Introduction
Predatory insects like reduviids are an important group of biological control agents. As the use of chemical insecticides gained currency, every farmer has been adapting pest management. Today, however, people are becoming increasingly aware that in the long run, the harmful effect of the insecticides far outweighs the advantage of temporary pest control. Reduviids are important predators of cotton, rice, brinjal, groundnut and various other crops and plantations crop pests. Currently the reduviids are not commercially available any where in the world. However, very little efforts have been made to rear few reduviids in small scale under laboratory conditions by larval card method, (Sahayaraj, 2002a).

1.1. Hemipteran as Biological Control Agents

The important hemipteran bugs used as biological control agents are *Platymeris laevicollis* Distant (Antony et al., 1979); *Nabis* spp. (Anonymous, 1987); *Geocoris punctipes* Say (Cohen, 1984, Cohen and Bryne, 1992); *Zelus renardii* Kolenati (Cohen, 1993); *Podisus maculiventris* (Say) and *P. sagitta* (Fab.) (De Clercq and Degheele, 1994); *Eocanthecona furcellata* (Wolff) (Usha Rani and Wakamura, 1993); *Cyrtopeltis tenius* (Torreno, 1994); *Cardiastethus exigus* Poppius and *Buchananiella sodalis* (Sujatha and Singh, 1999); *Rhynocoris marginatus* Fabricius (Sahayaraj, 1998, 1999 b, 2002 b; Ambrose and Claver, 1999 b; Sahayaraj and Martin, 2003); *Rhynocoris kumarii* Ambrose and Livingstone (Claver, 1998; Ambrose, 2000; Ambrose and Claver, 2001a, b) and *Pristhisancus plagipennis* Walker (Grundy and Maelzer, 2000). Seven hemipteran predators were included as biological control agents (Navarajanpaul, 2003). Ballal et al. (2003) also included *Blaptostethus pappescens* Poppius as a biological control agent.
1.2 Reduviids

Reduviids are generalist predators that mainly feed on lepidopteran, coleopteran, hemipteran and isopteran insects and are considered a potential biological control agent against various pests (Schaefer and Ahmad, 1987; Schaefer, 1988; James, 1994; Ambrose, 1980, 1991, 1995, 1996; Sahayaraj, 1999b, 2002b; Sahayaraj and Martin, 2003; Sahayaraj et al., 2006, 2007). The incidence of reduviid predators in diverse cropping system and their biological control potential is documented elsewhere (Werner and Butler, 1957; Whitcomb and Bell, 1964; Altieri and Whitcomb, 1980; Mc Pherson et al., 1982; Ambrose, 1987, 1988, 1991, 1995, 1996, 2000; Sahayaraj, 1991, 1998 a, 1999 b, 2001, 2002 b; Claver, 1998; Claver and Ambrose, 2001a, b; Sahayaraj et al., 2004). The quality and quantity of nutrients of the prey influence not only the growth rate and survival of the predator (Ambrose and Subbarasu, 1988; Ambrose et al., 1990; O’Neil and Widenman, 1990; Ambrose and Rani, 1991; Cohen, 1990, 1993; George et al., 2002) but also increase the fecundity and life table characteristics such as generation time and intrinsic rate of population increase (Awadallah et al., 1986; George, 1999, 2000 a). The nutritional quality of the prey has a high influence over the whole physiological process of a predator (Ananthakrishnan, 1996).

1.3 Rhynocoris marginatus (Fab.) (Heteroptera: Reduviidae)

*Rhynocoris marginatus* (Fab.), a harpactorine reduviid predator, redescribed by Ambrose and Livingstone (1986), is generally present in agroecosystems, semiarid zones, scrub jungles and tropical rain forests (Ambrose and Livingstone, 1986; Vennison and Ambrose, 1990; Sahayaraj, 1991; Kumar, 1993; Kumaraswami and Ambrose, 1994; Ambrose and Rajan, 1995; Edwin and Ambrose, 1996). Its biology (Ambrose and Livingstone, 1987 a; Claver, 1998); mating behaviour (Ambrose and Livingstone, 1987);
the saliva spitting behaviour (Vennison, 1988; Vennision and Ambrose, 1990, Sahayaraj et al., 2006) and predatory behaviour (Ambrose and Claver, 1996); nympha cannibalism (George, 2000 b) were studied extensively. Ambrose and George (1996) reported the effect of flooding on the incubation and hatchability of *R. marginatus* eggs. Five types of haemocytes were observed in the haemolymph of this bug (Ambrose and George, 1996; George, 1996). The insecticidal impact on the postembryonic development (George, 1996; George and Ambrose, 1999 a); and biochemical modulations by insecticides (George and Ambrose, 1999 b) were studied. The impact of antennectomy and eye blinding on the predatory behaviour (Claver and Ambrose, 2001 d) was also studied.

*Rhynocoris marginatus* has been reported as a potential predator on various economical important agricultural pests such as *Spodoptera litura* (Kumaraswami, 1991; Sahayaraj, 1994; Ambrose and Claver, 1995, 2001a; Sahayaraj and Siva kumar, 1995; Claver and Ambrose, 2001 a); *Papilio demoleus* L. (Kumaraswami, 1991) *Spodoptera litura* and *Dysdercus cingulatus* (Sahayaraj and Balasubramanian, 2008); *Dysdercus cingulatus* Fabricius, *Earias vitella* Fabricius, *Euproctis mollifera* Walker, *Oxycarneus hyalipennis* Costa, *Earias insulana* Boisdual (Kumaraswami, 1991, Ambrose, 1995); *Earias fraterna* Moore (Ambrose, 1995); *Achea janata* Linn. (Ambrose and Claver, 1995; Ambrose, 1996); *Ergolis merione* Costa (Ambrose, 1995; Ambrose and Claver, 1995); *Patanga succinata* L. (Ambrose, 1995); *Anomis flava* Fabricius (Ambrose and Claver, 1995; Ambrose, 2000); *Pectinophora gossypiella* Saunders (Ambrose, 1995; Ambrose and Claver, 1995); *Calacoris angustate* Lethiery (Ambrose and Claver, 1995; Ambrose, 1996); *Mylabris pustulata* Thunberg (Ambrose, 1995) and *Helicoverpa armigera* (Ambrose, 1995, 1996, 2000; Claver and Ambrose, 2001 b). In the laboratory, it feeds on stored product pests such as *Tribolium confusum* Duv. (Ambrose, 1988) and larvae of *Corcyra cephalonica* (Kumaraswami, 1991; Ambrose, 1996; Claver, 1998).
Biological control potential related aspects like host preference (Kumaraswami, 1991); searching behaviour (Claver and Ambrose, 2001a); functional and numerical response (Ambrose and Claver, 1996) were available. Bioefficacy of this Reduviid under the laboratory (Kumaraswami, 1991; Sahayaraj, 1994; Claver, 1998), field cages (Ambrose, 2000; Claver and Ambrose, 2001 b) and field such as cotton and groundnut (Sahayaraj and Paulraj, 2001, Sahayaraj and Martin 2003, Ravi, 2004) were investigated. Moreover, the development and life table on S. litura, E. vitella and C. cephalonica (George, 2002); S. litura and H. armigera was reported (Sahayaraj and Sathyamoorty, 2002). However, the role of Rhynocoris marginatus as natural pest control was greatly neglected and even forgotten.

Rearing and mass multiplication of the reduviids in the laboratory is an important requirement for the successful biological control programme (Schaefer, 1988; Cohen, 1993; Ambrose, 1995, 2001; Sahayaraj et al., 2006). Attempts were made by several workers to mass multiply the reduviids in the laboratory (Lakkundi, 1989; Sahayaraj, 1991; Kumaraswami, 1991; Claver, 1998; Grundy and Maelzer, 2000; Sahayaraj and Paulraj, 2001; Sahayaraj, 2002 b). Its high labor cost, laborious process (Sahayaraj, 2002) and nymphal cannibalism (Ambrose, 1999; George and Ambrose, 2000; George, 2000 b) are the major constraint. The reduviids are reared in the laboratory mainly on the rice moth Corcyra cephalonica alive larvae (Lakkundi and Parshad, 1987; Sahayaraj, 1991, 2001, 2002 b; Claver, 1998; George, 2000 a; Ambrose, 1999; Sahayaraj and Paulraj, 2001; Sahayaraj and Martin 2003, Sahayaraj et al., 2006) and other prey such as S. litura, Earias vitella Fabricius, (George et al., 1998, George, 2000 a; Sahayaraj and Paulraj, 2001); Helicoverpa armigera Hubner and Nezara viridula L. (Grundy and Maelzer, 2000); frozen larvae of C. cephalonica (Sahayaraj and Jayalakshmi, 2002) and H. armigera (Grundy and Maelzear, 2000) and oligidic diet (Sahayaraj et al., 2006, 2007,
2008). In India, a few reduviids like *Platymeris laevicollis* (Antony et al., 1979); *Acanthaspis quinquespinosa* Fabricius (Lakkundi, 1989; Sahayaraj, 1991, 2002); *Brassivola hystrix* Distant, *Coranus sp.*, *Endochus parvispinus* Distant, *Irantha armipes* Stal, *Isyndus heros* (Fabricius) (Lakkundi, 1989); *Acanthaspis pedestris* Stal (Sahayaraj, 1991); *Cyndocoris gilvus* Burm (Venkatesan et al., 1997); *R. kumarii* (Claver, 1998); *R. marginatus* (George, 2000b; Sahayaraj, 2002b); *Neohaematorrophus therasii* Ambrose and Livingstone (Sahayaraj, 2001, Sahayaraj et al., 2004, 2006 and 2007) were mass reared in the laboratory and a little success was achieved.

Although the technology required for the large-scale production of reduviids is relatively straightforward, it is not necessarily available to small laboratories and at present it appears that there is meager information available in the literature on small-scale reduviid production. Cohen (1993); James (1994); Ambrose (1995); Schaefer (1988); Vandekerkhove (2006); Sahayaraj et al., (1999a, 2002a, 2004, 2006, 2007) felt that there is an urgent need for evolving the strategies to mass rear the potential hunter reduviids. Furthermore, one of the basic requisites for a biological control agent is the availability of a sound, low cost rearing and mass multiplication technique, which is not available for the reduviids particularly *R. marginatus*.

A required number of bioagents can be obtained by rearing them either on their natural host or on oligidic diets. Rearing of this predator on natural and/or factitious host is entirely impracticable owing to non-availability of host throughout the year, (Sahayaraj, 1998, 2002a; Sahayaraj and Sathyamoorthi, 2002; Sahayaraj and Jeyalakshmi, 2002). Later, importance and applicability of the oligidic diet in reduviid rearing was reported by Sahayaraj et al., 2006. Sahayaraj et al., (2006) studied the feeding behavior of four reduviids on meat and insect-based oligidic diets and they
reported that irrespective of the reduviids, all the four studied reduviids preferred to feed meat-based diet. It was also reported that in general, oligidic diet reared *R. marginatus* consumed more number of preys than those reared on natural diet and/or factitious hosts (Sahayaraj and Balasubramanian, 2008). Literature survey reveals that no published work is available about the effect of oligidic diet on the biology of this reduviid or any other reduviid predators.

Diet quality can be measured in terms of growth rate, development, reproduction, mortality, longevity and occurrence of abnormalities (Singh, 1977). The development of effective and economically profitable technologies for mass rearing of entomophagous insects is at present a key goal for successful biocontrol programmes. Conditions for the nutrition of insect predators are of special value in the success of insect mass rearing programme. Inadequate nutrition usually results in great changes in the metabolism, behavior and other insect vital activities. These changes inevitably depreciate subsequent insect release. The ability of providing optimal nutrition will greatly affect both expenditures for entomophage production as well as colony quality and sometime determines economic expediency and indeed the possibility for mass culture (Yazlovetsky, 1986). The main development prospects for entomophage mass production for inundative release are, therefore, associated with the development of cheap and adequate artificial diets (Waage *et al.*, 1985, Yazlovetsky *et al.*, 1992). Successful development of such technologies based on artificial media will, however, requires a thorough knowledge of entomophage physiology, and an understanding of the peculiarities of their interactions with insect hosts and prey (Thompson and Hagen, 1999).
1.4. Oligidic Diet

The greatest barrier for the mass production of predatory insects is the lack of suitable artificial diets. Singh (1977) noted that 754 species of arthropod had been reared on artificial diets, of these 27 were arachnids. The remaining are insect species spanning 10 orders consisting of 19 families of Coleoptera, 24 Diptera, 11 Homoptera, 8 Hymenoptera, and 27 Lepidoptera. Sikorowski and Goodwin (1985) also reported similar numbers. However, Waage et al, (1985) pointed out that no suitable artificial diets had been developed for predators. An oligidic diet free of insect components (Cohen, 1985) was developed and sustained (says Cohen, 1985). The status of in-vitro culture of parasitic insect has been reviewed by House (1967), and Thompson and Hagen (1999).

In spite of some promising results obtained in the development of artificial diet for entomophage, the use of artificial diets in mass propagation programmes is currently limited to only a few species of predators and parasitoids (Ridway et al., 1984, Slansky and Rodriges, 1987, Waage et al, 1985, Yaloveltsky et al., 1992). Predatory insects such as, Geocoris punctipes Say (Cohen, 1984, Cohen and Bryne, 1992); Zelus renardii Kolenati (Cohen, 1993); Podisus maculiventris (Say) and P. sagitta (Fab.) (De Clercq and Degheele, 1994); Rhynocoris marginatus Fabricius (Sahayaraj et al., 2006, 2007 and 2008); Hylobius transversovittatus (Carruthers, 2007) have been reared with Oligidic diets. Some artificial diets have been proposed for rearing mired bugs (Cohen, 2000). A simple diet based on beef and liver was successfully developed for Geocoris punctipes Say. (Heteroptera: Lygaeidae) and Chrysoperla rufilabris Burmeister (Neuroptera: Chrysopidae) (Cohen, 1985a; Cohen and Smith, 1998) this diet was also suitable for rearing Podisus maculiventris Say and P. sagitta Fabricius (Heteroptera: Pentatomidae) after some adjustments (De Clercq and Degheele, 1992,
These meat-based diets were cheap and easy to prepare. Liver-based artificial diets were developed for the production of *Orius laevigatus* Fieber (Heteroptera: Anthocoridae) (Arijs and De Clercq, 2001, 2002, 2004). With reference to Mirid bugs, these diets have been successfully used for rearing *Dicyphus tamaninii* Wagner, a Mediterranean species with similar habits and a similar distribution to *M. caliginosus*. Iriarte and Castane (2001) reared *D. tamaninii* on the diet described for *P. maculiventris* in De Clercq and Degheele (1992).

1.5. Microbial Diversity in Insect Gut

The diversity of the insect is reflected in the large and varied microbial communities inhabiting the gut (Dillon and Dillon, 2004). The indigenous gut bacteria is regarded as a valuable metabolic resource to the nutrition of the host by improving the ability to live on suboptimal diets, improved digestion efficiency, acquisition of digestive enzymes and provision of vitamins (Douglas, 1992; Tanada and Kaya, 1993; Breznak and Brune 1994; Biggs and Mc Grego, 1994; Bignell *et al.*, 1997; Brauman *et al.*, 2001; Broderick *et al.*, 2004). The contribution of gut microbiota to nutrition and disease suppression was also studied by Dillon and Charnley (1986, 1988 and 1996).

The symbiotic bacteria harbored in the midgut caeca of the Heteroptera caused Aposymbiotic nymphs of several heteropterans were reported to exhibit retarded growth and/or nymphal mortality (Abe *et al.*, 1995) suggesting that the symbionts play some important roles for the host insects. The microbiological nature of symbiotic bacteria has been poorly understood. Although several bacteria have been isolated from the gut of some heteropterans in general (Dasch *et al.*, 1984) and reduviids in particularly it has scarcely been confirmed whether the isolates are identical to the predominant bacteria harbored in the midgut caeca.
Insects dependent on restricted diets, such as plant sap, Heamolymph feeder commonly carry symbiotic microorganisms that are thought to provide nutritional supplements for their hosts (Dasch et al., 1984). In this respect the Heteroptera are an interesting research subject for understanding the diversity and evolution of insect-microbe symbiotic associations, because a number of heamolymph feeders and predators of other arthropods are found in this well-defined insect group. Certainly, symbiotic relationships in the Heteroptera correlate reasonably well with diet; symbiotic bacteria tend to be found in heamolymph feeders. Among the Haemolymph-sucking groups of the Heteroptera, the family reduviidae shows the most remarkable behavioral and anatomical arrangement for transmission of the symbiont. Large-scale food processing machinery is available for making the hundreds or thousands of kilograms of diet per day that may be enquired in a mass rearing facility (Rothrock, 1996; Cohen, 2000). The insectary worker is the major source of microbes in a rearing facility (Sikorowski, 1984; Sikorowski and Goodwin, 1985), and once the worker is removed microbes from as much of the diet production and rearing process as possible, the contamination problem can be solved.

Advancement of augmentative biological control would also greatly profit in post-rearing distributional technology, field release and field evaluation systems. A number of arthropod natural enemies have been reared with variable success on artificial diet. Several predatory heteropterons, Chryospids, Reduviids and Coccinellids have been reared for consecutive generations on diets devoid of insect materials. In the present study microbiological aspects, such as microbial diversity, localization in-vivo and fitness effects on the host insect, of the bacteria contained in the gut were investigated.
1.6. Enzyme Activity

Several insect families contain omnivores. However, some predatory insects exclusively predate and feed on other animals (Alomar and Wiedenmann 1996). The origin of feeding habits among the Heteroptera remains controversial (Sweet 1979; Cobben, 1979; Cohen, 1990; Schaefer, 1997; Wheeler, 2001). The diverse trophic habits of bugs make the reduviidae ideal for studies of feeding strategies, including digestive enzyme composition employ macerate (or lacerate) and flush feeding (Miles, 1972; Hori, 2000; Wheeler, 2001) that incorporates piercing/sucking mouthparts and watery saliva from the salivary gland complex. Reduviids feed in a manner that is typical of heteropterans, piercing and cutting tissues with their stylets while injecting digestive enzymes through the salivary canal to liquefy food into nutrient rich slurry. The food slurry is ingested through the food canal and passed into the alimentary canal where it is further digested and absorbed (Cohen, 2000). Digestive enzymes are produced and distributed in various regions of the gut and salivary gland different proportion and quantity. Wide ranges of digestive enzymes were recorded in the alimentary canal of insects and their level varies in relation to diet. It is a well-known fact that the digestive enzymes play a major role in insect physiology by converting complex food materials into micro molecules necessary to provide energy and metabolites for growth, development and other vital functions. A consumers ability to use plant or animal materials for food is indicated by the presence of specific digestive enzymes (Miles 1972; Cohen 1990, 1995, 1996, 1998a, 1998b, 2000; Agusti and Cohen, 2000; Hori, 2000; Zeng and Cohen, 2000a, 2000b) which includes proteases, hyaluronidase, and lipase (Cohen 1998b, 2000) and amylase (Cohen 1996; Sahayaraj, 2007). The chemical composition of the watery saliva of hemipteran insect is crucial for effective feeding because there

The digestive physiology of reduviid predators solicits greater attention in view of its economic importance. The nutritional need and the knowledge of the functional organization of digestive system of reduviid predators may be useful in designing Oligidic diet for mass production (Sahayaraj et al., 2007). Moreover this information could be useful to understand how reduviids adopt to its natural or factitious prey or artificial diets. Among the digestive enzymes, amylase, invertase, lipase and protease, activities are of great importance in the digestion of food. Utilization of macronutrients from the available prey food depends on the digestive enzymes. Digestive enzymes of alimentary canal and the salivary gland of Sophorhinus insperatus Faust (Hori, 1969; Ravikumar et al., 2002) were investigated. Studies on digestive enzyme profile of Indian reduviids were not available except the preliminary works of Ambrose and Maran (2000) and Sahayaraj et al. (2007).

1.7. Gut Content Assay with ELISA

Progress in quantifying predation in agricultural systems has been hampered by the difficulty of studying predation in the field. Unlike parasitism, evidence of predation is seldom preserved in the field and researchers must generally rely on indirect and often less precise measures of activity (Luck et al., 1988; Sunderland, 1988; Naranjo and Hagler, 1998). Many other factors, such as, small size, nocturnal activity, cryptic behavior, and pre-oral digestion, contribute to the difficulty of observing and measuring predation under natural conditions (Hagler and Naranjo, 1994 a, b; Hagler and Naranjo, 2005).
Techniques to study the interactions between predator and prey communities have become increasing complex as they attempt to address the imbalance created by visual identification. These include radio-isotope labeling, the application of stable isotopes, electrophoretic detection of prey isozymes, the detection of prey pigments by chromatographic analysis and the detection of prey proteins using polyclonal antibodies (Sunderland, 1988; 1996; 2000; Pierce and Boyle, 1991; Greenstone, 1996; Greenstone et al., 2005). Current predator–prey studies, however, tend to rely on monoclonal antibody and/or DNA-based technology, which allow accurate and rapid detection of prey remains within predator guts or faecal samples. Immunological assays using prey-specific protein antibodies (Greenstone and Hunt, 1993; Powell et al., 1996; Hagler and Naranjo, 1997; Hagler, 1998; Symondson et al., 1999a, b; Shapiro and Legaspi, 2006) was widely used to identify predator gut contents. These assays are used to determine absence or presence of prey in the gut. The accuracy of the assay depends on several factors, including temperature, meal size, time since feeding, resistance of the target protein to digestion, and predator species (Hagler and Naranjo, 1997; Symondson 2002; Symondson et al., 1997, 1999b, Hagler, 1998).

The works were carried out on Lygus hesperus (Hemiptera: Miridae) predators (Hagler et al., 1992) Bemisia tabaci (Homoptera: Aleyrodidae) and P. sagitta (Hagler and Naranjo, 1994a); Pectinophora gossypiella (Lepidoptera:Gelechiidae), P. maculiventris (Hagler and Naranjo, 1994a, 2005); Collops vittatus (Coleoptera:Melyridae) (Hagler and Naranjo, 1994b), Hippodamia convergens (Coleoptera:Coccinellidae) (Hagler and Naranjo, 2004), Otiorhynchus sulcatus (Coleoptera:Curculionidae) (Crook and Solomon, 1997), Heliothis virescens and Helicoverpa zea (Lepidoptera: Noctuidae), Orius sp. (Heteroptera: Anthocoridae) (Sansone and Smith, 2001, Ruberson and Greenstone, 1998), Pterostichus melanarius (Coleoptera:Carabidae) (Bohan et al., 2000); (Araneae:
Linyphiidae) (Harwood et al. 2005); Helicoverpa armigera eggs and larvae (Lepidoptera: Noctuidae) (Sigsgaard et al. 2002); Nilaparvata lugens (Homoptera: Delphacidae) (Zhao et al., 2004), Lim and Lee, 1999), Homoptera: Aphididae Pachygnatha degeeri (Araneae:Tetragnathidae) Harwood et al. (2004 and 2005a), Homoptera: Aphididae (Coleoptera: Carabidae) Winder et al. (2005).

In the context of biological control, increased prey biodiversity would be predicted to enhance the ability of populations of generalist predators to achieve sustainable levels of pest control. However, pest species are often poor on terms of nutritional quality (Toft, 1999, 2005) and are avoided by some predators (Toft, 1997). Hence, increased dietary diversity has the potential of the predators from feeding on pests and ultimately reduce levels of biological control (Halaj and Wise, 2002; Madsen et al., 2004; Koss and Snyder, 2005; Wise et al., 2006). Elucidating possible shifting preference of Oligidic diet (OD) for alternative non-pest prey in complex food webs, and uncovering the strength of those tropic linkages, are therefore essential for incorporating biological control by predators reared with Oligidic diet in integrated pest management (IPM).

Of the many methods used for studying predation, postmortem approaches are among the most direct and least likely to introduce bias through unintentional experimental disruption (Luck et al., 1988; Sunderland, 1988). Postmortem methods include gut dissection and chromatographic, electrophoretic, PCR, and immunological analysis of predator gut contents. Depending on the type of antibody and assay system used, immunological methods can be species or stage specific, highly sensitive, and rapid enough to facilitate screening of thousands of predators in a shortest period (Sunderland, 1988; Greenstone, 1996).
Predator digestion rate, prey size, predator size, diet and their physiological state of the prey can affect the outcome of a gut content immunoassay (Sunderland, 1996). Before a precise estimate of predation can be made, these factors must be considered. Despite these characteristics, immunoassays remain a qualitative method that provides direct evidence of predation by specific species but rarely provides quantitative estimates of the number of prey killed. However, previous studies (Sopp and Sunderland, 1989; Symondson and Liddell, 1993; Shapiro and Legaspi, 2006), suggest that gut content ELISAs vary in efficacy among pest species. One of the fundamental parameters for qualitatively or quantitatively estimating predation using immunoassays is the period of time the prey antigens remain detectable in a predator's gut. The detection interval is a key parameter in most indices that have been developed to assess predation using immunoassays (Sopp et al., 1992) and is very important in comparative evaluations of different predator species feeding on the same prey.

1.8. DNA Quantification

Rapid PCR-based screening systems for the study of the prey diversity of generalist predators have been developed to expand the potential of molecular detection into various areas of food-web research. The techniques described by Harper et al., (2005) using a PCR to simultaneously amplify DNA from a range of prey species. The retention time for DNA within the gut of a predator during digestion is influenced by factors including the size of the target DNA molecule. Predation by the coccinellid beetle *Coleomegilla maculata* De Geer (Coleoptera: Coccinellidae) upon the eggs of the European Corn Borer *Ostrinia nubilalis* (Hubner) (Lepidoptera: Crambidae) has been characterized by PCR amplification of four fragments of prey genomic DNA of different sizes from predator guts (Hoogendoorn and Heimpel 2001, 2002). Use of PCR in the gut
contents analysis of predator (Agusti et al., 1999, 2000; Zaidi et al., 1999; Chen et al., 2000; Hoogendoorn and Heimpel, 2001) was studied by many workers.

Amplifying prey DNA from predator gut contents is used increasingly to elucidate predator-prey relationships, and is comparable to serology in many aspects (Symondson 2002, Dodd et al., 2003). For instance PCR amplified DNA of noctuid larvae by mirids (Agusti et al., 1999) aphid predation by a spider, ladybird and lacewing larvae (Chen et al., 2000, Greenstone et al., 2005), European corn borer predation by a Coccinellid (Hoogendorn and Heimpel 2001), mosquito predation by a dragonfly (Morales et al., 2003) were available in the literature.

Identification of the gut contents of predatory insects can provide information on trophic relationships and the dynamics of predator-prey interactions. Several problems may be encountered in determining the diet of predatory insects in the field. Direct observations of predation (Legaspi, 1996; Munyaneza and Obrycki, 1998) can be complicated by the fact that both prey and predator are often small and cryptic. Microscopic analysis of gut contents (Aussell and Linley, 1994; Powell et al., 1996; Sleaford et al., 1996; Triltsch, 1997) was possible for predators that ingest relatively large prey fragments. This work builds upon a number of recent studies on the use of PCR in the analysis of predator gut contents (Agusti et al., 1999; Agusti and Cohen, 2000; Zaidi et al., 1999; Chen et al., 2000; Hoogendoorn and Heimpel, 2001).

1.9. Augmentative Field Release and Biocontrol Potential Evaluation

Biological control is often viewed as a promising alternative or complement to pesticides in IPM programme (Bengtsson et al., 2005; Hole et al., 2005). The successes and failures of biological control have been extensively reviewed (van Driesche and
Bellows 1996; Cardinale et al., 2003; Aquilino et al., 2005; Byrnes et al., 2005; Wilby et al., 2005). Factors that can influence the effectiveness of biological control agents include agent specificity (generalist or specialist), the type of agent (predator, parasitoid, or pathogen), the timing and number of releases, the method of release, synchrony of the natural enemy with the host, field conditions, and release rate. Augmentative, or inundative, biological control is the release of large numbers of natural enemies to augment natural enemy populations or inundate pest populations with natural enemies, Snyder et al., 2008).

Augmentative release of the predators is a main component in the IPM and especially the reduviids play a major role in the suppression of various pests of economic importance (Schaeffer, 1988; Sahayaraj, 1999b; 2002b and Sahayaraj and Martin, 2003, Sahayaraj and Ravi, 2007). 120 pests attack groundnut both at crop stage and storage (Ramaraju et al., 1998). The pests are classified as defoliators, borers and sucking pests. The important defoliators are the larval forms of Amsacta albistrigia Walker, Aproarema modicella Dev., Spodoptera litura Fab., and Helicoverpa armigera Hubner etc. and they cause severe damage to groundnut (Amin, 1983; Panchabhavi and Nethradhaniraj, 1987 and Wightman and Rao, 1993). The irrigated groundnut in Tamil Nadu is severely attacked by S. litura and H. armigera (Peter and David, 1998). The other major pests of groundnut are jassids (Singh et al., 1993), thrips, white flies, bugs, beetles and grasshoppers (Jayanthi et al., 2000 and Sridhar and Mahto, 2000). The extent losses of groundnut by feeding and transmitting virus disease of aphids are well reported (Nandagopal and Gunathilagaraj, 2008). Grasshopper causes leaf damage and yield loss in groundnut. It was controlled by both biological and chemical agents in groundnut field (Peveling et al., 1999).
In India, groundnut cultivation is mostly monoculture in major groundnut growing states like Andhra Pradesh, Gujarat, Tamil Nadu, Karnataka, Maharashtra and Orissa. However, there is a great diversity in the cultural practices followed in different agroclimatic regions. Extensive cultivation in groundnut with introduction of new varieties and adoption of modern agro techniques has brought a great deal of changes in the abundance of cosmopolitan and regional pests and their associated natural enemy complexes.

In India, an exotic reduviid predator *P. laevicollis* was colonized and the laboratory reared bugs were released in large numbers on the coconut palm in Kerala, Lakshadeep and Karnataka and they controlled the beetle *Oryctes rhinoceros* Linn. (Antony et al., 1979). After a long time Sahayaraj (1999 b) Sahayaraj and Martin (2003), Claver and Ambrose, 2001b; Sahayaraj, 2002b mass reared *R. marginatus* in the laboratory and released in the groundnut field and reported that greatly suppressed the population of *Spodoptera litura, Helicoverpa armigera* and *Aproaerema modicella*. Initially *Platymeris laevicollis* was released in the coconut field to reduce the grubs and adults of *O. rhinoceros* (Antony et al., 1979). Sahayaraj (1999 b) released *R. marginatus* in the groundnut field and observed the suppression of lepidopteran pests and reported high groundnut yield. Grundy and Maelzer (2000) evaluated biological control of *P. plagipennis* in the pigeon pea field and reported the control of various pests in Australia. Sahayaraj (2002b) integrated certain botanicals along with *R. marginatus* in the groundnut field and obtained a good groundnut yield. Ambrose (2000) and Claver and Ambrose (2001b) released *R. kumarii* in cotton and pigeon pea field cages and reported the pest suppression by the predator. The present study was undertaken to find out the impact of the different prey reared *R. marginatus* separately on groundnut pest infestation, yield and cost benefit ratio in groundnut fields.
Carpenter and Greany (1998) showed that medium-reared *D. introita* searched for and parasitized host pupae in field-cage experiments. These authors suggested that the ability to rear *D. introita* on an inexpensive artificial medium significantly enhanced the possibility of mass rearing parasitoid for use in inundative releases against *Spodoptera* spp. Host location and host acceptance by female parasitoids can be influenced by maternal factors such as age (Doutt, 1959), physiological state, and previous experience (Morrison and King, 1976). However, until the development of effective artificial rearing systems, laboratory-reared parasitoids completely lacking, both as developing immatures and as adults, were not available.

The objectives of the current study was to assess the effect of factitious, natural prey and meat based artificial diets on the development, survival and reproduction of *R. marginatus*

1. To study the life table of *R. marginatus* on nymphal development of *R. marginatus* was monitored on five diets: fourth instar larvae of *C. cephalonica* (*T*₁), *C. cephalonica* weekly once with water (*T*₂), Oligidic diets (OD), (4, 5 and 6) (*T*₃), OD with weekly once with *C. cephalonica* (*T*₄) and *S. litura* (*T*₅).

2. To record the prey preference (visual observation and ELISA) and evaluate the biological control potential of *R. marginatus* both in laboratory and field conditions for two subsequent seasons at summer 2006 and khariff 2007, Tamilnadu, India.
3. To find out the impact of OD on the qualitative and quantitative enzyme profiles (salivary gland and alimentary canal). The activity values of the main digestive enzymes of *R. marginatus* to evaluate the nutrition specialization to other food substrates. Autothonomous gut bacterial populations and their hydrolytic enzyme activities of *R. marginatus*.

4. To record the genetic similarities and variability of *R. marginatus* using three common primers.