

STUDIES ON THE ECOLOGY OF KALYANI STRAIN OF  
Trichogramma chilonis ISHII, AN EGG PARASITE  
OF LEPIDOPTERAN PESTS

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**C E R T I F I C A T E**

This is to certify that the work recorded in the thesis entitled " STUDIES ON THE ECOLOGY OF KALYANI STRAIN OF Trichogramma chilonis ISHII, AN EGG PARASITE OF LEPIDOPTERAN PESTS " submitted by Mohammed Mohasin for the award of the Degree of Doctor of Philosophy in Agricultural Entomology of the Bidhan Chandra Krishi Viswavidyalaya, is the faithful and bonafide research work carried out under my personal supervision and guidance. The results of the investigation reported in the thesis have not so far been submitted for any other Degree or Diploma. The assistance and help received during the course of investigation have been duly acknowledged.

Signature of the Advisor.

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**CHAPTER-I**  
**INTRODUCTION**

## I N T R O D U C T I O N

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After being in the midst of pesticide syndrome for nearly four decades, the world is now working to the hazards they pose to environment and health. The futility of a uni-directional, self-perpetuating system to pest control is now becoming obvious. The lessons of Canete valley of Peru (Smith, 1969) during 1943-1948 and grape industry, in California in 1961 (Huffaker, 1969) has shown us how quickly an agricultural industry can recover from the pesticide syndrome. The success of alternative pest control methods that are more in harmony with nature has paved the way. Traditional methods like crop rotation, soil and water management and biological control methods, that employ natural enemies of insect pests to control them are gaining a new respectability under the integrated pest management programmes.

Biological control already has proved itself to be a valuable weapon against insect pests. De Bach (1961) indicated that on a world wide basis, there had been 214 cases in which pests had been completely or partially controlled by this method. Twentyfour of these were in Hawaii, where a combination of extensive research, importation, and a continuously favourable climate has produced some outstanding successes. The sugarcane industry in Hawaii has since, 1904, made a concerted effort at biological control, with the result that till no chemical control of sugarcane pests is necessary on these islands (Pemberton, 1948).

Biological control attempts have not always been successful. Summaries of national programs in the continental United States, Canada, Australia, New Zealand, and the Philippines (Miller, Clark, and Dubleton, 1936; Clausen, 1956; Wilson, 1960; Baltazar, 1964) revealed that only about 1/4 th of the natural enemies introduced became established. Beirne (1963) suggested that most past failures resulted from a lack of essential ecological information. The current trend is toward more detailed ecological studies prior to the introduction of natural enemies.

Biological control operations usually aim at sustained, self-perpetuating control of a pest by introducing one or more exotic natural enemies. However, before importing natural enemies, it should be determined how existing natural control agents can be more effectively utilized. Native agents are already adapted to the host and its environment, and their use does not involve the possible dangers associated with international movement of living material. One important approach is to better conserve native natural enemies by more judicious use of insecticides. A more <sup>o</sup>through knowledge of their ecology may also reveal ways of enhancing their mutual abundance by various cultural methods. Artificial supplementation of natural enemies by mass release, however, has limited value. The host-parasite or predator ratio is generally at a certain level because of a complex interaction of environmental factors. Temporary results, at best, can be expected by artificially changing that ratio. Mass releases to replace natural enemies temporarily reduced by some unnatural phenomenon or to improve their synchronisation with the host, are sometimes useful.

Since the results of this method are temporary, however, its merits must be compared with other temporary methods; for example, chemical control. Use of biological control agents for temporary control is regulated chiefly by the cost of obtaining the large numbers required (Clausen, 1956).

In China, nearly 12 species of Trichogramma have been identified which selectively destroy eggs of European corn worm, rice leaf roller, pink boll worm, sugarcane borer etc. (Nanda, 1985). A number of parasites are known to exist as strains which differ in habitat, in physiological or psychological characters rather than in morphological features. They exhibit differences in their adaptability to given pest control situation. The evidence that such adaptive differences occur presents important possibilities for turning many failures of the past into successes, for improving upon partially successful programs, and, of course, for the conduction of new programmes. The importance of strains and races of entomophagous insects has been recognised for many years (Clausen, 1936; Smith, 1941; DeBach, 1953, 1958; Wilson, 1965). Unfortunately very little work has been undertaken in this direction; the potentiality remains largely unexplored.

It is evident from the available literatures that the occurrence of adaptive differences exhibited by various strains involves aspects of host selection, host immunity or climatic tolerance (Huffaker, 1969). Several examples of host specific strains may be mentioned in this context. The two different strains of Aspidiotiphagus

citrinus (Graw) attack two different types of scale insect; two strains of Metaphycus luteolus (Timberlake), one attacking Saissetia oleae, the other, Coccus hesperidum L.; and two strains of Comperiella bifasciata attacking respectively, California red scale and yellow scale. The immune response of host insects to parasitoids may be explained in the light of existence of various strains within a species. Some strains of parasite species are able to attack a given host species without inducing an immune response, whereas others, which are non-host-adapted strains, do invoke such responses in this host. There are several examples of adaptive strains in which the biological or ecological differences between them are known. One of the earliest examples of climatically adapted strains concerns Trichogramma minutum Riley, which has been found to contain strains which either develop at different rates, have varying longivities, or take on different sizes, shapes or colour at different temperature and humidity levels (Flanders, 1931; Lund, 1934). The field value of such adaptive variations has not been demonstrated, perhaps because the practical value of Trichogramma, itself, as a useful natural enemy in periodic colonisation programs remains to be solved (Huffaker, 1969).

Different species of Trichogramma are well-known agents of biological control and their importance in controlling various lepidopteran pests have long been recognised by many workers (Pemberton, 1948; Telenga, 1956; Metcalfe and Breniere, 1969). Among various species, T. chilonis is the most commonest and has been used most

extensively in India in the control of sugarcane borers (Rao, 1969). The results were, for the most part, inconclusive. In recent years, successful control of various lepidopteran pests other than sugarcane borers has been achieved through the periodic recolonisation of Trichogramma spp. (Peteanu, 1972; Dimitrov, 1975; Tsekhanovskaya, 1975; Lipa, 1976; Nikolov, 1983; Eremyant & Starovoitova, 1983). Therefore, a renewed interest on the potentiality of Trichogramma spp. is on the offing among biological control specialists throughout the world. It has been proved beyond doubt that most of the Trichogramma projects have failed due to the incomplete knowledge on biology and ecology of parasite as well as the species and strains of Trichogramma used in these projects (Metcalf and Breniere, 1969).

The present author has, therefore, taken up these studies to reveal the existence of various strains/races/biotypes in Trichogramma chilonis, if any, as well as to identify the differences associated in between the same species of Trichogramma occurring in two different geographical regions i.e. West Bengal and Delhi, ~~the~~ <sup>our</sup> country. The existence of various forms within the same species of Trichogramma may be strains or biotypes. Biotypes occupy different ecological niches within the same habitat and therefore selection of a suitable biotype of a parasite would play a key role in the biological control of a given species. A perusal of world literatures on biological control of pests emphasizes the need to study on different forms found within a parasitic species.

CHAPTER- II  
REVIEW OF LITERATURE

## REVIEW OF LITERATURE

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The family Trichogrammatidae (Hymenoptera: Chalcidoidea) contains strictly primary egg parasites of various insect species. The most important genus of this family is Trichogramma which includes members known for their diverse host range, the great majority of which are lepidoptera (Clausen, 1940).

Most of the natural enemies periodically colonized in large number to control pests primarily by the action of the individuals released have been egg parasites. Among various egg parasites, Trichogramma spp. have been used most extensively in the control of tissue borers throughout the world. The process is known as "Trichogramma method". However, periodic colonisation of the parasite has become a subject of considerable controversy and the process has been discarded in the U.S.A., though it is still continued in India and the Far East (Metcalf and Breniere, 1969). Evaluation of effectiveness of Trichogramma method as a means of borer control demands an understanding of the taxonomy, biology and ecology of various species of Trichogramma.

### 2.1 Taxonomy

Initially the identification of the members of the genus Trichogramma was solely based on morphological characters like number and form of wing cilia and length of the fringes (Girault, 1912; Kryger, 1919). A thorough study on the taxonomy of different species

of Trichogramma (Marchal, 1927; Moutia and Courtotis, 1952) revealed the presence of intermediate types and morphologically inseparable races more or less adapted to particular hosts and environments which created confusion in the correct identification of Trichogramma species. Subsequently, the works of Quednau (1956) and Flanders and Quednau (1960) has helped to solve the confusion to a great extent. They adapted biological technique such as rearing of field collected parasites on several hosts under defined rearing conditions to assess fecundity, ovipositional habits and rate of development. The problem in the identification of Trichogramma get more complex with the ever increasing number of species from different parts of the world. However, the identification of the parasite was resolved to a considerable extent after the work of Nagarkatti and Nagaraja (1971). Their descriptions of Trichogramma spp. were based on male genitalia. The biotaxonomic studies undertaken by them in the subsequent year (1973) showed that the male genitalia may be considered as an important criteria.

## 2.2 Biology

It has been reported that the development time of various Trichogramma spp. on Corcyra cerhalonica staint. at 28°C would be around 8 days (Breniere, 1965). The various aspects of the life cycle of Trichogramma have been investigated by various authors (Marchal, 1936; Flanders, 1937; Moutia and Courtois, 1952). Fecundity varies between 20 and 120 eggs per female according to the

species, the host, and the longevity of the adult, availability of host eggs, temperature, humidity, and the activity of the female. Under identical conditions with Coryvra egg as host, the fecundity of T.australicum, T.fasciatum and T.minutum were 43,67 and 76 , respectively (Breniere, 1965). The oviposition habit also varies with species. For example, T.fasciatum lays most of its eggs in the 1st 24 hours while T.minutum does it within 2-3 days and T.australicum over 10-12 days (Quednau, 1960).

#### 2.2.1 Effect of major abiotic factors on biology

Rate of development of Trichogramma bears a positive relationship with temperature but the exact response varies with species (Quednau, 1957). The darkening of the body colour is intensified at low rearing temperatures and is characteristic of different species. The body colour of individuals reared at variable temperatures can not be used as a diagnostic character (Quednau, 1957). He (1960) established a colour spectrum based on the intensity of darkening when reared at temperature of 15,20,25, 30 and 35°C.

Adult Trichogramma are very susceptible to desiccation, and optimum humidity is between 80 to 100% varying slightly for different species (Lund, 1934). The immature stages are affected only to the extent that the hosts are, but host eggs laid on living leaves are unaffected by humidity provided the plant is transpiring normally (Peterson, 1930).

Sex ratio is affected by several factors such as temperature, relative humidity, parental age, host etc. (Messenger and Force, 1963; De Bach, 1964). Sex ratio, although variable, is usually in the order of two females to one males, females always predominate (Quednau, 1956). Somchoudhury (1978) reported that the percentage of female in the sex ratio of T. chilonis (Delhi strain) was 66.45 at 30°C and 60% r.h. when no food was supplied to the adults. No work had been undertaken to isolate the biotypes of T. chilonis biologically.

Trichogramma adults show a well marked positive phototaxis, and under natural conditions are found on the most lighted portion of a plant. Flanders (1929) viewed light intensity as a dominating factor in the activity of Trichogramma. Costas (1951) noticed that parasitism was higher in light than shade, and attributed it to greater activity on the part of the adults rather than to better visibility. On the other hand, T. evanescens can distinguish the host and oviposit in complete darkness (Salt, 1937). Breniere (1968) found that diffuse light caused a slight increase in oviposition. Quednau (1957) stated that light has no effect on rate of development, mortality or fecundity. Stern and Bowen (1963) while investigating the bionomics of T. gemifunatum observed no obvious difference in emergence time between those reared in darkness and those reared with a distant light. Klink (1964) recorded shorter length of life of T. cacaeciae under constant light and higher fecundity rate with a 12 L (Light): 12D (darkness) cycle than with either constant darkness or constant light. Rounbehler and Ellington (1973)

investigated the effect of 3 light regimes on T.gemifumatum which showed that length of life appeared to increase with the length of light period. Emergence of the adult was synchronized with light cycle.

### 2.3 Inundative release of Trichogramma against insect - pests

Howard and Fiske (1911) were first to release large numbers of T.minutum against brown-tail moth. They also suggested the possible control of greenhouse pests by releasing Trichogramma. The mass release programme of the parasite took a great momentum after the work of Flanders (1930) who reported Sitotroga cerealella as an excellent host of the parasite and the moth could be mass cultured rather easily. Since then the method has been tried against different pest insects in many countries. Therefore, voluminous reports have been accumulated over the years on the parasites and the present author would mention only a few of them <sup>where</sup> studies were made more critically.

#### 2.3.1 Sugarcane borers

Some reductions of borers' population by periodic colonisation of Trichogramma spp. was reported by various authors (Smyth, 1939; Tucker, 1939; Babayan, Fuentes and Alvarez, 1977). On the other hand, negative results from periodic colonisation were reported by workers like Myers (1932), Box (1951) and Breniere (1960 & 1965). In India, Gupta (1951) reviewed the trials conducted here and remarked that

the results obtained in Bihar is encouraging. He, however, advocated that further large scale trials should be carried out particularly with exotic strains and species of Trichogramma. Sithanantham, Muthusamy and Durai (1973) reported the significant reduction in the population of Chile indicus (Kapur) by release of T. australicum.

After reviewing the world literatures on Trichogramma method, Metcalfe and Breniere (1969) remarked that critical examination of the data presented by many authors showed many claims of success as unjustified. There are still no data proving beyond all doubt the efficacy of this method. Carefully controlled experiments, together with data on the natural host parasite balance, have shown that liberations are of no value in the U.S.A., Barbados, Guyana and Madagascar. They concluded, in saying, that at present the strongholds of the method is Peru, India and Far East, where the method should be re-examined mainly with the introduction of exotic species or the potential strains of Trichogramma.

### 2.3.2 Lepidopteran pests other than sugarcane borers

It is evident from the published literatures that this method is highly successful against many pest species. It has been reported that Cydia pomonella (L.) and C. funebrana were successfully controlled by release of Trichogramma species in Bulgaria and Poland (Karadzhev, 1975; Lipa, 1975). Use of this method in the control of Heliothis species and Platyedra gossypiella Saund on cotton was reported as highly satisfactory (Castilla Chacon, 1973; Sharafutdinov and Salikhov, 1975; Chiu, 1984; Glas and Hassah, 1985; ). Similarly, significant

control of Mamestra brassicae (L.) and Agrotis segetum (Schiff) by Trichogramma was obtained in U.S.S.R. and Bulgaria (Assaul, 1974; Karadzhev, 1974; Chekmenev, 1975; Goussev, Fedorintchik, Chtchepetilnikova, 1975). The use of this group of parasite is increasing each year in the U.S.S.R. The effectiveness of these parasites was, however, limited in certain parts of the U.S.S.R. where dry conditions prevailed in spring and early summer (Prokof'Eva, 1976). The control of Ostrinia nubilalis (Hubner) by inundative release of Trichogramma was obtained by Monolache and Tien (1973) in Rumania, and by Voegelé, Stengel, Schubert, Daumal and Pizzol (1975) in France and by Suter and Bobler (1976) in Switzerland.

A critical analysis of the literatures of the inundative release of Trichogramma against different insect pests reveals that various reasons have been brought forwarded for the failure of this method. The release of parasites from superparasitised eggs (Kovaleva, 1954; Iyatomi, 1958), reduction in ecological adaptability caused by continuous breeding in laboratory conditions (Kovaleva, 1954; Stein, 1960), poor searching and flight capacity (Tucker, 1932), lack of host specificity (Tucker, 1932; Salt, 1935), early larval mortality in high proportions hindering settlement of the parasite (Myers, 1929, 1932; Box, 1933), irrational release of parasite without proper evaluation of the ecological conditions of the released sites (Kovaleva, 1954; Gupta, 1951), imperfect selection of strains or species (Kovaleva, 1954; DeBach, 1964), release of

large dosage of parasites resulting in superparasitism, (Kovaleva, 1954; Iyatomi, 1958; Sandner, 1958) and lack of adequate host population at the time of liberation (Narayanan and Chacko, 1957). Metcalfe and Breniere (1969), reviewing the world literatures on Trichogramma method for control of sugarcane moth borers remarked that a very close relationship exists between Trichogramma and its host, largely as a result of the short life cycle and rapid dispersal of Trichogramma. Trichogramma is undoubtedly an important limiting factor on the maximal size of borer populations. Appraisal of the biology and ecology of Trichogramma suggests that the chances of useful integrating liberations of Trichogramma are limited to short critical periods in spring in continental subtropical regions.

#### 2.4 Host selection

Host selection process passes through four phases : i) host habitat finding, ii) host finding, iii) host acceptance and iv) host suitability (Salt, 1935, 1937). Trichogramma first attracted to particular habitats, the primary attractant usually being certain plant upon which the host feeds (Salt, 1935; Laing, 1938; Monteith, 1958). A particular plant species may exert a strong attraction for a parasitic species even though suitable hosts are not present on it. Conversely, the parasite may ignore suitable hosts growing on plants to which it is not attracted (Welyatt, 1947). Manjunath, Phalak and Subramanian (1970) observed that parasitisation of Heliothis egg by Trichogramma spp. differed with the host plants. Martin, Lingren,

Greene and Ridgway (1976) recorded higher rate of parasitism of eggs of Heliothis zea (Boddie) on tomatoes and soybeans than that of tobacco.

It has been reported that adult Trichogramma tends to congregate on the exposed leaves of sugarcane plant where pyralid eggs are found. There is little or no attraction exerted over a distance by the host, the parasites being drawn to the host environment rather than to the host itself (Laing, 1938; Stein, 1961). Jones, Lewis, Berosa, Bierl and Sparks (1973) demonstrated that four chemicals extracted from the scale of Heliothis zea (Boddie) were observed to be source of a mediator that stimulated the host seeking response of the parasite in the laboratory, green house and field. Under natural conditions, the chances of the host being found, depend not only on the size of Trichogramma population, but on the light and temperature which affect the general activity of the parasite (Metcalf and Breniere, 1969),

Searching capacity of a parasite has been accepted as the single important attribute of an effective parasite (DeBach, 1964). The searching behaviour of the parasite is a compromise between random and non-random searching (Salt, 1934; Ulleyett, 1943, 1947). Laing (1938) reported that females of T. evanescens travelling in fairly straight lines before they found hosts, made many short radial turns immediately after leaving the hosts. Franz (1960) reported the role of host on the searching capability of parasite.

Salt (1934, 1935) stated that the criteria for accepting a host include host odour, size, location and shape. The host parasite relationship may still not succeed if the potential host individual is immune or otherwise unsuitable. This matter of host suitability is, then, the fourth and final step in the process by which the host list of a parasitic species becomes restricted (Doutt, 19634).

#### 2.5 Importance of races or strains of natural enemies :

Smith (1941) pointed out that there are races of insects which are not visibly distinguishable from each other. They differ in habitat, in physiological or psychological characters rather than in structure or colour. With increasing experience in biological control it is evident that many so called species are often composed of races, strains or sibling species which are morphologically indistinguishable but are very distinct biologically. Thus, any given parasitic species may have forms which are adapted to different host species or to different habitats. Such forms may or may not interbreed one with the other, and usually this exact taxonomic status will be difficult to determine. The important thing is to recognize that such forms exist and that from the viewpoint of practical biological control these forms may be just as important as distinct species (DeBach, 1970).

Aphelinus mali (Haldeman), the famous parasite of the woolly apple aphid, Eriosoma lanigerum (Hausmann) exists in several strains derived from different regions, and presumably differently adapted to climate (Lung et al., 1960, cited in DeBach and Hagen, 1964). The tachinid parasite Metagonistylum minense Townsend, which attack<sup>on</sup> the sugarcane borer in Brazil, is reported to exist in two climatic strains (Tucker, 1939). Other examples of climatically adapted strains or ecotypes of natural enemies include the Korean and Japanese races of Tiphia popillivora Röhwer, which differ importantly in reproductive capacity and adult emergence time (Clausen, 1936).

#### Adverse effect of pesticides on Trichogramma spp.

Injurious effects of pesticides on parasites have been described by various authors (Ullyett, 1947; Brown, 1951; Ripper, 1956; Bartlett, 1964). Assessment of potential effects of pesticides on beneficial arthropods has been recognized as one of the prerequisites to the establishment of effective integrated pest control programmes (Stern, Smith, Van den Bosch and Hagen, 1959; Van den Bosch and Stern, 1962).

The importance of critical studies on the specific responses of parasites to pesticides has been emphasized in reviews by various authors (Croft, 1972; Georghious, 1972; Newsom, 1974). Applied pest control literatures, for example, contain implications that natural enemies characteristically susceptible to broad spectrum pesticides while it is only the pests which develop resistances.

Newsom (1967, 1974) and Ferguson (1969) pointed out that the existing experimental evidence does not justify the assumption of any physiological differences between the responses of pests and of natural enemies to insecticides.

It is revealed from the available literatures that the order of descending toxicity of some common insecticide to parasites are i) endrin, dieldrin, aldrin, lindane, DDT; ii) parathion, malathion, carbaryl, <sup>0</sup>taxaphene, phosphamidon, and iii) carbophenothion, trichlorobon, endosulfan, thiometon (Croft and Brown, 1975). The deleterious effect of insecticides to Trichogramma under cane field conditions is contradictory. Some workers reported that parasitism adversely affected by DDT, BHC, chlordane, toxaphene, parathion (Hinds and Spencer, 1928; Dugas and Concienne, 1956). While Simmonds (1951) recorded that the level of parasitism was not affected by dusting with DDT. This differential response indicates that judicious selection of <sup>insecticides and their</sup> formulations ~~and insecticides~~ could avoid significant damage to Trichogramma. Granular formulations of endrin, gusathion and sevin did not harm Trichogramma (Hansley, McCormick, Long and Concienne, 1961; Long, Hensley, Concienne and McCormick, 1961). While studying the susceptibility of adult Trichogramma evanescens to insecticides, Kot (1970) observed the three insecticides to follow the following order of toxicity as fenthion > carbaryl > methyl demeton. Kot and Plewka (1970) reported that starved adults of T. evanescens were almost ten times more susceptible to metasystox than those fed on sugar syrup.

B Paul, Mohanasundaram and Subramanian (1978) while working with 0.1% endrin, 0.5% parathion, 0.1% malathion, 0.1% endosulfan and 0.1% BHC observed that endosulfan and BHC were least toxic to the adults of T. australicum and T. japonicum. They also found that only parathion adversely affected emergence of adults from parasitised host eggs. Kostadinov (1979) reported that methyl parathion (Wofatox), tetrachlorvinphos, ~~phosalone~~, dimethoate and phosalone (Zolone) were highly toxic to thelytokous race of T. embryophagum, toxicity decreasing in that order. Kim (1978) while studying the effect of some insecticides on T. cyanascens found that when parathion, dimethoate, mevinphos, endosulfan were applied to different stages of the parasite almost no effect observed on the larval stage while it was slightly toxic to the pupal stage but the adult parasites showed high sensitivity to the insecticidal application. Somchoudhury (1978) while working on the effect of eight insecticides on T. australicum reported that thiodan is relatively non-toxic to the pupal stage of the parasite. Paul, Dass, Ahmed and Prasad (1979) studied the effect of six insecticides on the rate of parasitism of eggs of Coryca cephalonica (Stnt.) by T. brasiliensis. They observed that no parasitism was obtained with host eggs treated with malathion and parathion methyl while rate of parasitism and emergence of parasite were high when the host eggs were treated with phosalone and monocrotophos. Tron (1985) reported that granular insecticides has less effect on G. Trichogramma.

The effect of insecticides on the bionomics of parasites is considered important as length of life cycle, type of reproduction,

sex ratio influence the development of resistance in parasites (Croft and Brown, 1975). Though no report on the effect of insecticides on the bionomics of the different biotypes of T. australicum is available, Krukierok, Plewka and Kot (1978) while working on two ecotypes of Trichogramma species recorded no significant difference in susceptibility to insecticides between the two ecotypes.

**CHAPTER-III**  
**MATERIALS AND METHODS**

## MATERIALS AND METHODS

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Studies were undertaken on Trichogramma chilonis to reveal various aspects of ecology as well as ~~its response to various aspects of ecology as well as~~ its response to various insecticides. For the purpose of investigation various methods were employed.

### 3.1 Materials:

#### 3.1.1 Parasite

Investigations were undertaken on indigenous egg parasite T.chilonis collected from various crop ecosystem at Kalyani, Nadia, West Bengal. The Delhi strain of T.chilonis was also included in the studies. The nucleus culture of the parasite was obtained through the courtesy of Indian Agricultural Research Institute, New Delhi.

#### 3.1.2 Host of the parasite

Eggs of the rice meal moth, Corcyra cephalonica Stainton was used as host for rearing the egg parasites.

#### 3.1.3 Plant materials

Wheat flour was used as food for the multiplication of Corcyra cephalonica. Various potted plants such as paddy, maize, potato, ladies finger, jute, arhar were utilised to assess the searching capacity of the parasites. To study the prevalence of Trichogramma sp, thirteen crop plants viz., paddy, groundnut, maize, red-gram, citrus, moong, potato, ladies finger, jute, lantana, mango, bengal-gram and litchi were considered.

### 3.1.4 Insecticides

The following insecticides which are generally used for the control of various crop pests were included in the schedule of investigation :

<u>Sl.No.</u>	<u>Common Name</u>	<u>Formulation (%)</u>	<u>Source</u>
1.	Endosulfan	35 <sup>0</sup> /E.C	M/S Hoechst Pharmaceuticals Ltd., Bombay.
2.	Malathion	50 E.C.	M/S Cyanamid (India) Ltd., Bombay.
3.	Monocrotophos	36 E.C	M/S CIBA-GEIGY India Ltd., Bombay.
4.	Phosphamidon	85 E.C	-do-
5.	Dichlorvos	76 E.C	-do-
6.	Quinalphos	25 E.C	M/S Sandoz India Ltd., India.
7.	Formothion	25 E.C	-do-
8.	Dimethoate	30 E.C	M/S Shaw Wallace India Ltd., Calcutta.
9.	Ethion	50 E.C	-do-
10.	Carbofuran	3 G	M/S Rallis India Ltd., Bombay.
11.	Phosalone	35 E.C	M/S Voltas India Ltd., Bombay.
12.	Phorate	10 G	M/S Cyanamid India Ltd., Bombay.
13.	Vamidotion	40 E.C	M/S Voltas India Ltd., Bombay.
14.	Fenitrothion	50 E.C	M/S Rallis India Ltd., Bombay.
15.	Methyl demeton	25 E.C	-do-
16.	Aldicarb	10 G	M/S Union Carbide India Ltd., Bhopal.
17.	Phenthoate	50 E.C	M/S Motilal Pesticides Ltd., Bangalore.

### 3.2 Methods

#### 3.2.1 Collection of Trichogramma sp.

Egg cards containing approximately 30 freshly laid CORCYRA eggs were tagged randomly on ventral and dorsal surfaces of leaves at different height of crop plants. The colour of egg cards was same as that of leaf. Thirteen plant species mentioned earlier in this chapter each representing a particular ecosystem were chosen for the experimentation. Egg cards were tagged periodically at an interval of 7 days during the entire growth stages of each of the thirteen crop. Thus, the eggs were exposed to indigenous Trichogramma for parasitisation. There were six such egg cards/sq. meter. After an exposure of 24 hours in the fields, cards were brought back in the laboratory to note the parasitisation. The parasitisation of the host eggs was confirmed with the blackening of the eggs within 3-4 days. The rate of parasitisation was recorded under each crop ecosystem. The parasitised egg cards were then kept separately for the emergence of adult parasites. The adult parasites emerged from parasitised eggs were offered with corcyra eggs for multiplication. The parasites were identified on the basis of male genitalia (Nagarkatti and Nagaraja, 1971).

#### 3.2.2 Mass culture of the laboratory host of Trichogramma chilonis

The nucleous culture of the rice moth, C.cephalonica, a laboratory host of Trichogramma is being maintained in the Parasitology

Section, Dept. of Agril. Entomology, Faculty of Agriculture, Bidhan Chandra Krishi \* Viswavidyalaya, Kalyani, Nadia, West Bengal. Glass jars (25 cm x 18 cm) were used for the mass rearing of the host. Five hundred grams of wheat flour were used in each of the rearing jars. Wheat flour was sterilized at 58°C for 10 hours before use to eliminate other insects, if any. Fresh Corecya eggs amounting to 1/10th of a millilitre containing about 1,000-eggs were placed in each rearing jar. The mouth of jars were covered with a piece of cloth. Rearing jars were kept at 32°C without any regulation of relative humidity. After emergence of Corecya adults, they were collected and subsequently released for egg laying in a double mouthed black coloured glass cage (15 cm x 12 cm). Egg laying cages were kept at 25°C and 60 % r.h. Eggs were collected at different intervals, according to the experimental requirement.

### 3.8.3<sup>2,3</sup> Mass culture of Trichogramma chilonis

Eggs of Corecya of not more than 12 hours old were sprinkled on a card (15.5 cm x 8 cm) smeared with a uniform thin layer of 2% aqueous solution of pure gum arabic. The sprinkling of eggs on the 'egg card' was done by means of a fine sieve (30 mesh) to obtain an uniform single layer of Corecya eggs on the 'egg card'. Approximately 20,000 (1 CC) eggs were glued on each card. One such egg card was offered to the parasite in each rearing unit. The adult parasites were fed on a 1:1 (v/v) solution of honey and distilled water drawn on the inner wall of the rearing unit with one fine

brush so as to obtain fine streaks. Superparasitism was avoided by providing larger number of host eggs to the lesser number of parasites. The egg cards was removed from the rearing unit after 24 hours and a fresh egg card was offered again for parasitisation and the process was continued till 50 % of the parasites were dead which were mostly males. After the blackening of the parasitised eggs, each egg card was divided into small pieces and each piece was kept in separate rearing units for the emergence of adult parasites. CORYXA larvae hatching out from eggs that escaped parasitism were removed as they tended to be predacious on parasitised eggs.

#### 3.3.4 Taxonomic observations

Permanent preparations of adult Trichogramma were made in Hoyer's medium (Water-50 gm, gum, arabic 30 gm, chloral hydrate-20 gm, glycerine-20 gm) after prior treatment of individuals soon after their death, in glacial acetic acid for 12 hours for subsequent microscopic observation.

Permanent preparations of male and female genitalia of the parasites were also made after dissection and simultaneous mounting of specimens in Hoyer's medium. Measurements of body parts of Trichogramma collected from different crop ecosystems were done by means of an ocular attached in a binocular microscope.

### 3.3.5 Biosystematic studies

Reciprocal crosses i.e. the cross combinations of i) Kalyani strain of Trichogramma  $\sigma^7$  x Trichogramma Delhi strain  $\sigma_+$  ; ii) Trichogramma Kalyani strain  $\sigma_+$  x Trichogramma Delhi strain  $\sigma^7$  as well as between various types of Trichogramma collected from various crop ecosystems and Delhi strain of Trichogramma were released in separate vials. Another set was maintained wherein only females of each type of Trichogramma were released without male to note their type of reproduction. 50 % honey solution was supplied as food to adult parasites. Each egg card containing 600 host eggs was placed in each vial containing either ten pairs of cross combinations or ten  $\sigma_+$  individuals of any of the two strains of Trichogramma. Each egg card was replaced by a fresh one at an interval of 24 hours till death of females. The egg cards obtained from each vial were kept separately for emergence of  $F_1$  progeny. Sex and number of individuals were subsequently determined. The whole experiment was conducted at 25°C and 60 % r.h. and were replicated three times.

### 3.3.6 Biology

Freshly emerged males and females of T.chilonis (collected from various crop ecosystems as well as of Delhi strain of T.chilonis) were isolated and transferred in glass vials (4 dram size) with food (50 % honey solution) and subsequently kept at  $30 \pm 1^\circ\text{C}$ . The biology of the parasites were worked out at three levels of relative humidity i.e. 30, 60 & 90 %. Each pair from thirteen types along with the

Delhi strain of Trichogramma received an egg card containing 60 Corcyra eggs (i.e. @ 60 eggs/ ♀ ) to oviposit for 24 hours after which the egg card was replaced by another fresh egg card. This process was continued till the female parasite died. Observations on the longevity of female and male parasites were taken at an interval of 4, 12 and 24 hours . To study the rate of parasitisation by the female individuals, the number of host eggs turned black on the egg cards was counted. The blackened parasitised host eggs were allowed to emerge and observations were taken on the 4th , 12th and 24th hour in every 24-hour cycle from the expected date of adult emergence for observations on the duration of life cycle of the parasite. After the emergence of adult parasites, total number of females in progeny of the parasites and number of parasitised eggs collapsed were recorded. Experiments were replicated 15 times for each case.

### 3.2.7 Biological studies under field condition

To study the biology of the parasites under field condition, specially designed perforated plastic cylindrical cages as described by Somchoudhury and Dutta (1980) were used. Specially designed perforated plastic cylindrical cages (7 cm in length and 4.8 cm in diameter) with two round openings (2.5 cm diameter) in the middle of both the top and bottom surfaces were used. Small perforations (0.3 mm) were made on the body of the cage by means of a fine needle to allow evaporation of moisture vapour from inside the cage. A suitable maize leaf was selected on the top 15 cm of the plant. The eggs of Corcyra cephalonica St. used as host were exposed to low temperature (8°C) for 48 hr to

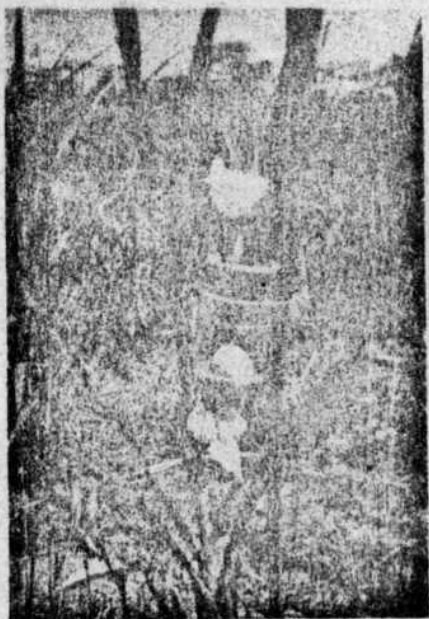


Fig.1. Bottom 7 cm of leaf-blade containing a pair of freshly emerged parasites, host eggs, and food enclosed within the first plastic cage with its ends plugged.



Fig.2. Second plastic cage enclosing the next 7 cm of the leaf-blade with host eggs and food fitted along with the first cage (covered with black alkathene sheet) for attracting the parasite pair in the well-lighted second cage.



Fig.3. Third plastic cage enclosing the next 7cm of the leaf-blade with host eggs and food fitted along with the second cage also covered with black alkathene sheet for attracting the parasite pair in the well lighted third cage.

to kill the developing embryo in order to make them suitable for parasitisation for a longer period . Three hundred C.cephalonica eggs were pasted on the underside of the leaf blade near its basal portion and food for the parasites was provided through fine streaks of 50 per cent honey solution on both the surfaces of leaf blade. The leaf containing host eggs and food was inserted inside the perforated plastic cage through the opening at the bottom end. It was adjusted to enclose only bottom 7 cm of the leaf blade and the uncovered portion of leaf blade remained outside the cage through the opening at the top (Fig.1). Bottom opening of the cage was plugged with a black alkathene covered cotton and a pair of freshly emerged parasites (obtained from the culture maintained continuously under field conditions) was released inside the cage through the opening at the top which was closed immediately after release by another black alkathene covered cotton plug. Support was provided to the cage by means of a bamboo stick to keep it in vertical position.

Two days after exposure of host eggs to the parasites, another batch of 300 C.cephalonica eggs was pasted on the underside of the same leaf blade, 3 cm away from the first cage along with streaks of 50 per cent honey solution around the Corcyra eggs as food for the adult parasite. Another similar cage was placed over these host eggs (Fig.2) after removing the cotton plug of the opening at the top end of first cage so that the bottom opening of the 2nd cage fitted with the top opening of the first cage. This made a continuous passage for parasites from the first into the second cage. Adhesive tape was used at the junction between the two cages to keep the second cage firmly in contact with the first cage. The top opening of the second cage was plugged with black alkathene covered cotton. To attract the

phototropic parasites into the well lighted second cage, the first ~~first~~ cage was darkened by covering it with a black alkathene sheet. Similarly, after a given exposure period, third cage was placed along with the second cage enclosing another 7 cm portion of leaf blade containing 300 host eggs as well as food for the adult parasite and then the second cage was also covered with black alkathene sheet to allow the third cage to be the most lighted one amongst the three cages placed in a row (Fig.3). This process was continued till the female parasite died. Observations were recorded daily at 8.00 A.M. and 4.30 P.M. on the longevity of the female parasites. The number of host eggs turned black were counted for rate of parasitisation by the parasite. The parasites were allowed to emerge from blackened parasitised host eggs inside the field cages and daily observations at 8.00 A.M. and 4.30 P.M. were recorded on the duration of the life cycle of parasites. After the death of adult parasite, total number of females in the  $F_1$  progeny of parasites and number of collapsed parasitised eggs were recorded. Each experiment was replicated 10 times.

### 3.2.8. Searching capacity

To study the searching capacity of each type of T.chilonia, specially designed cages (30 cm x 25 cm) were used. The cages were made of wire nets (30 mesh) and each cage was covered on the sides with polythene sheets while the top of the cage was covered with a sheet of fine cloth. Thereafter, each cage was placed over a pot containing various crop plants mentioned earlier in this chapter (Materials). Egg cards containing 50 Coryca eggs were then tagged on the lighted portion of plants. Thereafter, 5 pairs of each type of T.chilonia were released separately at the centre of each cage. They were returned back to the laboratory after an exposure period of eight hours to record the number of parasitised eggs. Experiments were replicated five times in each case.

### 3.2.9. Laboratory evaluation of some insecticides on T.chilonia

Insecticides mentioned earlier in the chapter Material were tested in the form of spray prepared by diluting the commercially available emulsifiable concentrates. Each insecticide was used in two concentrations viz., 0.03, and 0.01 % a.i. against the pupal stage of

T.chilonis. Tests were carried out 30°C with 60 % r.h.

Each egg card containing around 100 Corcyra eggs was offered to the parasites for an hour to oviposit in the host egg after which the egg cards were removed and kept separately in glass vials to follow the course of development of the parasites. At the beginning of the 3rd larval instar, the host egg turned black. The parasite was allowed to complete three more days in its life cycle so that it reaches the pupal stage. Thus egg cards containing only pupal stage of the parasite were dipped in insecticidal solutions and were removed immediately. They were placed separately in glass vials to allow the emergence of the adult parasites from the insecticide treated host eggs. A similar set was maintained where egg cards were dipped in water to serve as control treatment. The mortality of the parasites was recorded on the basis of parasitised host eggs which failed to emerge. The mortality in the control experiment varied between 10.32-14.86 per cent. The percent mortality for each observation was corrected by the use of Abbott's formula. Each experiment was replicated three times with each strain of T.chilonis and there were 100 parasitised host eggs in each treatment.

3.2.10 Field evaluation of some pesticides on the rate of parasitisation by T.chilonis vis-a-vis major crop pests

3.2.10-1 Paddy

The experiment was conducted in a farmer's field located near the campus of this Viswavidyalaya at Kalyani during boro, 1981-82 using 'Jaya' variety in a randomised block design with three

replications and seven treatments (including control). The plot size was 5 x 4 m. with 20 x 10 cm spacing. First spraying was given 15 DAT, followed by the second 30 DAT and the third at the boot leaf stage. To record the incidence of the pest two rows were discarded on all the sides as border rows. Then 20 hills were selected randomly on diagonals. Observations were recorded on the incidence of stem borer as indicated by dead hearts at 35 DAT and white ears at 55 DAT over 20 hills selected random. The amount of spray fluid varied between 300-400 lit/ha. Furadan and Phorate granules were broadcasted into paddy water at 15 and 35 DAT.

To study the rate of parasitisation by T.chilonis, freshly laid Coryca eggs were tagged randomly on the lighted portion of the plant at the rate six green coloured egg cards/sq.m. containing 100 eggs/card. Then 6 hours old parasites were released at the rate of 50,000/ha at around 7.A.M. The tagged host eggs were returned to the laboratory after 2524 hours exposure to parasites to note the rate of parasitisation in treated and control plots. The observations were based on five spots each consisting of one sq.m. area. The parasites were released once fifteen hours after first pesticidal application which was done at 4 P.M.

### 3.2.10.2 Lady's finger

The experiment was conducted in a farmer's field at Kalyani during rabi, 1981-82 using 'Pusa Sawani' variety of bhindi in a randomised block design with three replication and seven treatments

(including control). The plot size has 5 x 4m. with 30 cm spacing between plants and 45 cm between rows. The first application of the treatment was made with the initiation of incidence of the pest and thereafter another three applications of pesticides were given at 10 days intervals. The observations on the infested bhindi fruits in different treatment were recorded at the time of harvesting. The quantity of water used per hectare varied between 350-400 lit. Two applications of furadan (3G) was made @ 20.75 kg in the soil at 30 and 50 days after planting. The procedure of parasite liberation was same as followed in the case of paddy.

### 3.2.10.3 Brinjal

The field trial was carried out on a variety "Rajpur" at Krishnanagar, West Bengal during April to June, 1982 in randomized blocks with eight treatments and two replications. The plot's size was 20.25 sq.m. Quantity of spray fluid varied between 650 to 700 lit/ha. The first spraying was made at 15 DAT followed by 30 and 45 DAT (total three applications and no pesticides was applied after flowering). Only one application of Temik and furadan was made 0.75 and 1.25 kg AI/ha in the soil at 30 DAT. Observations were recorded on the % infestation of plants, shoots and fruit. The procedure of parasite liberation and mode of observation was similar to those undertaken in paddy ecosystem.

7.2.10.4. Jute

The experiment was carried out in a simple randomized block design in 3 replications in a farmer's field located near the campus of Bidhan Chandra Krishi Viswavidyalaya, Kalyani, West Bengal during May to July, 1980. The plot size was 3m x 3m. There were eight treatments viz., T<sub>1</sub> - malathion 50EC @ 0.1% a.i., T<sub>2</sub> - 50 EC @ 0.05 % a.i., T<sub>3</sub> - Sevimol 40 LV @ 0.15 % a.i.; T<sub>4</sub> - Malathion 50 EC + Sevimol 40 LW @ 0.1% + 0.15% a.i.; T<sub>5</sub> - Ekalux 25 EC @ 0.05 % a.i.; T<sub>6</sub> - Malathion 50 EC + Ekalux 25 EC @ 0.1% + 0.05% a.i.; T<sub>7</sub> - Elsion 35 EC @ 0.05 % a.i.; T<sub>8</sub> - Untreated control (water spray). Quantity of spray fluid was 500 lit/ha. The first spray was given 35 days after sowing repeated on 50 and 70 days after sowing. Nine jute plants were selected randomly and the number of semilooper was recorded on the top three leaves. The observations were taken one day, 5 day and ten days after the application of pesticides as well as one day before the application. The data obtained were analysed. The procedure of parasite liberation was same as followed in the case of paddy.

7.2.11. Statistical method

To analyse the data obtained during the course of investigation, various statistical methods were used. Randomized block design was used to find out the components of variation due to various factors as in the case of morphological and toxicological studies while completely randomised design was laid out in the case of

biological experiments. Prior to analysis, all the data on percent were subjected to inverse sine transformation (Fisher and Yates, 1938).

In the toxicological studies, percent mortality of the parasites obtained due to the treatments of two concentrations of various insecticides were corrected in respect to control mortality by Abbott's formula (1925).  $P = \frac{P' - C}{100 - C} \times 100$ , where  $P$  = % corrected mortality ;  $P'$  = % observed mortality ;  $C$  = % control mortality.

CHAPTER - IV  
RESULTS AND DISCUSSION

Studies were undertaken to reveal the ecology of local Trichogramma sp. based on occurrence, distribution and searching capacity under various crop ecosystems. A comparative study between the local and Delhi based Trichogramma based on the biological differences was undertaken to identify them biologically. The possibility of presence of various biotypes within a Trichogramma sp. was also considered based on biological and morphometrical observations. Attempts were also made to screen out the selective insecticides considering the responses of the parasite vis-a-vis some important insects pests. The results obtained from various experiments have been represented below.

#### 4.1 Occurrence and distribution of Trichogramma sp. under various crop ecosystems

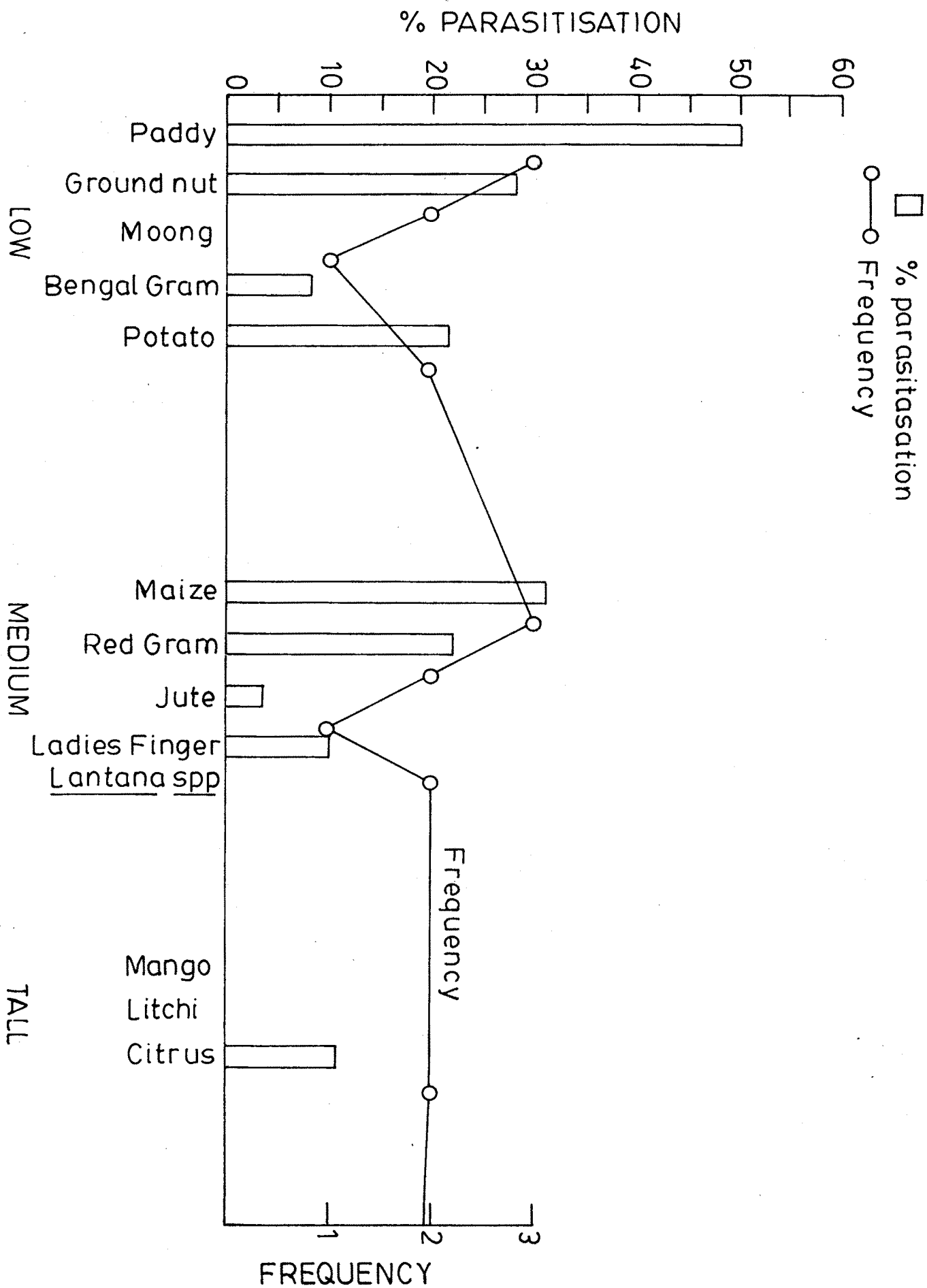
To study the occurrence of local Trichogramma sp. on various crop ecosystems, 13 plant species were selected representing annual and perennial plants with various height from low lying to tall types. Observations were undertaken on the occurrence of Trichogramma sp. on various crop ecosystems based on frequency of occurrence judged from the percent parasitisation of tagged Coryra eggs. The distribution of parasites, on the other hand, based on their capacity to parasitise tagged coryra eggs at different height of the plant.

The data collected on the occurrence and distribution of Trichogramma sp. under various crop ecosystems has been presented in Table 4.1. It may be seen from Table that the frequency of occurrence

Table 4.1 : Occurrence and distribution of Trichogramma sp. in various crop ecosystem.

Crop type (based on height)	Crop plant	Period of observa- tion	Frequency of occurrence (out of eight observations)	% parasitisa- tion
Low	Paddy	May-Aug.	3	50.1
	Groundnut	August- Oct.	2	28.3
	Moong	March- May	1	8.4
	Bengal gram	Jan-March	-	-
	Potato	Jan-March	2	21.5
Medium	Maize	May-Aug.	3	31.2
	Redgram	May-Aug.	2	22.54
	Jute	May-Aug.	1	3.8
	Lady's finger	March-May	2	9.6
	Lantana sp.	May-Aug.	-	-
Tall	Mango	May-Aug.	-	-
	Litchi	May-Aug.	-	-
	Citrus	May-Aug.	2	10.7

**Fig. 1 :** OCCURRENCE AND DISTRIBUTION OF Trychogramma sp IN VARIOUS CROP ECOSYSTEM



of the parasite was maximum under certain crop ecosystem, viz., paddy, groundnut and maize etc. The minimum occurrence of the parasite was noticed on crop plants like moong and jute. The total absence of the parasite was noticed on various other plants like bengal gram, Lantana sp., mango and litchi.

It was observed that there was no parasitisation of Corcyra eggs when they were distributed above 8 metre height on any of the crop ecosystem. Similarly no parasitisation of tagged corcyra eggs was recorded when they were placed near the ground level. The best rate of parasitisation was provided when the host eggs were placed between 1-  $1\frac{1}{2}$  metre height provided the area was a lighted portion of the plant. The second best rate of parasitisation was obtained from 2-3 metre height. A negligible parasitisation was obtained when the corcyra eggs were between 4-7 metre height.

It is revealed from the present investigation that the occurrence of the egg parasite, Trichogramma sp. varied greatly under various crop ecosystems. The parasite showed a clear preference for certain crop ecosystems, namely paddy, groundnut etc. It appears that they rarely visit certain crops like mango, litchi, Lantana and so on. It is now known that the parasite gets attracted to a particular crop ecosystem in search of its hosts. Alternatively, it prefers to live in certain ecological niche which might be found only under certain crop ecosystems. It has already been established that Trichogramma is not a host specific type of parasite and it

attacks a very wide range of eggs of various pests along with spider eggs. Therefore, it may be postulated that all the 13 plant species harbour one or other kind of insect eggs which may serve as host of the parasite. In particular, certain plants like gram, litchi and mango obviously contain various lepidopteran pests during different seasons of a year. Therefore, the <sup>non</sup>availability of Trichogramma sp. on these host plants can not be explained from the view point of non existence of the host eggs. It is generally said that the parasite prefers lepidopteran eggs and there are no dearth of lepidopteran eggs on these plants. However, the phenomenon of absence of Trichogramma may be explained in the light of non-availability of preferred ecological niche. A perusal of available literatures reveals that very limited informations are available in this direction particularly on the preference difference of various types of Trichogramma to various crop ecosystems. The present author feels that due to the <sup>non</sup>availability of sufficient published literatures the discussion could not be undertaken in depth.

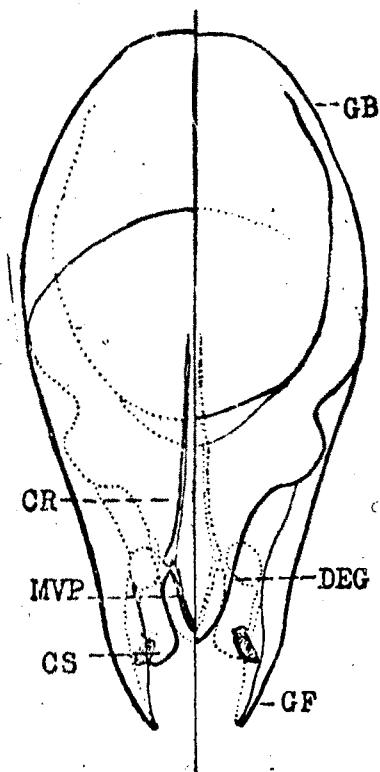
The distribution of Trichogramma sp. in relation to various crop heights provided an interesting picture. It was observed during present investigation that the parasite prefers low lying crops as is evidenced from higher rate of egg parasitisation in between a crop height ranging from  $1-1\frac{1}{2}$  metre. The parasite always prefer the lighted areas of plant. Similar observations have also been recorded by other workers.

It is evident that the parasite does not like dark areas found near the ground level under a dense canopy of crop plants. Informations relating to distribution of Trichogramma sp. at various crop heights are mostly lacking. A more detailed study in this direction may throw light on the behaviouristic pattern of Trichogramma sp.

#### 4.2 Taxonomical studies on various types of Trichogramma sp.

The taxonomy of nine types of Trichogramma sp. collected from various crop ecosystems was studied to confirm their identity on the basis of body colour and male genitalia which are considered as major criteria in the identification of Trichogramma species. (Girault, 1912, Nagarkatti and Nagarajan, 1971).

It was observed that the pattern of body colour of the nine types of Trichogramma maintained a close resemblance among themselves. Adult males were yellowish in colour with dark blackish abdomen and mesoscutum. The structure of male genitalia showed a close parity among various types. Dorsal expansion of gonobase of the genitalia <sup>is</sup> triangular with very prominent lateral lobes; chelate structure much below the level of tip of gonoforceps; median ventral projection prominent, broad at base; median chitinized ridge paired, extending anteriorly to about 2/3rd of length of genitalia; aedeagus as long as apodemes both together slightly shorter than hind tibia.



**Fig.2 :** Diagrammatic sketch of male genitalia of Trichogramma with aedeagus separated out. Explanations to abbreviations: DEG - Dorsal expansion of gonobase; GF - Gonoforceps; CS-chelate structure, MVP - Median ventral projection, CR-Central ridges; GB - Gonobase.

Adult females were also yellowish in colour with first three abdominal terga black. Ovipositor slightly longer than hind tibia.

Nagarkatti and Nagaraja (1971) reported that the dorsal expansion of gonobase of the male genitalia of T.australicum (Syn: T.chilonis) bears a very prominent lateral lobes which, according to them, are the most important characters to separate them from all other arrhenotokous Trichogramma. The characteristic features of male genitalia of all the nine types of Trichogramma considered during the present study are very similar to that reported by Nagarkatti and Nagaraja (1971). Therefore, the present author confirms the identity of Trichogramma collected from various crop ecosystems as T.chilonis (synonym T.australicum). Similarly, the dorsal expansion of gonobase of male genitalia of Trichogramma sp. obtained from Delhi has been observed to bear prominent lateral lobes due to presence of which it could be established as T.chilonis (Synonym T.australicum). Therefore, the local Trichogramma and that obtained from Delhi are similar species i.e. both are T.chilonis.

#### 4.3 Biosystematic studies on local and Delhi based T.chilonis

It is revealed from the taxonomic studies mentioned in the foregoing para that the local Trichogramma and that obtained from Delhi are similar species i.e. both are T.chilonis. In order to ascertain whether these morphological similarities were due to the fact that they belong to the same species, biosystematic studies in

the form of reciprocal process were undertaken using both male and female of local Trichogramma and Delhi based Trichogramma sp. The results obtained have been represented in Table 4.2. It appears that in crosses between nine types of Trichogramma and Delhi based T.chilonis ; the progeny production varied between 633.28 - 798.81 individuals in  $F_1$  generation. and the percentage of female and male ranged between 66.38 to 81.68 and 18.32 to 33.62 , respectively. But in two cases of reciprocal cross combinations i.e. between ~~Indya~~ <sup>Indya</sup> ~~Indya~~ x Delhi and between citrus x Delhi , no progeny production was noticed.

Frequent matings were recorded in all the sets of experiment. To study the type of reproduction known as arrhenotokus in the case of T.chilonis, an experiment was designed. Freshly emerged females of nine types of local Trichogramma and Delhi based T.chilonis were kept separately before mating. They were allowed to parasitise host eggs and the progeny emerged in  $F_1$  generation were subject to test for sex identification. In the case of local types, 59.13-84.14 individuals were obtained and all of them were males. In the case of Delhi based T.chilonis, number of progeny obtained in  $F_1$  generation in such case were 104.88 and all of them were male members (Table-4.3).

The controversy surrounding the identification of Trichogramma has not been resolved fully till to-date. The existence of intermediate types and morphologically inseparable sibling species

Table 4.2 : Intraspecific crosses between local types and Delhi strain of *Trichogramma* at 25°C and 60% r.h. and the F<sub>1</sub> progenies obtained (Mean of 3 replications)

Cross combination	No. of parental ♀ x ♂ per replication	Mean number of progeny obtained	Mean male in F <sub>1</sub> progeny (%)	Mean female in F <sub>1</sub> progeny (%)
Paddy ♀ x Delhi ♂	10 x 10	798.81	27.81	72.19
Delhi ♀ x Paddy ♂	10 x 10	824.32	18.32	81.68
Groundnut ♀ x Delhi ♂	10 x 10	763.12	29.64	70.36
Delhi ♀ x Groundnut ♂	10 x 10	718.54	31.47	68.53
Moong ♀ x Delhi ♂	10 x 10	633.28	25.14	74.86
Delhi ♀ x Moong ♂	10 x 10	698.04	27.58	72.42
Potato ♀ x Delhi ♂	10 x 10	708.44	33.62	66.38
Delhi ♀ x Potato ♂	10 x 10	736.82	25.02	74.98
Maize ♀ x Delhi ♂	10 x 10	744.88	18.96	81.04
Delhi ♀ x Maize ♂	10 x 10	713.36	28.64	71.36
Redgram ♀ x Delhi ♂	10 x 10	703.39	31.69	68.31
Delhi ♀ x Red gram ♂	10 x 10	699.18	29.16	70.04
Jute ♀ x Delhi ♂	10 x 10	-	-	-
Delhi ♀ x Jute ♂	10 x 10	-	-	-
Lady's finger ♀ x Delhi ♂	10 x 10	699.18	28.82	71.18
Delhi ♀ x Lady's finger ♂	10 x 10	710.08	24.67	75.33
Citrus ♀ x Delhi ♂	10 x 10	-	-	-
Delhi ♀ x Citrus ♂	10 x 10	-	-	-

**Table 4.3 : Reproduction in various types of T.chilonis without intervention of males at 30°C and 60% r.h. (mean of 3 replications)**

<b>Types</b>	<b>No.of parental female/replication</b>	<b>Mean number of progeny</b>	<b>Mean number of male in F<sub>1</sub> progenies</b>	<b>Mean number of female in F<sub>1</sub> progenies</b>
<b>Paddy</b>	10	75.36	75.36	-
<b>Groundnut</b>	10	70.48	70.48	-
<b>Moong</b>	10	59.26	59.26	-
<b>Potato</b>	10	72.92	72.92	-
<b>Maize</b>	10	79.42	79.42	-
<b>Red gram</b>	10	73.62	73.62	-
<b>Jute</b>	10	59.13	59.13	-
<b>Lady's finger</b>	10	82.24	82.24	-
<b>Citrus</b>	10	84.14	84.14	-
<b>Delhi</b>	10	104.88	104.88	-

and races and the body colour changing with the temperature, have created confusion in the correct identification of various species of Trichogramma. However, it has been resolved to a great extent after the work of Nagarkatti and Nagaraja (1971) on male genitalia, though it is applicable only in Trichogramma species having arrhenotokous type of reproduction such as T. chilonis, T. parkinsi, T. fastiatum, T. japonicum etc. A critical observation by the present author shows that the male genitalia of the local types and that of Delhi type are similar. The descriptions of the genitalia of the two groups run very close to those described by Nagarkatti and Nagaraja (1971) for T. australicum now synonymised with T. chilonis.

It was found during present investigation that reciprocal crosses between the local types and the Delhi type resulted both male and female progenies. But when the females alone were kept in isolation before mating, they produced only male members. This is a clear indication of arrhenotokous type of reproduction in case of both types of T. chilonis. This means that T. chilonis will produce only male progeny when intervention of male in mating will not take place. In other words, unfertilised eggs will produce male member and fertilised eggs will produce female members alone. The results depicted in Table 4.2 clearly demonstrate that successful mating followed by fertilisation of eggs in reciprocal crosses ~~has~~ resulted in female members. Therefore, the two ecotypes may be synonymised as the same species as successful breeding and progeny production through emergence of female members has taken place. This is in full conformity with the definition given to demarcate a 'species'.

#### 4.4 Morphometrical studies on nine types of *T.chilonis* collected from various crop ecosystem

Morphometric studies were undertaken on nine types of *T.chilonis* in order to compare their morphological characteristics. The comparative biometrical data have been presented in Table 4.4. Biometrical data on body size revealed that the length and breadth of nine types of *Trichogramma* varied significantly among themselves. The maximum size of *Trichogramma* was noticed when they were collected on citrus followed by lady's finger, potato, maize, paddy and so on. The minimum sized *Trichogramma* on the other hand, was obtained on moong and red gram. Similarly, other characters like length of antennal hair width of fore wing, length of aedeagus varied significantly among nine types of *Trichogramma*. The sequence of decrement or increment of length of various parts followed more or less same sequence as were observed in cases of body length and breadth. The characters like width of flagellum and forewing, length of tibia and apodemes did not show significant difference among themselves when nine types of *Trichogramma* were considered. The length of fringe on tornus of forewing also did not differ significantly among the nine types. Among the female body characters, biometrical data on body length and width as well as length of hind tibia and ovipositor showed significant difference among nine types of *Trichogramma*. Only the length of antennae was statistically at par in all the nine types. The maximum body length was recorded in lady's finger type followed by citrus, maize, ground nut etc. It was minimum in jute and moong type. \* The maximum width was

Table 4.4: Comparative biometrical data (mm) <sup>of</sup> male of *T. ghallana* collected from different crop ecosystem (mean of 20 observations).

Place of collection of samples (Crop type)	Body length	Body width	Length of longest antennal hair	Width of flagellum	Shortest antennal hair	Length of fringe on tornus of forewing	Width of forewing	Length of hind tibia
Paddy	0.471	0.176	0.088	0.038	0.040	0.040	0.240	0.158
Groundnut	0.468	0.166	0.072	0.043	0.038	0.042	0.249	0.161
Moong	0.457	0.152	0.075	0.032	0.027	0.031	0.231	0.153
Potato	0.482	0.188	0.089	0.041	0.038	0.041	0.251	0.161
Maize	0.478	0.172	0.086	0.044	0.043	0.039	0.244	0.158
Redgram	0.453	0.161	0.068	0.032	0.028	0.033	0.229	0.155
Jute	0.457	0.163	0.071	0.035	0.027	0.035	0.236	0.158
Lady's finger	0.492	0.188	0.094	0.048	0.043	0.043	0.254	0.166
Citrus	0.498	0.190	0.092	0.048	0.045	0.046	0.251	0.164
'F' test	Sig.	Sig.	Sig.	N.Sig.	Sig.	N.Sig.	Sig.	N.Sig.
C.D.at 5%	0.019	0.013	0.009	-	0.007	-	0.011	-

Table 4.4<sup>2</sup> : Comparative biometrical data (mm) of female of *T. chilonis* collected from different crop ecosystem (mean of 20 observations).

Place of collection of samples	Length of aedeagus	Length of apodemes	Body length	Body width	Length of antennae	Length of hind tibia	Length of ovipositor
Paddy	0.071	0.072	0.489	0.180	0.250	0.158	0.169
Groundnut	0.073	0.072	0.493	0.181	0.248	0.161	0.166
Moong	0.061	0.068	0.472	0.173	0.238	0.151	0.156
Potato	0.076	0.074	0.490	0.181	0.248	0.158	0.169
Maize	0.079	0.073	0.493	0.183	0.253	0.160	0.168
Redgram	0.064	0.066	0.477	0.170	0.241	0.153	0.158
Jute	0.059	0.063	0.472	0.173	0.240	0.150	0.160
Lady's finger	0.081	0.078	0.505	0.201	0.263	0.168	0.177
Citrus	0.083	0.077	0.501	0.203	0.267	0.169	0.175
'F' test	Sig.	N.Sig.	Sig.	Sig.	N.Sig.	Sig.	Sig.
C.D.at 5%	0.014	-	0.011	0.014	-	0.009	0.010

noticed in citrus type followed by lady's finger, maize, potato and so on. More or less similar sequence followed in the case of other body parts.

Various species of Trichogramma have locally adapted populations called ecotypes that are the result of selection by their environment. Although different ecotypes and races of other parasitic species have been studied though not in details by some workers (White, DeBach and Garber, 1970; Simond, 1947). Yet no biometrical studies have been undertaken on Trichogramma. The present investigation is a preliminary approach in the direction of establishing correlation between different crop ecosystem and morphometric characters. This, in turn, would help in the identification of pure ecotype/biotype of Trichogramma. Besides taxonomic implications, such studies may have a bearing on parasite selection and breeding programmes.

It is revealed from the present findings that certain key characters like length of the longest antennal hair, width of forewing, and length of aedeagus varied significantly within the nine types of Trichogramma. Therefore, their validity as key characters may be questioned. Obviously, these characters can not be used reliably in the identification of different Trichogramma species as they varied widely among nine types collected from various crop ecosystems.

On the other hand, length of fringe on tornus of forewing, width of flagellum, length of hind tibia and apodemes are stable characters and may be postulated as important key characters for their identification.

It is said that biotypes are morphologically identical. But deviation has been recorded in the case of brown plant hopper of paddy. The number <sup>of</sup> spines in hind basitarsus of adult, an important key character, has been found to vary widely among biotypes (Sogawa, 1978). Mandal (1980) initiated a preliminary work for the first time on the morphometric of various biotypes of Trichogramma collected from various crop ecosystems. He reported that significant difference was recorded among the four biotypes of T. chilonis in respect to their wings and antennae. The ratio between the maximum length of fringe and maximum width of the fore wing, and length of the longest antennal hair and maximum width of the antennal flagellum varied from  $1/6$ ,  $1/7$  and  $2-2\frac{1}{2}$ , respectively in four biotypes collected from paddy, jute, lantana sp. and Delhi type. The findings of the present author lend further support to his work though some differences were also observed. He reported that length of fringes on tornus of forewing varied significantly among four types while it did not found to be so during the present investigation. This may be attributed to the indepth studies undertaken by the present author considering nine types of Trichogramma instead of four taken by Mandal (1980).

#### 4.5 Biology of nine types of *T.chilonis* under laboratory condition

Experiments were laid out to study the biology of the nine types of *T.chilonis* (Kalyani strain) under 30°C and 60% r.h. under laboratory condition. Among various parameters, longevity, rate of parasitisation and emergence, duration of life cycle and percentage of female in  $F_1$  progeny of various types were taken into consideration. No food was supplied to the adult parasites. The data have been presented in Table 4.5.

##### 4.5.1 Female longevity

It showed that the longevity varied significantly among nine types of *Trichogramma*. It was maximum in the parasites collected on lady's finger followed by citrus, maize, paddy etc. It was minimum in moong followed by jute and groundnut and the last two types did not differ significantly between them.

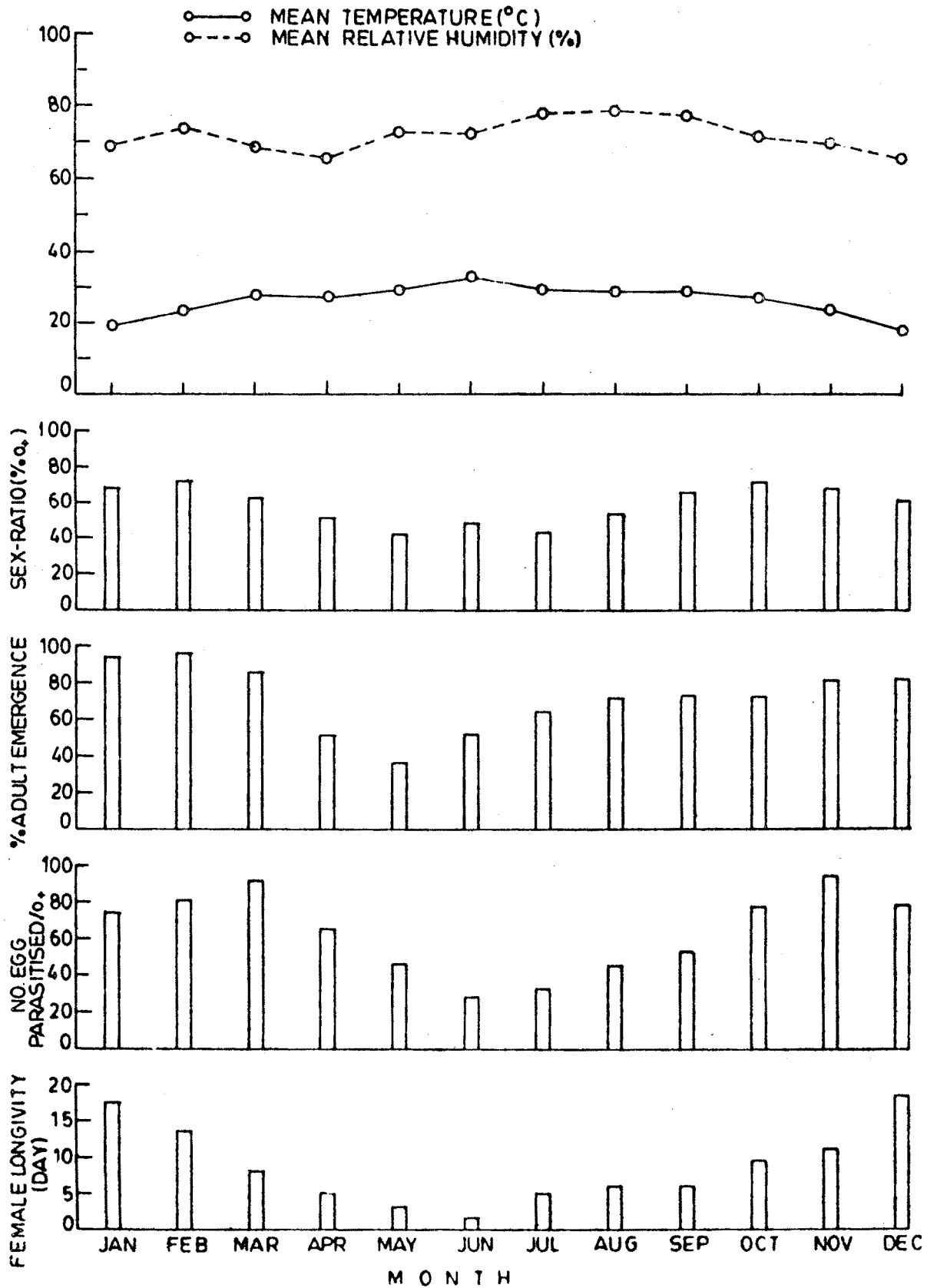
##### 4.5.2 Rate of parasitisation of host eggs

It also varied significantly among nine types of parasite. The maximum fecundity was noticed in citrus type followed by lady's finger, red gram and paddy. The minimum was recorded in moong followed by jute.

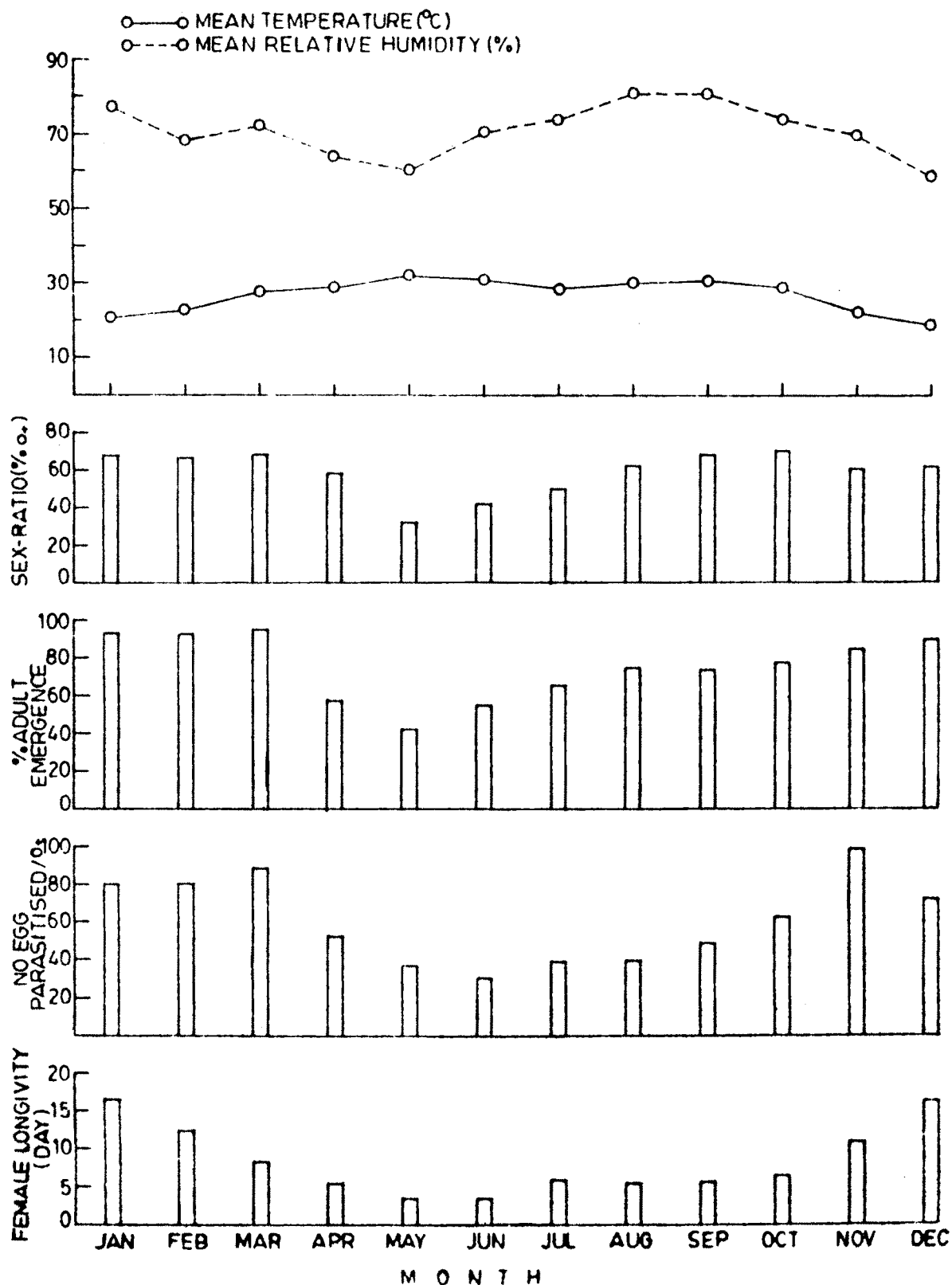
Table 4.5 : Longevity, rate of parasitisation and emergence, duration of life cycle and percentage of female in  $F_1$  progeny of various types of *T. chilonis* at 30°C and 60 % r.h. (mean of ten replications)

Types	Female longevity (hour)	No. of host eggs parasitised	Duration of life cycle (days)	% female in $F_1$ progeny	Rate of emergence (%)
Paddy	45.2	40.3	6.0	75.36	78.92
Groundnut	41.8	37.9	6.0	71.48	80.24
Moong	39.5	32.6	6.0	69.80	72.36
Potato	43.6	38.1	6.0	72.48	82.67
Maize	46.8	42.5	6.0	79.36	85.62
Red gram	42.3	40.4	6.0	76.28	75.23
Jute	41.3	33.7	6.0	70.11	71.14
Lady's finger	48.2	43.8	6.0	79.58	83.31
Citrus	47.7	45.9	6.0	80.36	86.88
'F' test	Sig.	Sig.	N.Sig.	Sig.	N.Sig.
C.D. at 5%	1.02	2.37	-	1.89	-

**Fig. 3:** MEAN LONGIVITY, RATE OF PARASITISATION, DURATION, RATE OF ADULT EMERGENCE AND PROPORTION OF FEMALE PROGENY OF *T. chilonis* (KALYANI STRAIN) UNDER THE FIELD CAGED CONDITION DURING THE YEAR 1981 (JAN - DEC) (MEAN OF TEN REPLICATION)



**Fig. 4:** MEAN LONGEVITY, RATE OF PARASITISATION, DURATION RATE OF ADULT EMERGENCE AND PROPORTION OF FEMALE PROGENY OF *T. chilonis* (KALYANI STRAIN) UNDER FIELD CAGED CONDITION DURING THE YEAR 1982 (JAN-DEC) (MEAN OF TEN REPLICATION)



#### 4.5.3 Duration

There was no significant variation in the duration of life cycle among nine types of T.chilonis. It was found to be completed within six days in all the cases at 30°C with 60 % r.h.

#### 4.5.4 Sex-ratio (% female)

Significant variation was noticed among nine types of Tri-chogramma in respect to sex-ratio. The proportion of female was maximum in citrus type. But it did not differ significantly from those observed in lady's finger and maize types. The minimum number of females was recorded in moong followed by jute and these two did not vary significantly between themselves.

#### 4.5.5 Rate of emergence

The maximum rate of emergence was noticed in citrus type followed by maize, lady's finger etc. However, the differences observed among nine types were statistically at par. However, the minimum rate of emergence was observed in jute type.

Most of the renowned workers in the field of Trichogramma science have advocated the existence of various types/races within a Trichogramma species. They may be inseparable morphologically (Marchal, 1927; Flanders, 1930; Peterson, 1930). The identification of Trichogramma species based on morphological characters alone may

lead to serious inaccuracy. Quednau (1956) and Flanders and Quednau (1960) explored the possibility of identification of different species of Trichogramma biologically, i.e. on the basis of fecundity, ovipositional habit and rate of development. He was able to separate out different species of Trichogramma based on this system. It may be mentioned in this context that the fecundity of T.australicum (Syn: T.chilonis), T.fasciatum and T.minutum was 43, 67 and 76, respectively (Breniere, 1963). The rate of parasitisation is often used as an index of fecundity of Trichogramma species. Significant variation in respect to fecundity was observed among nine types of Trichogramma. Quednau (1960) further reported that the developmental period of T.minutum, T.fasciatum and T.australicum were 148, 150 and 150 hours, respectively at 30°C and 80 % r.h. and this may be utilised in the identification of different species of Trichogramma biologically. This character could not be considered important in the separation of various types of Trichogramma as they did not vary significantly among nine types during the present investigation. However, sex-ratio varied significantly among various types. Again, rate of emergence of adult parasites from the parasitised eggs did not differ significantly among nine types.

Messenger (1964) focused the importance of life table studies to differentiate various races of Trichogramma. Subsequently, orphanides and Gonzalez (1971) undertook a detailed investigation on fertility and life table studies with T. pretiosum and T. retortridum. They reported that under certain conditions, the intrinsic rate of natural increase appears to offer some potential as a biological method for differentiating species and/or races of Trichogramma that are biologically distinct. However, variations obtained within the component variables of 'r' may be greater than the actual differences between species especially for closely related species.

Mondal (1980) took up some investigation on the biological parameter of four biotypes of Trichogramma. He reported that four biotypes differed significantly in their rate of parasitisation of host eggs. However, the duration of life cycle and sex-ratio of the four biotypes were statistically <sup>at par</sup> ~~similar~~. More or less similar observations were recorded during the present investigation. The present author could not elaborate the discussion due to the absence of published literatures. ~~Similar observations~~

#### 4.6 Searching capacity of nine types of T. chilonis

Experiments were designed to study the searching capacity of nine types of T. chilonis, under caged condition, on four plant species viz., paddy, maize, jute and red gram, with an exposure period of eight hours to the tagged gorgyza eggs. The data obtained

from the experiments have been presented in Table 4.7. It is evident that on paddy plant, the maximum parasitisation of host eggs was obtained with the release of paddy (11.23 %) or maize types (11.88) which differed significantly in their rate of parasitisation from other types. In other words, it may be said that paddy/maize type were the best searcher on paddy plant. Similarly, on maize plant, type collected from maize plant provided the best parasitisation of the host eggs. The second best result was obtained with the paddy type. The difference in their rate of parasitisation was statistically significant. The pattern was more or less similar in jute and red-gram where best parasitisation was obtained with the release of jute and red-gram types, respectively. Their performance was much superior and statistically significant when compared with other types.

The searching capacity of a parasite has been accepted as the single important attribute of an effective parasites (DeBach, 1964). The searching capacity of the parasites involves primarily the host habitat finding i.e. orientation of the parasitic species towards the host plants of the phytophagous pests. It is revealed from the present investigation that the rate of parasitisation will be significantly higher when a given type of Trichogramma would be released on the crop plant from which it was recovered. For example, it may be mentioned that the paddy type would always provide higher rate of parasitisation on paddy plant. Similarly jute type on jute

Table 4.7 : Effect of four plant species on the rate of parasitisation of host egg (*CORYVA SAPHALONICA*) by nine types of *I. SHILOHIA* under one level of host density (25 eggs) and exposure period of eight hours in the field caged condition.

Period of observation	Type	Number of mated female released/ cage	% Parasitism of host eggs when on			
			Paddy	Maize	Jute	Red gram
3.3.81 to 7.3.81	Paddy	5	11.23	11.88	1.21	4.83
	Groundnut	5	2.28	7.38	1.36	3.04
	Moong	5	1.12	4.43	2.99	3.37
	Potato	5	5.52	9.27	1.37	8.29
	Maize	5	6.83	17.22	3.84	5.68
	Red gram	5	3.05	8.33	3.77	13.83
	Jute	5	1.04	6.61	9.13	3.26
	Lady's finger	5	3.86	10.54	2.83	7.37
	Citrus	5	4.92	8.86	2.77	6.14
	'F' test		Sig.	Sig.	Sig.	Sig.
	C.D.at 5%		1.23	2.08	0.99	1.72

plant and red-gram type on red gram plant would give the best result. It may be explained in the light of their adaptations on such host plants from which they were collected. By virtue of their long association on a preferred host, for example, paddy type in the case of paddy plant, they could locate the host eggs much earlier in comparison to other types. They could only realise their full potentiality of searching capacity only on such plant with which they are associated for long. But these types of informations are relatively scarce on parasites. Mandal (1980) first reported that the paddy biotype (collected from paddy ecosystem) was superior among four biotypes in respect to their searching capacity of host eggs located on paddy plant. Therefore, the findings recorded during the present investigation were in parity with that of Mandal (1980).

#### 4.7 Comparative biology of two strains of T. chilonis under three levels of humidity

Investigation on the effect of relative humidity viz., 30, 60 and 90 % under a constant temperature (30°C) on the female longevity, rate of parasitisation, duration, rate of adult emergence and sex ratio <sup>were undertaken</sup> ~~was investigated~~ in the laboratory. The data obtained have been presented in Table 4.8.

Table 4.8 : Comparative biology of two strains of *T. chilonis* at 30°C under three levels of humidity (mean of 15 replications).

Parasite	Exposure at % r.h.	Longevity (hours)	No. of host egg parasitised/0 <sub>+</sub>	Duration (egg to adult) hours	% emergence of adult	% female progeny
<i>T. chilonis</i> (Kalyani strain) rain paddy type)	30	56.22	34.13	165.38	58.16	52.13
	60	45.38	42.36	159.33	76.84	74.66
	90	58.14	54.28	166.89	79.28	83.18
<i>T. chilonis</i> (Delhi strain)	30	69.46	62.20	171.88	83.48	58.26
	60	46.26	51.33	165.39	78.16	69.26
	90	61.33	49.24	164.54	61.29	77.73
'F' test		Sig.	Sig.	Sig.	Sig.	Sig.
C.D. at 5%		1.24	1.94	2.08	0.84	0.92

#### 4.7.1 Female longevity

It was observed that highly significant difference in the longevity between the females of two strains (Kalyani and Delhi) was observed. The longevity of female of Delhi strain was maximum under 30% r.h. followed 90% and 60 % . It was exactly reverse in the case of Kalyani strain where maximum longevity was recorded under 90 % followed by 30 and 60 % r.h.

#### 4.7.2 Rate of parasitisation

It also varied significantly between two strains as well as among three levels of relative humidity. The maximum parasitisation of eggs by <sup>Kalyani</sup> strain was recorded under 90 % r.h. followed by 60 and 30 %. On the other hand, it was opposite in the case of Delhi strain where the descending order was 30, 60 and 90 % . The difference observed between two levels of relative humidity always varied significantly between themselves.

#### 4.7.3 Duration of life cycle

The duration of life cycle of the two strains of Trichostrongylus also varied significantly among three level relative humidity. The maximum duration was noticed at 90% followed by 30 and 60 % r.h. in the case of Kalyani strain while it was 30, 60 and 90% in the descending order in the case of Delhi strain.

#### 4.7.4 Rate of emergence of adult parasites

The emergence rate of the two strains of parasites also varied significantly among three levels of relative humidity. The descending sequence was 90, 60, 30 % r.h. in the Kalyani strain and the corresponding r.h. for Delhi strain was 30, 60 and 90% r.h.

#### 4.7.5 Sex ratio

The sex ratio of the two strains of the parasite again varied significantly among three levels of relative humidity. The maximum number of female was found under 90 followed by 60 and 30% r.h. in Kalyani strain. Similar trend of female production was also noticed in the Delhi strain being maximum under 90 followed by 60 and 30 % r.h.

The intension of the above investigation was to ascertain the established contention that the parasite gets adapted or acclimatised under the ecological conditions where they occur. The place of investigation (Kalyani) is a costal area of West Bengal where high humidity prevails throughout the year. It is possible that the egg parasite, Trichogramma spp. which are under our condition may have an inclination towards higher range of humidity. On the other hand, the Delhi strain of Trichogramma comes from an arid zone being situated far away from sea nearing to the desert areas of India. The Delhi strain, obviously may not prefer high humidity

conditions. Alternatively, it would perform in a much better way than the Kalyani strain under low humidity range. It is evident from the present investigation that Kalyani strain showed a clear inclination and exhibited better performance under high humidity condition. Similarly, the delhi strain of Trichogramma was much superior to Kalyani strain under <sup>low</sup> humidity condition. Somchoudhury (1978) while working on the ecology of T.perkinsi and T.chilonis (Delhi strain) observed that Delhi strain of T.chilonis had a clear preference for lower humidity and T.perkinsi for higher humidity. There are several other examples of adaptive strains in which the biological or ecological differences between them are known. One of the earliest examples of climatically adapted strains concerns T.minutum which has been found to contain strains which either develop at different rates, have varying longevities or take on different size, shapes or colour at different temperature and humidity levels (Flanders, 1931; Lund, 1934). Abelonus mali, the famous parasite of the woolly apple aphid, Eriosoma lanigerum exists in several strains derived from different regions and presumably differently adapted to climate (DeBach and Hagen, 1964). The tachinid parasite, Metagonistylum minense Townsend exists in two climatic strains viz., 'wet race' and 'dry race'. Other examples of climatically adapted strains or ecotypes include Korean and Japanese races of Tiphia popillivora Rohwer, which differ importantly in reproductive capacity and adult emergence time (Clausen, 1936).

#### **4.8 Biology of Kalyani strain of T.chilonis under field condition**

Female longevity, rate of parasitisation of host egg, duration of life cycle, rate of emergence from the parasitised eggs and percentage of females in the total progeny of T.chilonis were investigated monthwise representing seasonal variation in climatic condition for the two years from Jan., 1981 to Dec., 1982 in the field in specially designed cages developed by Somchoudhury (1978). The results have been presented in Table 4.6.

##### **4.8.1 Longevity of female**

The longevity of female varied significantly during different months of the two years under observation. Maximum longevity was observed during the month of December followed by January and February in both years. It was minimum during the months of May-June. Longevity of the parasites increased with the decrease in temperature and therefore the maximum longevity was observed during the month of December and January when the mean temperature was around 18-19°C.

##### **4.8.2 Rate of parasitisation**

The rate of parasitisation reached its peak during the months of March and November while the lowest rate was recorded during the June-July. The lowest immature rate was observed in months when temperature attained highest level around 33°C. The fall of temperature in the subsequent months help the parasite for its

Table 4.6 : Mean longevity, rate of parasitisation, duration, rate of adult emergence and proportion of female progeny of *I. shillonia* (Kalyani strain) under the field caged condition during the years Jan., 1981 to Dec., 1982. (Mean of ten replications).

Month	Longevity of No. of host female(days)		Duration (egg to adult (days)		% emergence of adult		% female in progeny		Mean temperature (°C)		Mean r.h. (%)			
	1981	1982	1981	1982	1981	1982	1981	1982	1981	1982	1981	1982		
January	17.53	16.82	74.14	79.89	25.07	26.85	91.73 (74.85)	93.08 (75.36)	67.26 (55.16)	69.07 (57.41)	19.53	20.12	69.31	70.84
February	13.44	13.86	81.36	80.46	18.38	19.91	94.81 (78.15)	93.54 (74.82)	70.96 (57.14)	66.91 (55.94)	23.32	22.75	74.86	68.83
March	8.32	8.88	92.75	88.21	13.19	13.54	87.08 (69.32)	95.00 (81.04)	62.35 (53.44)	67.94 (56.85)	27.75	27.63	69.17	72.31
April	5.04	5.83	64.81	53.54	8.24	8.38	53.85 (48.42)	58.45 (49.18)	51.66 (46.64)	58.30 (51.41)	27.50	29.83	65.61	64.26
May	3.14	3.65	46.54	36.81	7.15	7.37	38.45 (37.46)	42.62 (41.81)	43.44 (41.83)	32.28 (33.16)	29.50	32.84	73.76	61.19
June	3.32	3.74	28.23	31.94	7.04	7.92	53.36 (46.89)	57.42 (49.04)	48.33 (45.19)	41.41 (40.92)	32.50	31.89	72.82	70.38
July	5.28	6.08	36.18	39.26	8.61	8.43	64.18 (52.72)	67.54 (55.28)	42.94 (41.54)	49.13 (44.23)	29.48	29.29	78.42	74.15
August	6.35	5.89	44.89	39.78	8.95	7.34	71.98 (58.12)	75.48 (60.26)	57.47 (49.16)	61.61 (52.54)	28.94	31.36	79.28	80.73
September	6.44	5.76	53.31	48.18	9.32	7.81	73.08 (59.24)	74.58 (60.44)	66.30 (54.63)	68.97 (56.24)	29.15	31.84	78.16	81.04
October	9.28	8.23	77.55	81.71	10.78	10.27	71.32 (58.13)	78.78 (62.48)	71.61 (58.04)	71.67 (57.37)	27.31	29.08	71.64	74.33
November	11.03	11.17	93.23	99.36	15.04	15.26	81.94 (64.34)	84.77 (67.91)	68.23 (56.33)	61.28 (51.84)	23.54	23.73	70.32	70.03
December	18.14	17.36	78.71	73.82	23.14	22.38	82.89 (65.56)	89.69 (70.99)	61.52 (46.88)	63.90 (52.62)	18.72	19.41	66.12	58.86
'F' test	Sig.	Sig.	Sig.	Sig.	-	-	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
C.D. at 5%	1.03	1.02	2.58	2.86	-	-	2.96	2.76	1.99	2.06				

better realisation of fecundity. Significant difference was observed in the rate of parasitisation recorded during different months of a year.

#### 4.8.3 Duration of life-cycle

Wide variation in the duration of life-cycle during different period of the year with similar wide variation in temperature was noticed. Shortest duration was recorded during May-June (7.15 days) when maximum temperature was noticed. With lowering of temperature from the month of November onwards, the duration also prolonged.

#### 4.8.4 Rate of emergence

The emergence rate of adult parasites varied significantly among various months of a year. Rate of emergence of T. chilonis reached its peak during the months of January-March. Thereafter it gradually declined till July. With the decrease in air temperature and increase in humidity from the month of July, the emergence rate again increased.

#### 4.8.5 Sex-ratio

It also varied significantly among various months in a year. It was observed that maximum number of female in sex ratio was recorded during February-March as well as during September-October. It was minimum during July. It is evident that the higher percentage of female in the total progeny of the parasite was directly related with mild temperature with high to moderate relative humidity. The lower production of female is associated with either higher temperature along

with low percentage of relative humidity or moderately high temperature along with high percentage of relative humidity.

A perusal of available literatures reveals that most of the field studies on Trichogramma include inundative release of the parasite for control of tissue borers. Detailed studies on the bionomics of Trichogramma under field condition have mostly been neglected. As a matter of fact, failure or success of Trichogramma method could not be explained logically in most of the cases.

Field studies reveal that longevity of female parasite was maximum during winter (Dec.-Jan.). Therefore longevity bears an inverse relationship with temperature. As regards parasitisation of host, maximum could be found under warm temperature condition prevailing during March and November. High temperature found during June-July affected the reproductive potential of the parasite most adversely. It was further observed that hot condition of summer months (May-July) initiated production of larger number of males compared to females. But condition reversed as the temperature decreased during November, January and March. The rate of emergence of parasite was the highest under low temperature conditions found during January-March and November-December. Duration of life cycle as influenced by temperature, also revealed that warmer conditions during May-June shortened the duration to minimum while cooler conditions of December-January caused maximum lengthening of life cycle of parasite.

It appears that the rate of multiplication of Trichogramma will be slow during summer months due to low rate of fecundity, emergence and lower number of female in sex-ratio. But a period of favourable condition would be found from July onwards due to lowering of temperature and increase in air humidity. The parasite population again <sup>remained</sup> ~~remains~~ at a low ebb during the months of January-February due to longer life cycle in winter months, but the climatic conditions of March-April become very favourable for rapid multiplication of Trichogramma.

#### 4.9 Effect of some insecticides on the pupal stage of two strains of Trichogramma

Effect of twelve pesticides namely, endosulfan, malathion, monocrotophos, phosalone, formothion, quinalphos, phosphamidon, Fenitrothion, dimethoate, methyl demeton, dichlorvos and vamidothion were tested in two concentrations viz. 0.03 and 0.01% a.i. on the pupal stage of two strains of T. chilonis under laboratory condition.

The effect on the mortality of pupae has been presented in Table 4.9.

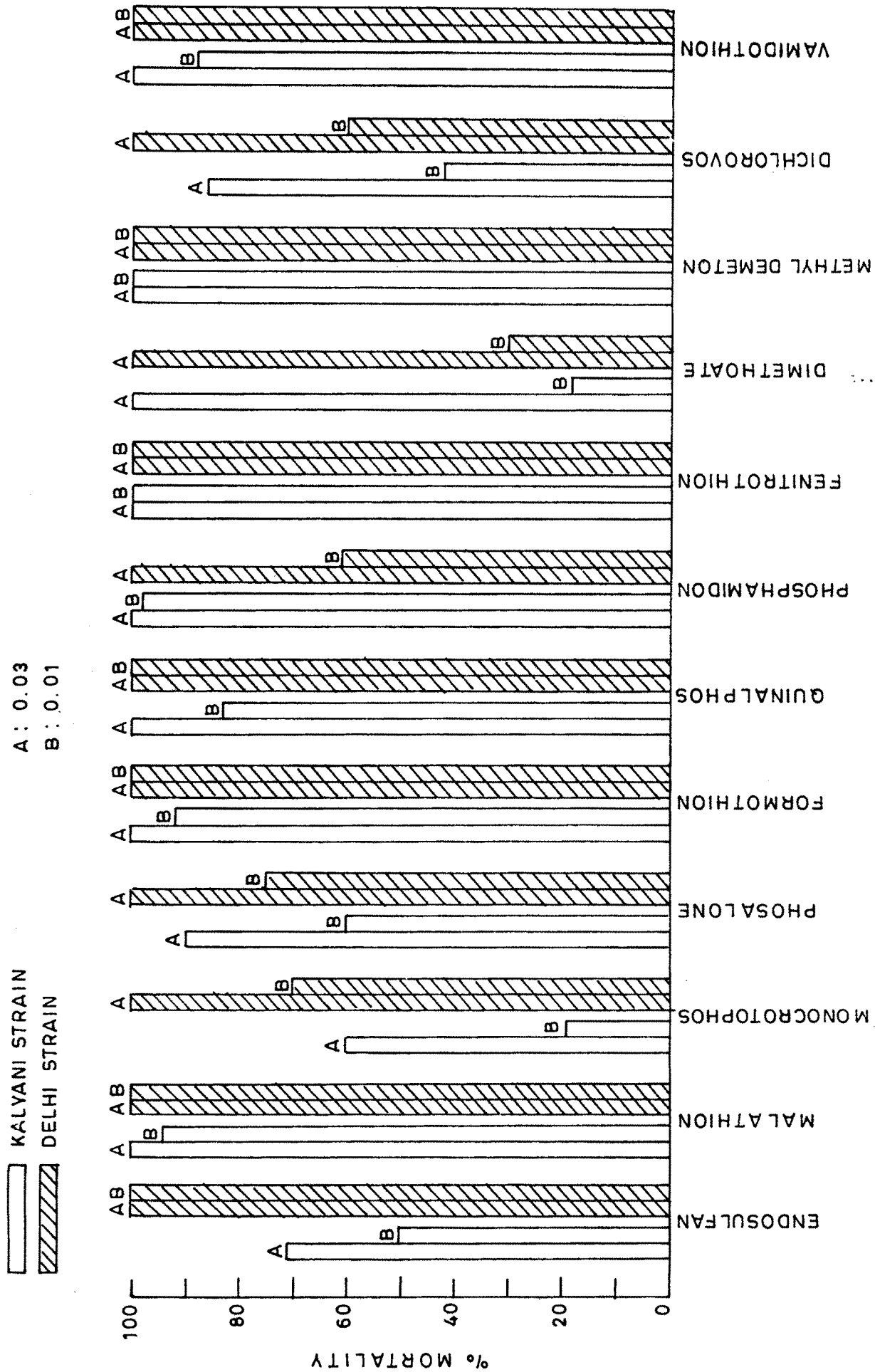
Highly significant difference on the mortality among the pupae of two strains was observed irrespective of insecticide and their concentration.

Table 4.9 : Effect of different insecticides on pupal stage of two strains of *T.chilonis* at 25°C and 60% r.h.(mean of three replications)

Insecticide	Concentration (% a.i.)	No. of individuals used /treatment	Corrected % mortality (within host egg)	
			Kalyani strain (paddytype)	Delhi strain
Endosulfan 35EC	0.03	100	70.79	100.00
	0.01	100	50.30	100.00
Malathion 50 EC	0.03	100	100.00	100.00
	0.01	100	93.82	100.00
Monocrotophos 36 EC	0.03	100	60.66	100.00
	0.01	100	17.86	70.48
Phosalene 35 EC	0.03	100	90.05	100.00
	0.01	100	60.00	74.91
Formothion 25 EC	0.03	100	100.00	100.00
	0.01	100	92.48	100.00
Quinalphos 25 E.L	0.03	100	100.00	100.00
	0.01	100	82.92	100.00
Phosphamidon 85 E.L	0.03	100	100.00	100.00
	0.01	100	98.35	60.72
Fenitrothion 50.E.L	0.03	100	100.00	100.00
	0.01	100	100.00	100.00
Dimethoate 30 E.L	0.03	100	100.00	100.00
	0.01	100	18.62	30.16
Methyl Demeton 25.E.L	0.03	100	100.00	100.00
	0.01	100	100.00	100.00
Dichlorvos 76 EC	0.03	100	86.84	100.00
	0.01	100	42.15	60.58
Vamidothion 40 EC	0.03	100	100.00	100.00
	0.01	100	88.34	100.00

	<u>Strain</u>	<u>Insecticide</u>
'F' test	Sig.	Sig.
C.D. at 5 %	7.38	5.98

**Fig. 5.** EFFECT OF DIFFERENT INSECTICIDES ON PUPAL STAGE OF *T. chilonis* AT 25°C AND 60% R.H. ( MEANS OF THREE REPLICATIONS )



In general, mortality of pupal form of Delhi strain was more than that of Kalyani strain. However, no difference in the mortality was observed only when malathion (0.03%), formothion (0.03%), Quinalphos (0.03%), phosphamidon (0.03), fenitrothion (0.03% and 0.01%), Dimethoate (0.03%), methyl demeton (0.03 & 0.01%) and Venidothion (0.03%) and in such cases mortality was total. The difference in response <sup>to</sup> of the two strains to twelve pesticides varied significantly among themselves.

The maximum pupal toxicity (100%) was recorded in the case of Kalyani strain under methyl demeton and fenitrothion. Both the concentrations of the pesticide (0.03 and 0.01%) provided total mortality. Various other pesticides like malathion (0.03%), formothion (0.03%), Quinalphos (0.03%), phosphamidon (0.03%), dimethoate (0.03%) and venidothion (0.03) only at higher concentration ~~also~~ provided total mortality of Kalyani strain of T. chilonis. On the other hand, the pupal stage of Delhi strain was affected more adversely under pesticidal application. Pesticides like endosulfan (0.03 & 0.01%), malathion (0.03 & 0.01%) monocrotophos (0.03%), phosalone (0.03%), formothion (0.03 & 0.01%), Quinalphos (0.03 & 0.01%) phosphomidon (0.03), fenitrothion (0.03 & 0.01), dimethoate (0.03%), methyl demeton (0.03 & 0.01%), dichlorvos (0.03%) and Venidothion (0.03 & 0.01%) gave total mortality of the parasite. It appears that endosulfan (0.01), monocrotophos (0.01), dimethoate (0.01) and dichlorvos (0.01) were relatively safe for Kalyani strain of Trichogramma while dimethoate alone (0.01%) was safe to the Delhi strain of Trichogramma.

However, insecticides like phosphamidon (0.01) and dichlorvos (0.01) may also be considered as selective insecticide as they provided 60% mortality of the pupal stage of the parasite.

The descending orders of the toxicity of the twelve pesticides along with the mortality data in parentheses was as follows:

i) Kalyani strain : fenitrothion 0.03 (100.00) = fenitrothion 0.01 (100.00) = methyl demeton 0.03 (100.00) = methyl demeton 0.01 (100.00) = Vamidothion 0.03 (100.00) = dimethoate 0.03 (100.00) = phosphamidon 0.03 (100.0) = Quinalphos 0.03 (100.0) = formothion 0.03 (100.0) = malathion 0.03 (100.0), phosphamidon 0.01 (98.35), malathion 0.01 (98.82), formothion 0.01 (92.48), phosplone 0.03 (90.05), Vamidothion 0.01 (88.34) dichlorvos 0.03 (86.84), Quinalphos 0.01 (82.92), endosulfan 0.03 (70.79), monocrotophos 0.03 (60.66), phosalone 0.01 (60.00), endosulfan 0.01 (50.30), dichlorvos 0.01 (42.15), dimethoate 0.01 (18.62), monocrotophos 0.01 (17.86);

ii) Delhi strain: endosulfan 0.03 (100.00) = endosulfan 0.01 (100.0) = malathion 0.03 (100.0) = malathion 0.01 (100.0) = monocrotophos 0.03 (100.0) = phosalone 0.03 (100.0) = formothion 0.03 (100.00) = formothion 0.01 (100.0) = Quinalphos 0.03 (100.0) = Quinalphos 0.01 (100.0) = phosphamidon 0.03 (100.0) = fenitrothion 0.03 (100.0) = fenitrothion 0.01 (100.0) = dimethoate 0.03 (100.0) = methyl demeton 0.03 (100.0) = methyl demeton 0.01 (100.0) = dichlorvos 0.03 (100.0) = vamidothion 0.03 (100.0) = vamidothion 0.01 (100.0) phosalone 0.01 (74.91), monocrotophos 0.01 (70.48), phosphamidon 0.01 (60.72), dichlorvos 0.01 (60.58), dimethoate 0.01 (30.16).

It is evident from the available literatures that little attention has been paid to study the quantitative aspect of the effect of common insecticides usually recommended against the pests. The need for more study of the specific responses of predators and parasites to insecticides has been emphasized in reviews by (Croft, 1972; Georghious, 1972; Newsom, 1974). Applied pest control literature, for example, contains implications that natural enemies characteristically are susceptible to broad-spectrum insecticides. While it is only the pests which develop resistance. On the other hand, Newsom (1967, 1974) and Ferguson (1969) pointed out that the existing experimental evidence does not justify the assumption of any physiological differences between the responses of pests and of natural enemies to insecticides. According to Croft and Brown (1975), the order of descending toxicity of the common insecticides to parasite are as follows : i) endrin, dieldrin, lindane, DDT ii) parathion, malathion, carbaryl, toxaphene and iii) carbophenothion, endosulfan, thiometon. Again, some workers have reported that parasitism was adversely affected by DDT, BHC, Chlordane, parathion, toxaphene (Hinds and Spencer, 1928; Ingram Mathes, Wilson and Hayslip, 1951; Dugas and Concienne, 1956). Kot (1970) remarked carbaryl to be more toxic than methyl demeton <sup>to</sup> T. evanescens.

It was observed during the present investigation that fenitrothion, ~~kk~~ methyl demeton formethion, phosphamidon, malathion, vamidothion and quinalphos <sup>were</sup> highly toxic to the pupal stage of both the strains of Trichogramma. The Kalyani strain showed a wide degree

of tolerance against some pesticides like endosulfan, monocrotophos. But Delhi strain was highly susceptible to most of the pesticides. However, some pesticides at lower concentration (0.01 % a.i.) are relatively safe for the strain. These are phosphanidon (60.72 %), dichlorvos (60.58) and *m* dimethoate (30.16). For Kalyani strain, the corresponding pesticides are endosulfan 0.01(50.30), monocrotophos 0.03 and 0.01 (60.66 and 17.86), phosalone 0.01 (60.00) dimethoate 0.01 (18.62). Somchoudhury (1978) while working on the effect of pesticides on two species of Trichogramma reported that the order of susceptibility of different stages of the parasites was : adult > pupa > larva. He further reported that pesticides like malathion, parathion, carbaryl are highly toxic to the parasites. While endosulfan and diazinon were relatively safe. Mandal (1980) reported that the descending order of pupal toxicity of three pesticides as : carbaryl, BHC, monocrotophos. However, due to the availability of only limited informations in this regard, the present author could not elaborate the discussion into further depth.

In most of the holometabolous natural enemies, the pre-pupal and pupal stages are relatively <sup>immu</sup>immune to all types of toxicant (Bartlett, 1964). But an opposite view has been expressed by Thurston and Fox (1972). According to them, internal parasites become more susceptible to poisoning as they approach pupation. Bartlett (1964) has generalised that it is in the adult stages that predators

and parasites are the most susceptible to insecticide while eggs are the least affected. The adult stage has proved to be the most susceptible (Lingappa, Starks, Eikenbary, 1972; Lingren, Wolfenbarger, Nosky and Diaz, 1972), often being the only stage to live an exposed life. The present author, therefore, found it fit to undertake some field trials to understand the adverse effect of pesticides under field conditions. The findings have been reported in the subsequent paragraphs.

The types of pesticides are broadly characterized by different degrees of selectivity. Both the physical and physiological patterns of selectivity associated with each type. However, the manner of use of the pesticide will determine the ultimate favourability of any individual toxicant in integrated control practice. Critical studies on bioefficacy of various pesticides against pest species vis-a-vis natural enemies under field condition would reveal the true picture.

#### 4.10 Effect of pesticides on T.chilonis vis-a-vis pests under field condition

For the purpose of investigations, four crops viz., paddy, lady's finger, brinjal and jute were selected where lepidopteran tissue borers are most important. The data collected from various experiments have been presented below ;

#### 4.10.1 Paddy

The results of the experiment have been presented in Table 4.10. It is revealed that among the five pesticides tested on against yellow stem borer of paddy, Scirpophaga incertulas (Walk) vis-a-vis rate % of parasitisation of tagged coryra eggs by T. chilonis, dimethoate treated plots showed the maximum rate of parasitisation (29.85) followed by Carbofuran (28.69); phosphamidon (26.16) and phorate (22.45). The corresponding figure for control plot was 33.21 %. The lowest rate of parasitisation was observed in ethion treated plot. The parasitisation rate was found to vary significantly among various treatments. The difference observed between the two best treatments was not statistically significant.

The data collected on the efficacy of pesticides on stem borer showed that all the pesticidal application provided significant reduction of the population of stem borer over the control as is evidenced from the dead <sup>heart</sup> and white <sup>head</sup> ~~heart~~ symptoms. It is also revealed that carbofuran provided the most effective control of the borer but it was statistically at par in its performances with phosphamidon and phorate. When the overall performance of the various insecticidal treatments in reducing the infestation of the borer is taken into consideration, the order of efficacy was : Carbofuran = phorate = phosphamidon > dimethoate = ethion.

Table 4.10 : Effect of insecticidal applications on the rate of parasitisation of tagged *CORYZA* egg by *I. CHILONIA* (paddy type) YAS-2-12 the stem borer of paddy, (*Scirpophaga incertulas* W)

Insecticide	Concen- trations (% a.i.)	% parasiti- sation	% damage	
			Dead heart	White heart head
Phosphamidon 85EC	0.05	26.16	3.02(11.08)	1.01(5.43)
Phorate 10G	1.25 kg/ha	22.45	2.77( 9.87)	1.15(5.81)
Carbofuran 3G	1.25 kg/ha	28.69	2.28( 9.22)	0.92(4.86)
Dimethoate 30EC	0.04	29.85	4.11(11.95)	1.80(6.47)
Ethion 50EC	0.05	1.04	5.03(12.02)	2.13(8.06)
Control	Water spray	33.21	15.55(23.22)	4.21(9.55)
'F' test			Sig.	Sig.
C.D. at 5%		2.28	2.65	1.07

#### 4.10.2 Lady's finger

The results obtained during the course of investigation have been presented in Table 4.11. It shows that among the five pesticides considered during the present investigation ethion treated plots showed the minimum rate of parasitisation (0.001) while it was maximum in carbofuran treated plots (19.34%) followed by dimethoate (17.33%) phosphamidon (14.10 %) and dichlorvos (11.89%). The rate of parasitisation varied significantly among the treated plots and the difference in rate of parasitisation between carbofuran and control plot though significant was not worth mentioning.

It is also evident from Table 4.11 that all the pesticidal applications brought about a significant reduction of the shoot and fruit borer Earis vittella (F) population. The best result was obtained with the application of dimethoate. But similar reduction of the pest population was obtained with the applications of carbofuran, dimethoate <sup>and</sup> phosphamidon. The order of efficacy was : carbofuran = dimethoate = phosphamidon > dichlorvos = ethion.

#### 4.10.3 Brinjal

The data have been presented in Table 4.12. It may be seen that among the five pesticides, carbofuran treated plots showed maximum rate of parasitisation (15.27 %) followed by dimethoate (13.77), aldicarb (12.36) <sup>and</sup> monocrotophos (8.52). The host eggs tagged on quinalphos treated plot showed no sign of parasitisation. The rate of parasitisation varied significantly among various treatment.

**Table 4.11 : Effect of insecticidal applications on the rate of parasitisation of tagged *Coxysia* egg by *T. chilonis* (Lady's finger type) vis-a-vis on fruit and shoot borer of lady's finger, *Earias vitella* (F).**

Insecticide	Concentration (% a.i.)	% parasitisation	% fruit infested
Carbofuran 3G	1.25 kg/ha	19.34	6.24(14.05)
Dichlorovos 76 E.C	0.05	11.89	9.50(17.24)
Dimethoate 30 E.C	0.04	17.33	5.40(13.95)
Phosphamidon 85 E.C	0.05	14.16	6.74(14.94)
Ethion 50 E.C	0.05	0.00	8.63(17.07)
Control	Water spray	21.68	17.02(24.16)
'Y' test		sig.	sig.
C.D. at 5%		* 1.94	2.63

Table 4.12: Effect of insecticidal applications on the rate of parasitisation of tagged *Conyza* egg by *T. shillongia* (paddy type) via-s-via on fruit and shoot borer of brinjal, Leucinodes orbonalis (Guen). Shoot

Insecticide	Concentration (% a.i.)	% parasitisation	% infestation on	
			Plant	Shoot
Aldicarb 10 G	1.25 kg/ha	12.36	23.81	4.00
Carbofuran 3 G	1.25 kg/ha	15.27	19.05	3.92
Dimethoate 30 E.L	0.04	13.77	20.24	3.69
Quinalphos 25 E.L	0.03	-	27.38	5.57
Monocrotophos 36 E.L	0.03	8.52	32.14	5.14
Control	Water spray	18.98	27.38	9.69
'F' test		sig.	sig.	sig.
C.D. at 5%		2.63	5.21	3.15
				36.80
				28.74
				34.73
				36.61
				41.01
				43.39
				sig.
				11.34

The rate of parasitisation obtained in control and carbofuran treated plot though statistically different may be comparable. It is also evident from Table 4.12 that carbofuran provided the most effective control of the shoot and fruit borer, Leucinodes Orbonalis Guen. of brinjal when the rate of infestation on plants, shoots and fruits were taken into consideration. The second best yield was recorded in the Aldicarb treated plots followed by dimethoate treated plot.

#### 4.10.4 Jute

The results obtained from the experiment have been presented in Table 4.13. It is evident that among six pesticides, only endosulfan treated plots showed very negligible rate of parasitisation of tagged host eggs (1.86 %) while in other insecticidal treated plots the rate of parasitisation was nil. In untreated plots it was 9.17 %.

It is also evident from the above mentioned Table that all the treatments provided significant reduction of the population of seita Anomis sabulifera Guen. semilooper over the control. Endosulfan treated plot provided the best result followed methyl parathion, carbaryl, malathion and quinalphos. Phenthoate provided the least control of the jute semilooper though it provided far superior result in comparison to control plot.

The field experiments conducted to assess the adverse effect of pesticides on T. chilonis revealed some interesting informations,

Table 4.13 : Effect of insecticidal applications on the rate of parasitisation of tagged coreyra egg by *T. chilonis* (jute type) vis-a-vis on jute semilooper, *A. sabulifera*

Insecticide	Concentrations	% parasitisation	Mean % reduction in population after 5 days
Endosulfan 35 E.C	0.04	1.86	93.82
Methyl parathion 50 E.C	0.05	-	73.58
Carbaryl 50 W.P	0.1	-	69.43
Quinalphos 25 E.C	0.05	-	61.17
Malathion 50 E.C	0.05	-	68.18
Phenthoate 50 E.C	0.05	-	50.74
Control	Water spray	9.17	5.21

Chemical control methods <sup>now</sup> oriented to achieve the preservation of natural enemy while simultaneous destruction of a satisfactory portion of the pest ~~species~~ could also be found. Natural enemies vary greatly in their susceptibility to pesticides and manipulations of treatments to take advantage of these tolerances to pesticides offers favourable opportunities for integrated control programmes. Physiological selectivity is obtained when a pesticide is preferentially more poisonous to pest species than to natural enemies. In a general sense, this is not as frequent in occurrence as might be expected since many natural enemies are very susceptible to small amounts of toxicants. However, it is said that systemic insecticides, when applied to seed or through soil (or in other fashion) so as to avoid contact effect, are highly selective (DeBach, 1964). Similar observations have been recorded during the present investigation. The systemic insecticides such as phorate, carbofuran, aldicarb etc when applied in soil provided the least mortality of the parasite as evidenced from the higher rate of parasitisation of host eggs. Similarly phosphamidon, dimethoate etc, which are applied on leaf for systematic action also selective in nature as their applications did not discourage the activity of the parasite to a great extent. The rate of parasitisation under such situation was comparable to those obtained under untreated plots. On the other hand, most of the common insecticides were highly injurious to T. chilonis as is

revealed from the rate of parasitisation found under such condition. Such insecticides which were tested here are methyl parathion carbaryl, quinalphos, malathion, phenthoate, ethion etc. Among conventional insecticides only endosulfan showed some degree<sup>of</sup> selectivity. Monocrotophos though systemic in action is injurious to the parasite to a certain extent. Considering its high level of efficacy against several pest species, it may also be recommended in the integrated control programme of pest species along with endosulfan and granular pesticides.

It has been clearly demonstrated during the various field trials that certain insecticides are least toxic to T. chilonis but highly toxic to pest species. Therefore, crop wise following recommendation may be made ;

i) Paddy : Phorate, carbofuran, dimethoate may be considered as selective insecticide to save Trichogramma sp. <sup>for</sup> ~~with~~ simultaneous destruction of the yellow stem borer.

ii) Lady's finger : Carbofuran, dimethoate, phosphamidon may be considered as selective insecticide to save the parasite <sup>for</sup> ~~with~~ simultaneous control of fruit and shoot borer.

iii) Brinjal : Carbofuran, dimethoate and aldicarb may be considered as selective insecticide to save the parasite <sup>for</sup> ~~with~~ simultaneous destruction of fruit and shoot borer.

iv) Jute : Endosulfan alone can be considered as selective insecticide to save Trichogramma as well as to obtain a high degree of control of pest species. According to DeBach (1964) , occasionally a parasitic species shows exceptional tolerance to a wide toxicity spectrum pesticide, but, as with pest species, these particular responses do not follow any determinable pattern and such few isolated cases as have been found are of little practical use where, as is usually the case, many host -parasite associations must be considered in the treatment of a crop. Unless the parasites showing this exceptional tolerance to an otherwise wide-toxicity spectrum pesticide are particularly effective against major pests on the crop, the gains from their individual preservation ordinarily will not outweigh the overall loss from the destruction of other natural enemies.

CHAPTER - V  
S U M M A R Y

## S U M M A R Y

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i) Studies were undertaken to reveal the ecology of local Trichogramma sp. based on occurrence, distribution and searching capacity under various crop ecosystems. A comparative study between the local and Delhi <sup>type</sup> ~~local~~ Trichogramma based on the biological differences was undertaken to identify them biologically. The possibility of presence of various biotypes within a Trichogramma sp. was considered based on biological and morphometrical observations. Attempts were also made to screen out the selective insecticides considering the responses of the parasite vis-a-vis some important insects pests.

ii) It was observed that the frequency of occurrence of the parasite was maximum under certain crop ecosystem, viz., paddy, groundnut and maize etc. The minimum occurrence of the parasite was noticed on crop plants like moong and jute. The total absence of the parasite was noticed on various other plants like bengal gram, Lantana sp, mango and litchi.

iii) It appears from the investigation that no parasitisation of host egg was observed when they were distributed above 8 metre height on any of the crop ecosystem. Similarly no parasitisation of tagged corcyra eggs was recorded when they were placed near the ground level. The best rate of parasitisation was provided when the host eggs were placed between  $1-1\frac{1}{2}$  metre height provided the area

was a lighted portion of the plant. The second best rate of parasitisation was obtained from <sup>between</sup> 2-3 metre height. A negligible parasitisation was obtained when the coryra eggs were <sup>placed</sup> between 4-7 metre height.

iv) A detailed study on the structure of male genitalia of nine types of Trichogramma revealed that they belong to the same species i.e. T.chilonis by virtue of the presence of very prominent lateral lobes on genitalia. Similarly, Delhi strain of Trichogramma also possess similar structures on genitalia revealing its identity as T.chilonis.

v) In order to ascertain whether morphological similarities were due to the fact that they belong to the same species, reciprocal crosses were undertaken using both male and female of the each of the nine type of local Trichogramma and Delhi type. The progeny production varied between 633.28 - 798.81 and the percentage of female and male were between 66.38 to 81.68 and 18.32 to 33.62 , respectively. Therefore, it indicates that successful breeding has taken place and they are authentically the same species.

vi) To study the type of reproduction, the females alone were kept in isolation before mating. In the case of local types, 59.13 -84.14 individuals were obtained and the all of them were males. Similarly in the Delhi type 104.88 individuals emerged and all were

males thereby confirming arrhenotokous type of reproduction in all the cases.

vii) The type of Trichogramma sp. collected on citrus was maximum in size (0.498 x 0.190 mm) followed by lady's finger (0.492 x 0.188 cm), potato (0.482 x 0.188), maize (0.478 x 0.172), paddy (0.471 x 0.176 mm) etc. The size was minimum when the sample of Trichogramma obtained from moong (0.457 x 0.152 mm) and red gram (0.453 x 0.161 ). Similarly, other characters like length of antennal hair, width of forewing, length of aedeagus varied significantly among nine types of Trichogramma. The sequence of decrement or increment of measurement of various body parts followed more or less same sequence as were observed in cases of body length and breadth. However, the characters, like width of flagellum and forewing, length of tibia and apodemes did not ~~differ~~ <sup>showed</sup> significant difference among themselves in nine types of Trichogramma sp.

viii) It is revealed from the studies undertaken on biology of nine types of Trichogramma sp. that the longevity varied significantly among nine types of Trichogramma being maximum in lady's finger (48.2 hours) followed by citrus (47.7 hr), maize (46.8 hr), paddy (45.2 hr). It was minimum in moong (39.5 hr). The rate of parasitisation also varied significantly among nine types of Trichogramma, the fecundity being maximum in Citrus (45.9 eggs) and minimum in moong (32.6 eggs) and jute (33.7), ~~respectively~~

There was no significant variation in the duration of life cycle among various types. It is completed in six days in all cases at 30°C with 60 % r.h. Similarly the rate of emergence did not differ significantly among various types of Trichogramma which varied between 71.14 - 86.88 %. But the sex ratio showed wide variation among various types of Trichogramma being statistically significant. The maximum percentage of female was noticed in citrus (80.36 %) and the minimum in moong (69.80%) and jute (70.11 ).

ix) Searching capacity of nine types of Trichogramma were investigated in four types of crop viz., paddy, maize, jute and gram. The maximum parasitisation of host eggs (used as an index for searching capacity) was obtained with the release of paddy (11.23 %) or maize types (11.88) which differed significantly in their rate of parasitisation from other types. Therefore, it may be said that paddy /maize type were the best searcher on paddy plant. Similarly, on maize, type collected from maize plant provided the best parasitisation (17.22 %) followed by paddy type (11.88%). Obviously, on jute and red-gram, best parasitisation was obtained with the release of jute and red-gram types, respectively (9.13 % and 13.83 %).

x) Comparative biology of the two strains of Trichogramma viz., Delhi and Kalyani were studied at 30°C under three levels of relative humidity i.e. 30, 60 & 90 %. The female longevity of the two strains varied significantly between themselves. The longevity

of female of Delhi strain was maximum under 30% r.h. followed by 90 and 60 %. It was exactly reverse in the case of Kalyani strain where maximum longevity was recorded under 90 % followed by 30 and 60 % r.h.

The rate of parasitisation also varied significantly between two strains as well as among three levels of relative humidity. The maximum parasitisation of eggs by Kalyani strain was recorded under 90 % r.h. followed by 60 and 30 %. On the other hand, it was opposite in the case of Delhi strain where the descending order was 30, 60 and 90 % . The difference observed between two levels of relative humidity always varied significantly between themselves.

The duration of life cycle of the two strains of Trichostrongylus also varied significantly among three level of relative humidity. The maximum duration was noticed at 90 % followed by 30 and 60 % r.h. in the case of Kalyani strain while it was 30, 60 and 90 % in the descending order in the case of Delhi strain.

The emergence rate of the two strains of parasites also varied significantly among three levels of relative humidity. The descending sequence was 90, 60, 30 % r.h, in the Kalyani strain and the corresponding r.h. for Delhi strain was 30,60 and 90 % r.h.

The sex ratio of the two strains of the parasite again varied significantly among three levels of relative humidity. The maximum number of female was found under 90 followed by 60 and 30%

r.h. in Kalyani strain. Similar trend of female production was also noticed in the Delhi strain being maximum under 90 followed by 60 and 30 % r.h.

xi) Biology of Kalyani strain of T. chilonis was investigated under field condition. The female longevity, rate of parasitisation, duration of life cycle, rate of emergence and sex ratio of the parasite varied significantly among twelve months of observations in each of the two years. Maximum longevity was recorded during December and January (16.82 - 18.14 days) and the minimum during May and June (3.14-3.74 days). Longevity increased with the decrease in temperature. The rate of parasitisation of host eggs was the lowest during June-July (28.13-36.18 eggs) and it was maximum during March (88.21-92.75 eggs). The shortest duration of the parasite was observed during May-June (7.15 days) and with lowering of temperature from the month of November onwards, the duration prolonged. The rate of emergence reached its peak during the months of January to March (87.08-95.00 %). The minimum was recorded during May (38.45-42.62 %). The sex ratio ( %  $\phi$  ), was maximum during February-March (62.35-66.91) as well as during September-October (66.30-71.67). It was minimum during July (67.54-64.16%). Higher percentage of female production was directly related with mild temperature with high to moderate relative humidity. The lower

production of female is associated with either higher temperature along with low percentage of r.h. or moderately high temperature along with high percentage of r.h.

xii) Relative toxicity of twelve pesticides namely, endosulfan, malathion, monocrotophos, phosalone, formothion, quinalphos, phosphamidon, fenitrothion, dimethoate, methyl demeton, dichlorvos and vamidothion were tested in two concentrations viz. 0.03 & 0.01 % on the pupal stages of two strains of T.chilonis under laboratory condition. In general, Delhi strain of Trichogramma was most affected.

Pesticides like endosulfan (0.03 & 0.01 %), malathion (0.03 and 0.01 %) monocrotophos (0.03 %), phosalone (0.03 %), formothion (0.03 & 0.01%), Quinalphos (0.03 & 0.01%) phosphamidon (0.03), fenitrothion (0.03 & 0.01), dimethoate (0.03%), methyl demeton(0.03 & 0.01%), dichlorvos (0.03%) and Vamidothion (0.03 and 0.01 %) gave total mortality of the parasite. It appears that endosulfan (0.01); monocrotophos(0.01), dimethoate (0.01) and dichlorvos (0.01) were relatively safe for Kalyani strain of Trichogramma while dimethoate alone (0.01%) was safe to the Delhi strain of Trichogramma. However, insecticides like phosphamidon (0.01) and dichlorvos (0.01) may also be considered as selective insecticide as they provided 60 % mortality of the pupal stage of the parasite.

xiii) Effect of pesticides on T.chilonis vis-a-vis important pest species revealed that on paddy crop, dimethoate treated plants showed the maximum rate of parasitisation (29.85 %) of tagged

host egg followed by carbofuran (28.69 %), phosphamidon (26.16) and phorate (22.45). Similarly the best control of the yellow stem borer of paddy was obtained with carbofuran (2.28) phosphamidon (3.02 %) and phorate (2.77 %). The order of efficacy was carbofuran = phorate & phosphamidon > dimethoate = ethion.

In lady's finger, the maximum parasitisation of tagged host eggs, was found in carbofuran treated plots (19.34 %) followed by dimethoate (17.33 %), phosphamidon (14.10%) and dichlorvos (11.89%). The best control of fruit and shoot borer of lady's finger was obtained with the application of dimethoate (5.40 %). The order of efficacy was = carbofuran = dimethoate = phosphamidon > dichlorvos = ethion.

On brinjal, the maximum rate of parasitisation (15.27%) was observed in carbofuran treated plots followed by dimethoate (13.77 %), aldicarb (12.36 %) and monocrotophos (8.52 %). Similarly, carbofuran provided the best control (28.74 %) of the shoot and fruit borer of brinjal. The second best result was obtained with the application of dimethoate (34.73).

On jute where mostly conventional pesticides were used in the form of spray fluid, only endosulfan treated plots allowed negligible rate of parasitisation (1.86 %) while in other treated plots it was nil. Similarly, endosulfan provided the best control of jute semilooper (93.82). The semilooper efficacy of other pesticides against jute in descending order was : methyl parathion (73.58), Carbaryl (69.43), malathion (68.18), Quinalphos (61.17).

CHAPTER - VI

C O N C L U S I O N

## C O N C L U S I O N

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It is evident from the results summarised in the foregoing para that T. chilonis do<sup>e</sup> exist in different forms which are to be considered as biotypes. Various types collected from nine different host plants showed wide degree of variation in their biology. Furthermore, they are truly adapted to certain host plant condition as is revealed from their searching capacity exhibited on the respective host plants from which they were collected. Again, Trichogramma collected from the two far<sup>off</sup> distant places with wide climatological variations appears to be two distinct strains and may be termed as climatologically adapted strain. Among the two strains one obtained from arid part of the country and the other from the coastal area showed clear preference for a humidity range. The coastal strain would thrive better under high humid condition while the arid strain is better adapted under low to moderate humid condition. The studies on field biology clearly demonstrated that the optimum conditions for multiplication of Trichogramma are found during Feb-April and September to November. Therefore, to obtain a good control of paddy stem borer, periodic ~~xxx~~ colonisation of Trichogramma would be required from the months of July to September on 'aman' paddy. However, the prospect in achieving a good control of the pest on 'Aus' crop is very much limited. Again, period colonisation of T. chilonis (paddy) on 'boro' crop would provide a highly effective control of the paddy stem borer.

It is further evident from the present work that a good control of fruit and shoot borer of lady's finger may also be obtained with the release of T.chilonis as the period of pest occurrence is highly favourable to T.chilonis. But the success would obviously depend on the release of the particular type collected on lady's finger alone.

The inclusion of Trichogramma in integrated pest control programme would face with some limitation. Most of the conventional pesticides when applied as direct spray on crop plant hindered the activity of Trichogramma to a great extent. However, the answer would be <sup>the</sup> use of granular pesticides. Alternatively, systemic pesticides like dimethoate or monocrotophos which sprayed on the leaf surfaces, may be incorporated in the integrated control schedule.

It may now be postulated that the entire 'Trichogramma' method should be oriented to unilateral direction for identification of biotypes and their subsequent periodic colonisation to make the failure story into a success one.



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