1.1. BACKGROUND

Throughout Earth's history there have been five major and several lesser Extinction events which concern the sudden disappearance of many species. The most 'infamous' of all the events was the extinction of the dinosaurs at the end of the cretaceous era (65 million years ago). The fossil record shows that many life forms, with different body plans from those seen in living phyla, evolved and subsequently became extinct during the Precambrian and Cambrian periods, representing possibly over 100 phyla not alive today. We now face 'The Sixth Extinction' event. This new event differs significantly from the others that were caused by catastrophic natural disasters or gradual changes to earth's chemistry and physical topography. It is different because it is happening over a very short period of time, within time scales of decades, not millennia, and it is a direct result of one species substantially modifying the planet at the expense of the other. That species is US, the *Homo sapiens*. At the current rate of habitat destruction it is estimated that within the next 100 years or so about half of the world's existing species may be extinct, and this does not include the countless thousands of species we have already made extinct. Man's impact on the environment has been, and continues to be, catastrophic. The rate of species loss during this, 'The Sixth Extinction', is estimated to be somewhere between 100 and 1000 times greater than during any previous extinction events. Irrespective of the huge technological advances made in science, we cannot replicate or recreate nature's bounty. Extinction is fundamentally a one-way street. (Biodiversity Crisis: the sixth extinction, www.qm.qld.gov).

At one hand we have problem of habitat destruction and species extinction while on the other is even more important issue - ignorance about the number of species existing on the planet. At present fewer than two million species of organisms are scientifically identified and named while an estimated 5-100 million or more await discovery (Wilson,
2003). The later situation is more true in the so called developing countries mostly lying in the biodiversity rich tropical and sub-tropical region of the world which are seriously strapped by financial crisis. Assessment and identification of the existing biodiversity in a habitat of concern can’t be achieved without knowing the taxonomy of species because each of the species has its individual biological peculiarities, ecological role, distribution, and interactions within the local community and each may differ in habit and appearance both from its closest relatives and also across its range to reflect local influences and conditions. Every species is thus a mosaic of physical variety and genetic constitution that can lead to both taxonomic and ecological ambiguity in interpreting its integrity and the ways in which it may evolve and persist.

Among all diverse forms of life insects are most exuberant manifestation of Earth’s many and varied life forms. A majority of the species on earth are insects. Considerable debate continues over how many species of insects are in the world. Estimates range from 2 to 50 million (Stork, 1993). The lower figure is given by Hodkinson and Casson (1991). The higher figure of up to 50 million is provided by Erwin (1988, 1993). The number of insects described at present is estimated to be 9,25,000 (Grimaldi and Engel, 2005) in a total biota described to date of 1.4 to 1.8 million (Stork, 1988, 1993; May, 1990; Hammond, 1992). Using the 9,25,000 species described, versus the estimate of 5 million total, Grimaldi and Engel (2005) suggested that only about 20% of the insects are named. They have invaded every niche, except the oceanic benthic zone (Grimaldi and Engel, 2005), which has established themselves as the most spectacularly successful living organisms and without reliable insect taxonomy the aims of other fields would be seriously compromised including those of agriculture, vector biology, ecology, ecosystem studies, conservation biology and biodiversity.

Insects create the biological foundation for all terrestrial ecosystems. They cycle nutrients, pollinate plants, disperse seeds, maintain soil structure and fertility, control populations of other organisms, and provide a major food source for other taxa (Majer, 1987). Virtually any depiction of a food web in a terrestrial or fresh water ecosystem will show insects as a key component, although food web architectures in these two ecosystems are quite different (Shurin et al. 2005).
Amid Insects the most widely recognized Hymenopterans – bees, ants and wasps have long been part of art, ritual and folklore worldwide (Hanson and Gauld, 1995), first appear in the fossil record in the late Triassic, about 230 million ago is a result of tremendous diversification into a variety of morphological forms and various ways of life over the past 150-200 million years. The primitive lineages were plant feeding and parasitoid mode of life did not appear until about 210 million years ago (Grimaldi and Engel, 2005). An estimation of total number of insect parasitoids suggests being 87,000 species or roughly 10% of all described species (Eggleton and Belshaw, 1992). More than 80% of all parasitoid species (about 1,15,000 species described) belong to the Hymenoptera (Eggleton and Belshaw, 1992; Quicke, 1997) and the vast species richness and numerical abundance of parasitoids are contained in just four superfamilies - the Ichneumonoidea, Cynipoidea, Platygastroidea and Chalcidoidea. In the control of insect pests increasing attention is being paid to their natural enemies.

Among these enemies many parasitoids belong to Hymenoptera parasitica, the superfamily Chalcidoidea. Despite the fact that they are usually of minute size, chalcids are of great importance in the regulation of populations of pest species and many species have been used successfully used in the biological control of insect’s pests (Noyes, 1985). In fact the majority of successful biological control projects of insect pests have used chalcidoids to achieve substantial or complete control (Greathead, 1986). More than 800 species of Chalcidoidea have been used in biological control programs and overall have had the greatest rate of establishment and success (Noyes, 2007). Chalcids are grouped into 19 subfamilies and are known to attack hosts from 13 orders of Insects (Coleoptera, Diptera, Hemiptera, Homoptera, Hymenoptera, Lepidoptera, Neuroptera, Odonata, Orthoptera, Psocoptera, Siphonoptera, Strepsiptera, and Thysanoptera) as well as egg sacs of spiders, ticks and gall forming mites (Boucek, 1988).

Within the superfamily Chalcidoidea, the Eulophidae (Westwood, 1828) is one of the largest families in terms of the numbers of genera and species, with approximately 4300 species in 294 genera and their number is constantly swelling. Eulophidae is a largest family of the superfamily Chalcidoidea followed closely by Encyrtidae and Pteromalidae. The family is present and common in all geographic regions (Noyes,
2002). Most eulophids are entomophagous, attacking insects and other arthropods such as spiders and mites. Parasitoid forms are considerably divergent: they can be endoparasitoids or ectoparasitoids, primary parasitoids or hyperparasitoids, specialists or generalists in their host selection, and they can have a gregarious or solitary larval development. A few genera are known to be phytophagous, but the species of these phytophagous genera again display various lifestyles (Gauthier et al. 2000; Noyes, 2002). Most species are less than 3mm in length, averaging 1.5 mm. Their small size can make them extremely difficult to collect and study and as a result they have received comparatively little attention from taxonomists. The majority of Eulophidae are primary parasitoids of concealed larvae, especially those inhabiting leaf mines. The best known species attack Lepidoptera, but many species parasitize larvae of other insects living in similar concealed situations such as Agromyzidae (Diptera), Tenthredinidae (Hymenoptera) and Curculionidae (Coleoptera). Other eulophids attack various gall-forming species of insects, mites (Boucek & Askew, 1968) and also gall-forming nematodes (Berg et al. 1990). The family is comprising of four subfamilies i.e. Tetrastichinae, Eulophinae, Entedoninae and Euderinae (Graham, 1975; Boucek & Graham, 1978).

These tiny insects are very much promising agents for the control of insect pests of agricultural, horticulture and forestry importance. Despite the fact that they are usually of minute size, eulophids have a great repressive effect on pest population and have been successfully utilized for the control of many pests world over.

1.2. TAXONOMY – BIODIVERSITY LINKAGES

Taxonomy is the science of classifying organisms. The word “taxonomy” was first proposed by French Professor A. P. de Candolle (1813) as ‘Taxonomie’. The word Taxonomy originated from the Greek words “taxis” meaning “arrangements” and “nomos” meaning “law”. Mayr (1971) considers taxonomy as the theory and practice of classifying the organisms. The term “Systematics” originates from the Latinized Greek word ‘Systema’ and defined as the scientific study of the kinds and diversity of organisms and of any or all relationships among them (Narendran, 2006b).
The term biological diversity was used first by wildlife scientist and conservationist Raymond F. Dasmann (1968) in his book *A Different Kind of Country* advocating conservation. The term was widely adopted only after more than a decade, when in the 1980s it came into common usage in science and environmental policy. The term's contracted form *biodiversity* may have been coined by W.G. Rosen (Takacs, 1996) while planning the National Forum on Biological Diversity organized by the National Research Council (NRC) which was to be held in 1986. It first appeared in a publication in 1988 when entomologist E. O. Wilson used it as the title of the proceedings of that forum (Wilson, 1988).

In most biodiversity studies, the unavailability of a taxonomic service creates a lacuna of detailed information which is much needed to formulate successful biodiversity conservation strategies. We need detailed information about the biodiversity and species composition for specific locations in order to understand how different species contribute to ecosystem services (Ke Chung *et al.*, 2006). Biodiversity studies with a lack of taxonomic precision, a taxonomic bottleneck in biodiversity inventory and assessment and a lack of much-needed site-specific data on the species composition of communities hinders ecosystem management and biodiversity conservation.

A sound taxonomic knowledge base is a prerequisite for effective conservation, environment assessment, ecological research, management and sustainable use of biological resources. In the current Millennium, India will become a major economic power because of its biodiversity. For this, conservation and sustainable use of living resources are needed. These two forces, in turn, can come into operation only if we have a strong taxonomic base. (Khan *et al.*, 2005.).

The sole reference system for biodiversity interpretation is catered by the science of taxonomy. Extinction and loss of biodiversity can be prevented only if we know the basic units in any taxonomic hierarchy that are species and their relationships. These are the lone versatile currency to recognize and characterize the enormous biodiversity on our planet. Taxonomy provides discovery and identification of these basic units and their relationships and involves not only collecting, identifying, naming new species and
developing sound classification but also analysis of biological variations, biogeography, evolutionary biology and host – parasitic relationships. A strong base work in taxonomy of diverse groups is the only way to address the multidimensional challenges underlying the issues of biodiversity conservation. It is believed that several hundreds of species may become extinct before we discover them. In order to know which species are endangered or threatened we must know what they are and what we have to conserve. Thus it is apparent that taxonomy and biodiversity are so intimately connected and linked in order to produce and formulate effective conservation strategies (Narendran, 2006b).

The biodiversity of Indian fauna of parasitic Hymenoptera has remained unexplored. Harnessing the potential, which exist, shall be of great interest for their application in the field of biological control. Many of the species have proved their efficacies on management of pests. But, biointensive integrated management is hindered for lack of information on basic knowledge of natural enemies, and their improper identification. An advancement of taxonomic knowledge is greatly needed in the arena of basic studies in relation to biodiversity of faunal studies, host parasitoids relationship, etc. before going in for an adventure in the field of biological control (Singh, 2005).