
<th>Temperature</th>
<th>Relative humidity</th>
<th>Rainfall</th>
</tr>
</thead>
<tbody>
<tr>
<td>L. erysimi (1993-94)</td>
<td>0.88*</td>
<td>-0.32</td>
<td>0.15</td>
<td>-0.21</td>
</tr>
<tr>
<td>L. erysimi (1994-95)</td>
<td>0.68*</td>
<td>-0.55*</td>
<td>0.05</td>
<td>-0.21</td>
</tr>
</tbody>
</table>

* = Significant at 5% level.

Table III: Feeding rate of syrphid larvae on L. erysimi.

<table>
<thead>
<tr>
<th>Syrphid Species</th>
<th>Number of aphids consumed per predator**</th>
<th>Calculated 't' value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I instar</td>
<td>II instar</td>
</tr>
<tr>
<td>Epsiysyrphus balteatus</td>
<td>46 ± 5</td>
<td>121 ± 19</td>
</tr>
<tr>
<td>Ischiodon scutellaris</td>
<td>15 ± 2</td>
<td>62 ± 10</td>
</tr>
</tbody>
</table>

** Mean of 5 replications; (*) Significant at 5% level (Student's 't' test).

Feeding efficiency of the predators

The prey-predator relations in terms of prey consumption showed significant variation between syrphid species. For instance, the voracity of E. balteatus and I. scutellaris on L. erysimi was 392 and 358 aphids/predator, respectively (Table III). In both the cases, the feeding rate increased with age-instar and the III instar larvae exhibited higher efficiency than I and II instars. The duration of the three larval stages was found to be 11 ± 1.2 and 13 ± 1.3 days for E. balteatus and I. scutellaris and hence their average feeding rate would be 36 and 28 aphids per day, respectively.

The comparative study of the above two predatory species revealed that E. balteatus was more efficient than the other in terms of prey consumption, density and frequency of occurrence in the aphid colonies of mustard. The efficiency of E. balteatus as potential predator has been well established with different prey species such as graminaceous aphids (Hamid, 1977), tea aphids (Radhakrishnan & Muraleedharan, 1993), oak aphids (Shantibala et al., 1994) and so on. On the basis of these examples and also the present observation on feeding rate and prey-predator ratio, it may be viewed that the involvement of E. balteatus in the field regulation of L. erysimi cannot be under estimated. Further, the synchronised seasonal variations of both the prey and predator especially on the same plant host reflect the dependence of the latter survival (Fig. 1). This is also evident from the fact that both aphids and syrphids exhibit significant positive correlation in terms of density at varying periods (Table II). Aspects on interrelations based on numerical abundance of aphids and aphidophagous syrphids showing higher level of interdependence have been documented in many other species (Agarwal et...
& Saha, 1986; Radhakrishnan & Muraleedharan, 1993; Singh et al. 1995)

Although the abiotic factors exert little pressure on the density of L. erysimi which is being
examplified here from the weak negative correlation with certain climatic factors (Table II), it is
possible to highlight that the predatory effect is much more important in the present system. This is
because the predatory species follow a successional pattern, as a result predators occur continuously
with the aphid host and regulate the prey density.

ACKNOWLEDGEMENTS

The authors thank the Head, Department of Life Sciences, Manipur University for providing
necessary facilities to carry out the above work.

REFERENCES

AGARWAL, K. & SAHA, J. L. 1986. Larval voracity, development and relative abundance of predators
of Aphis gossypii on cotton in India. In: Ecology of Aphidophaga (Hodek, J. Ed.). Academia, Prague &

ANANTHAKRISHNAN, T. N. 1993. Changing dimensions in the chemical ecology of phytophagous insects

BAKHTIA, D. R. C., BRAR, K. C. & SEKHON, B. S. S. 1986. Seasonal incidence of Lipaphis erysimi (Kalt.)

Pakistan. 28 (4).

brassicae (Linn.) in the mid - hill regions of Himachal Pradesh. Indian J. Agric. Sci. 54 : 1011 - 1012.

RAI, B. K. 1976. Pests of oilseed crops in India and their control. Indian Council of Agricultural Research,
New Delhi, pp. 121.

of the tea aphid, Toxaoptera aurantii (Boyer De Fonscolombe) in Southern India. Entomon. 18 (3 & 4) :
175 - 180.

Control Insects Pests. 5 : 117 - 121.

nervatus Chakravarti and Raychaudhuri (Homoptera : Aphididae) on Quercus serrata (Fagaceae) in
relation to predatory and certain abiotic factors. Phytophaga. 7 (1) : 33 - 40.

SINGH, R. & MISHRA, SUDHA, 1988. Development of a syrphid fly Ischiodon scutellaris (Fabricius) on
Rhopalosiphum maidis (Fitch). J. Aphidology. 2 (1 & 2) : 28 - 34.
ON THE DENSITY AND COMPOSITION OF NATURAL ENEMIES OF CABBAGE INFESTING APHIDS FROM MANIPUR

P. Bijaya Devi, L. Chitra Devi, R. Varatharajan and T. K. Singh*
Aphid Research Laboratory, Department of Life Sciences
Manipur University, Imphal-795 003, INDIA

ABSTRACT: Field populations of Brevicoryne brassicae, Myzus persicae and Lipaphis erysimi infesting cabbage were monitored continuously for two crop seasons along with a dozen natural enemies comprising of 5 species of Syrphids, 3 species of Coccinellids and 4 species of Aphidid parasitoids. The population data showed significant high positive relation between pests and predators/parasitoids. Their period of occurrence also synchronised with that of aphids indicating that the natural populations of cabbage aphids being regulated predominantly by predators and to a limited extent by parasitoids and other abiotic factors.

INTRODUCTION

The cabbage Brassica oleracea var. capitata is cultivated in Manipur in an area of 1360 hectares (Anonymous, Information Unit, Deptt. of Agri./Hort. & Soil Cons., Govt. of Manipur and it has been found infested by aphid species such as Myzus persicae (Sulz.), Brevicoryne brassicae (Linn.) and Lipaphis erysimi (Kalt.). The heavy infestation of aphids in general results in leaf curling, yellowing and stunted growth of the plant and thereby reducing its market value. Though abundant literature has been accumulated over the period with reference to cabbage aphids and associated natural enemies, that pertaining to the agroecosystem of North Eastern India in general and Manipur in particular has not been studied from the view point of aphid species that infest cabbage together. Keeping this in mind, the present study has been carried out with the emphasis on possible bio-control measures using an array of predators and parasitoids. This aspect has been justified in this paper on the basis of phenology of occurrence of natural enemies and their density in relation to the respective aphid hosts.

MATERIALS AND METHODS

The population of the aphids and their natural enemies were monitored on a local variety of cabbage, Brassicae oleraceae var. capitata at the interval of 15 days for two continuous crop seasons i.e., 1993-94. At each sampling ten replicates of 3 leaves one each from upper, middle and lower strata of the plant were randomly examined for the population count. The same exercise was extended during the sprouting stage also but care was taken to see the plants being free from the application of insecticides. The observations were recorded only upto July because the plants became moribund stage after July due to heavy rain.

While taking on the spot count of the different species of aphids, density of the mummified aphids of the respective parasitoids and density of coccinellid larvae and adults and syrphid larvae were also separately noted. In addition to these biotic factors, data on the abiotic factors such as temperature, relative humidity and rainfall were also obtained from nearby meteorological observatory. The data were then pooled and subjected to suitable statistic analysis.

RESULTS AND DISCUSSION

Regular monitoring of insect population in the cabbage field showed the presence of three species of aphids viz., Myzus persicae,
Brevicoryne brassicae and Lipaphis erysimi (Fig. 1) and a dozen natural enemies comprising of 5 species of Syrphids, 3 Coccinellid species and 4 species of Aphidid parasitoid (Fig. 2). The aphid infestation on cabbage began from November and continued till January wherein the head stage harboured more number of aphids than ramon stage (Fig. 1). On the basis of density of occurrence B. brassicae could be categorised as dominant species and M. Persicae and L. erysimi as secondary and tertiary species respectively.

Although the above 3 species were seen on cabbage with overlapping populations, none of the natural enemies exhibited preference to any particular prey species. Both predators and parasites were found active from November to April which coincided with the period of abundant occurrence of the aphid hosts. Hence statistical relation between aphid and aphidophagous insects yielded significantly high positive correlation (r = 0.92) between them.

Among the predators, Eryperyphus balteatus was found to be the dominant species in view of its continuous occurrence with aphid hosts and also its numerical abundance being comparatively more than the rest. The remaining predators were observed in the aphid colonies with less incidence and invariably with varying proportions. Owing to these factors, the total predators and prey ratio also ranged from 1:15 to 1:709 during different months (Table 1).

Similarly out of the four species of parasitoids Aphidius matricariae was found to be the dominant one in parasitising the aphids followed by Aphidius colemani, Diacretiella rapae and Ephedrus plagiatore. They were found active from December to March. The total percentage parasitism ranged from 0.6 to 7% at different periods with the exception of 26% in February 1995. All the parasitoid showed significant positive correlation (r = 0.65) with aphids reflecting that the rate of parasitization increased with the abundance of aphids. This observation was in conformity with M. persicae and L. erysimi being parasitized by D. rapae as reported by Chandra & Khushwaha.2

Analysis on the density and species composition of the natural enemies in the aphid colonies of cabbage revealed that their abundance and species aggregation being more during certain months which synchronised with the abundance of aphids. Further the fluctuation of their population was also found to be in tune with that of prey and this became evident from the significant positive correlation obtained on the basis of density of aphids and associated natural enemies. Similar relations were also

---

**Table 1: Predator-prey ratio and percentage parasitism on cabbage aphids**

<table>
<thead>
<tr>
<th>Month</th>
<th>1993-94</th>
<th>1994-95</th>
</tr>
</thead>
<tbody>
<tr>
<td>October</td>
<td>0.0</td>
<td>1:23</td>
</tr>
<tr>
<td>November</td>
<td>0.0</td>
<td>1:91</td>
</tr>
<tr>
<td>December</td>
<td>1:35</td>
<td>1:100</td>
</tr>
<tr>
<td>January</td>
<td>1:100</td>
<td>1:91</td>
</tr>
<tr>
<td>February</td>
<td>1:97</td>
<td>1:384</td>
</tr>
<tr>
<td>March</td>
<td>1:291</td>
<td>1:709</td>
</tr>
<tr>
<td>April</td>
<td>1:15</td>
<td>1:202</td>
</tr>
<tr>
<td>May</td>
<td>1:50</td>
<td>1:70</td>
</tr>
<tr>
<td>June</td>
<td>1:119</td>
<td>1:422</td>
</tr>
<tr>
<td>July</td>
<td>1:200</td>
<td>--</td>
</tr>
</tbody>
</table>

* Figures within the parenthesis indicates % parasitism by Aphidiid parasitoids.

---

2 Chandra & Khushwaha.
Figure 1: Numerical response of cabbage aphids in relation to biotic and abiotic factors
Figure 2: Seasonal abundance of parasitoids and predators of cabbage aphids
highlighted by David Pimental, Atwal et al. and Daiber on the cabbage aphid-predatory system wherein the predators were found to be effective against aphids.

While looking at the effect of predators and parasitoids on cabbage aphids the study indicated that predators showed profound influence than parasitoids. This would be owing to the poor response of all the four species of parasitoids which contributed together to the extent of 7% parasitism. The poor efficiency of the parasitoids was also observed by Van Emden on M. persicae. Nevertheless, the little role played by them cannot be ignored. One of the reasons of less parasitism could be due to the influence of predators. For instance, in the present study particularly during February 1995, the parasitism was found to be more and the density of predator was comparatively lesser than the yester season (Fig. 2).

Further the data also indicated that the role of biotic factors seemed to be dominant in the examined system because the abiotic factors showed only a weak negative relation with aphid density. Thus the results of high positive correlation between aphid and associated insects and the availability of all the 12 species of natural enemies during the period of maximum occurrence of aphid reflected that they would be involved in a collective way to regulate the field density of cabbage aphids.

ACKNOWLEDGEMENT

The authors are grateful to the Head, Life Sciences Department, Manipur University, Canchipur for the laboratory facilities.

REFERENCES


IMPACT OF PREDATORS AND CLIMATIC FACTORS ON THE POPULATION DENSITY OF THE APHID, CERVAPHIS RAPPARDI INDICA BASU ON CAJANUS CAJAN MILL.

K. Shantibala, L. Somesingh, T. K. Singh & L. Chitra Devi
Aphid Research Laboratory, Department of Life Sciences
Manipur University, Canchipur, Imphal-795 003, India

Abstract: The field observation on the population trend of the aphid, Cervaphis rappardi indica Basu was studied on Cajanus cajan during 1989-92 at Imphal. The density of the aphid was correlated with the biotic factors such as coccinellids, syrphids and neuropteran predators and also with certain abiotic factors like temperature, relative humidity and rainfall. Significant positive correlation was obtained between the aphids and coccinellids whereas comparatively weak negative correlation was evident between the aphid and temperature and rainfall and weak positive correlation with relative humidity. The results indicated that in the natural regulation of the field density of the aphid, C. r. indica, the predators seemed to be more contributory than the abiotic factors.

Key words: Cervaphis rappardi indica, predators, Coccinellidae, Syrphidae, biocontrol.

INTRODUCTION

Pulse crop, Cajanus cajan Mill is grown in about 10,000 hectares in hilly regions of Manipur where altitude varies between 1000 to 2000 metres. It is cultivated during March and grown throughout the year and is attacked by a number of insect pests (Ram, et al., 1981). The aphid, Cervaphis rappardi indica Basu is considered as the dominant species, which infests both surfaces of the young leaves as well as apical shoots of C. cajan (Shantibala, 1993). C. r. indica is monophagous species and recorded from Assam, Manipur, Nagaland and West Bengal (Raychaudhuri, 1978). Considering its association based on monophagy, an attempt has been made here to report its seasonal abundance in relation to certain biotic and abiotic factors.

MATERIALS & METHODS

The population trend of C. r. indica infesting C. cajan was observed in the experimental field located at the University for a period of three years (March 1989 to February 1992). The seed was sown in plots (5x3 m) during March with a spacing of...
25–30 cm (plant to plant). For the estimation of aphid population, during each sampling, ten twigs each of 10 cm long were randomly selected as one twig/plant at an interval of 15 days. The density of aphids and predators was assessed by following delayed counting method (Irwin & Yergen, 1989). Individuals of various morphs and stages of aphids and predators were counted at each sampling. To study the influence of abiotic factors on aphid population, monthly mean of field meteorological data such as temperature, relative humidity and rainfall were recorded. The data were subjected to suitable statistical analysis after suitably transforming the counts into log values (Hughes, 1962).

RESULTS & DISCUSSION

The three year data on the population assessment of the aphid, C. r. indica revealed that the infestation of the aphid was usually noticed in April-May coinciding with the abundance of young leaves. During 1989, the population of the aphid gradually increased in June, maintained the same trend until July. Subsequently being reduced in August due to heavy rainfall in July. Further, the population increased gradually upto November with a maximum abundance of 5711 aphids including all the morphs of the aphid (Fig. 1). However, in 1990-91, two peaks were obtained, first peak in July and second one in November. The incidence of the aphid during 1991-92 exhibited almost similar pattern like previous year. The pooled data of three years indicated that the percentage of nymphs (86.24%) was higher than apterous (13.44%) and alate (0.32%) adults.

Colonies of the aphid were associated with an array of predatory insects such as coccinellids, syrphids and neuropterans. Altogether 17 species of predators were observed in the colonies of aphids. Among them 12 are coccinellids, 4 being syrphids and one neuropteran predator (Fig. 2). The occurrence of all the predators did not show any sequential pattern over time but most of them overlapped with one or another species. Some species were observed during the specific period, for example Lemnaria saucia Mulsant and Menochilus scutellatus (Fabricus) occurred from June to February, whereas L. bissellata (Mulsant) and Oenopia quadripunctata Kapur were observed in June and July only (Fig. 2). It is pertinent to state here that this aphid species is cent percent free from the attack of parasitoids due to dense body processes. The correlation coefficients between aphid and its coccinellid predators indicated a significant positive correlation ($r = 0.89$ for 1989-90, $r = 0.82$ for 1990-91 and $r = 0.92$ for 1991-92 at $P < 0.05$) whereas the remaining predatory groups (syrphids and neuropterans) and abiotic factors (temperature, relative humidity and rainfall) showed insignificant correlation with the aphid density. The fluctuation in the density of the aphid during different months coincided with the numerical abundance of the predators (Fig. 1). Among the predatory groups, coccinellids exhibited a dominant tendency both in terms of density as well as in species composition (Fig. 2)
Fig. 1. Population fluctuation of *C. r. indica* in relation to biotic and abiotic factors during three successive years.

Fig. 2. Seasonal occurrence of the aphidophagous predators of *C. r. indica*.
The present finding was similar to that of oak aphid (Singh, et al., 1995). The prey density dependent predatory abundance is characteristic phenomenon of aphidophagous insects irrespective of the predatory groups (for coccinellids: Saha & Agarwala, 1986; Hijam & Singh, 1989; for syrphids, Radhakrishnan & Muraleedharan, 1993; for Neuroptera, Radhakrishnan & Muraleedharan, 1989).

Approximately high positive correlation between the prey and predators reflects that as the aphid density increases, the abundance of predators will also go up proportionately under the field condition (Fig. 1). Such prey density dependent increase in the predator population has also been noticed in various species of aphid-aphidophagous interactions (Saha & Agarwala, 1986; Agarwala et al., 1988; Shantibala et al., 1995). From the above result, it can be concluded that the predators played an important role in regulating the pest population.

While analysing the aphid density with temperature and rainfall, the study revealed a weak negative correlation and an insignificant positive correlation with humidity. Hence, the adverse effect of density independent factors on aphid population seemed to be less, on the other hand the influence of predatory effect apparently regulates the field density of this aphid.

Acknowledgement: The authors are thankful to the Head, Department of Life Sciences, Manipur University for working facilities and to Dr. R. Varatharajan, Assistant Professor of the Life Sciences Department for his valuable suggestions.

REFERENCES


Impact of ecological factors on *Cervaphis rppardh indica* 137


(Received on: October 28, 1996; Accepted on: May 12, 1997)
STUDIES ON THE IMPACT OF ENVIRONMENTAL FACTORS ON THE POPULATION DENSITY OF THE CABBAGE APHID, BREVICORYNE BRASSICAE (L.)

Y. DEBARAJ*, P. DEVJANI, L. CHITRA DEVI AND T.K. SINGH

REGIONAL TASAR RESEARCH STATION, MANTRIPUKHRI, IMPHAL-795002, INDIA*
DEPARTMENT OF LIFE SCIENCES, MANIPUR UNIVERSITY, IMPHAL-795003, INDIA.

Population trends of Brevicoryne brassicae (L.) in relation to abiotic and biotic factors was studied on cabbage, Brassica oleracea L. var. capitata at Imphal during 1991-92. The aphid was found to occur for a period of about eight months having two distinct peaks during February and May in two different stages of the plant. It built up its population in December with the onset of severe winter and continued upto July. Fluctuating population was correlated with both the abiotic (temperature, relative humidity and rainfall) and biotic (predator and parasitoid) factors in both the stages of the plant, i.e. head formation stage and sprouting stage (raitaon crop). None of the factors showed any significant impact on the population throughout the crop period but humidity played a crucial role in influencing the aphid population build up in raitaon crop. All the factors are equally important in regulating the aphid population.

INTRODUCTION

The cabbage aphid, Brevicoryne brassicae (L.) is a serious pest of all cruciferous crops in general and cabbage in particular. It attacks different parts of the plants such as leaves, buds, stems, flowers, flower stalks, fruits, cauliflower heads, etc. Due to heavy infestation plants show many serious symptoms of leaf curling, yellowing, stunted growth and this in turn causes considerable reduction in seed yield and their market value (Bhana & Karuhize, 1986). It is also reported as a vector of at least 23 viral diseases within the family Cruciferaceae (Hill, 1975).

The multiplication of the aphids has been observed to be favoured by various climatic factors. Of them frost, rain, severe cold and heat wave have been reported to be important natural mortality factors for the aphids (Brar & Sandu, 1976). Few workers studied the population dynamics of this pest in relation to abiotic and biotic factors in India and abroad (George, 1957; Lamb. 1961; Hughes, 1963; Rao, 1969; Tandon et al., 1977; Herakly & El-Ezz, 1970; Kotwal, 1982; Bhana & Karuhize, 1986).

No study has been done on any aspects of this pest in North east India particularly in Manipur. Present studies were, therefore, undertaken to determine the impact of environmental factors (abiotic and biotic) on the population trends of B. brassicae on cabbage (which is acclimatised in this region since time immemorial and taken as good as indigenous variety throughout year).

MATERIAL AND METHODS

The observations on the population trends of B. brassicae on the cabbage, Brassica oleracea var. capitata were made at the cultivator’s field in the vicinity of Imphal. The plants were transplanted during the last week of October, 1991. The normal agricultural practices were followed and no insecticidal treatments were applied during the period of experiment. Fortnightly samples were taken from each replicate, randomly. Three leaves - one each randomly representing upper, middle and lower portions of each plant were sampled for population of the aphid and its natural enemies (Church & Strickland, 1954). Similar sampling
was made in the sprouting stage selecting two sprouts randomly from each plant and counted aphids present in upper, middle and lower leaves of a sprout. The meteorological parameters, viz. temperature, relative humidity and rainfall were also recorded.

The correlations were worked out between the aphid population and both abiotic and biotic factors. The correlation coefficients were calculated separately in both the stages of the plant, viz. main crop (head formation stage) and ratoon crop (sprouting stage). The minimum, maximum and mean aphid population present on different leaves were also determined to know the concentration of aphid in both stages of the crop.

RESULTS AND DISCUSSION

The data on the incidence of cabbage aphid revealed that the pest commenced on the crop, four and five weeks after transplantation of the crop. The total infestation period was about eight months, i.e. December to July. Since the crop is acclimatized in this region, there were two distinct crop stages, viz. head formation stage and sprouting stage. Both the stages were infested by the pest showing two distinct peaks during February and May (Fig. 1). None of the workers reported the infestation of this pest on cabbage sprouts. With the completion of the head formation stage, a sudden decline of the population was observed during the first fortnight of March. It may be due to the change in the quality of the food plant which is appeared to be important for the abundance of the aphid (Daiber, 1971). The aphid gradually build up its population with the formation of sprouts and attained second peak. Tandon et al. (1977) reported the similar peak period of this pest on cauliflower seed crop. The period of infestation of the pest was prolonged in the sprouting stage.

Data presented in Table I indicated that the mean population concentration of aphid was more in the lower leaf of both the stages. The maximum infestation was found on the lower portion (leaf) of the plant in head formation stage. But in sprouting stage the heavy population was observed on the upper portion (leaf) of the sprout. Larger population of the pest was recorded on the sprouting stage (355 aphids/plant) than head formation stage (253 aphids/plant). The variation in concentration of aphid population at different stages of the plant may be due to the change in the morphological structure and nutritional quality of the plant.

Table 1. Concentration and variation of B. brassicae on cabbage.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean value (x)</th>
<th>Minimum value</th>
<th>Maximum value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head formation stage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper leaf</td>
<td>25.50</td>
<td>3.00</td>
<td>36.00</td>
</tr>
<tr>
<td>Middle leaf</td>
<td>33.33</td>
<td>8.00</td>
<td>61.00</td>
</tr>
<tr>
<td>Lower leaf</td>
<td>62.50</td>
<td>5.00</td>
<td></td>
</tr>
<tr>
<td>Sprouting stage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper leaf</td>
<td>40.38</td>
<td>0.80</td>
<td>135.32</td>
</tr>
<tr>
<td>Middle leaf</td>
<td>38.17</td>
<td>1.30</td>
<td>97.66</td>
</tr>
<tr>
<td>Lower leaf</td>
<td>51.74</td>
<td>0.80</td>
<td>126.20</td>
</tr>
</tbody>
</table>

The correlations between aphid population and abiotic factors on different stages of cabbage are shown in Table II. It observed that a weak positive correlation between aphid population and mean temperature in head formation stage but there is no correlation in sprouting stage. However the pest can survive and build up at a wide range of temperature
(5.6 - 32.4°C) as also reported (5-37°C) by Tandon et al. (1977). Hughes (1963) reported 4.1°C as the threshold of development temperature for the cabbage aphid.

**Table II. Correlation of aphid population with respect to abiotic factors on cabbage.**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Average Temperature (°C)</th>
<th>Average Relative Humidity (%)</th>
<th>Total Rainfall (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head formation stage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper leaf</td>
<td>0.346</td>
<td>0.163</td>
<td>-0.220</td>
</tr>
<tr>
<td>Middle leaf</td>
<td>0.444</td>
<td>0.219</td>
<td>-0.425</td>
</tr>
<tr>
<td>Lower leaf</td>
<td>0.338</td>
<td>0.151</td>
<td>-0.111</td>
</tr>
<tr>
<td>Sprouting stage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper leaf</td>
<td>0.023</td>
<td>-0.542</td>
<td>-0.199</td>
</tr>
<tr>
<td>Middle leaf</td>
<td>-0.060</td>
<td>-0.636</td>
<td>-0.304</td>
</tr>
<tr>
<td>Lower leaf</td>
<td>-0.123</td>
<td>-0.535</td>
<td>-0.367</td>
</tr>
</tbody>
</table>
It is interesting to note that *B. brassicae* population and the relative humidity showed a very weak positive correlation in head formation stage but high negative correlation was obtained in sprouting stage (Table II). Among the factors humidity showed little impact on the aphid population in ratoon crop. It played a crucial role in influencing the aphid population build up when the humidity was minimum. Rainfall showed a weak negative correlation with the aphid population throughout the crop period. The aphid population declined drastically with the onset of monsoon during second fortnight of July. Rainfall along with the other factors have been reported as limiting factors for the build up of other aphids on cruciferous crops (Atwal *et al.*, 1971; Roy, 1975; Singh *et al.*, 1986).

Besides the abiotic factors, the biotic factors like the predators and the parasites were also observed in the aphid colony. The predators, *Coccinella septempunctata*, *M e n o c h i l u s s e x m a c u l a t u s*, *Coccinella transversalis*, *Epidophus balteatus*, *Ischnod on scutellaris* and *Metazyrophus (M). confrater* and the parasites, *Diacreteilla rapae* were recorded during the period of aphid infestation. However, their abundance was very low and their role in reducing the aphid population was found to be ineffective due to the rapid multiplication of the aphid. The aphid population and the predators showed weak positive correlation in both the stages of the plant (r = 0.24; r = 0.27) and a weak negative correlation was obtained with that of parasites (r = 0.29) in sprouting stage. Of these factors, the parasite, *D. rapae* was reported to be effective on cabbage aphid population minimization in nature by several workers (George, 1957; Hafez, 1961; Herakly & El-Ezz, 1970; Bahana & Karuhize, 1986). However, the present findings of ineffectiveness of this parasite corroborates the reports of Van Emden (1966) in England and Tandon *et al.* (1977) in Himachal Pradesh. The greater impact of the natural enemies than the abiotic factors on *L. erysirn* and *M. persicae* infesting cruciferous crops was reported by Atwal *et al.* (1971) and Daiber (1971) which is reverse to the present investigation.

The role of different factors and their impact on the populations of *B. brassicae* reported by several workers are due to varying agro-ecological conditions. The present investigation may be concluded that none of the factors showed any significant impact on the aphid population except little impact of relative humidity. However, the abiotic factors played important role than the biotic factors. One factor always acted in combination with another. Therefore, all the factors are equally important in regulating the aphid population in nature.

**ACKNOWLEDGEMENTS**

Authors are thankful to the Head, Department of Life Sciences, Manipur University for providing laboratory facilities. Thanks are also due to Dr. H. Nandiram Sharma, D.M. College of Science, Imphal, for critical comments on the host plant.

**REFERENCES**


