INTRODUCTION

The Chironomidae, often known as 'non-biting midges' or 'blind mosquitoes' represent an abundant, widespread and most diverse family of predominantly aquatic insects. Members of this family of insects occupy virtually every type and condition of aquatic habitats and its species number in the thousands (Coffman & Ferrington 1984). Estimates vary for the total number of world Chironomid fauna. The present consensus is that a minimum of 5000 species are found around the world (Cranston & Judd 1987; Cranston & Martin 1989; Oliver, Dillon & Cranston 1990). The family is distributed in all zoogeographical regions, including Antarctica. The two species found in Antarctica are the southernmost free-living holometabolous insects known (Wirth & Gressitt 1967, Cranston 1985). Chironomids also extend to the northern limits of land making up one fifth to one-half of the total number of species in the Arctic insect fauna (Oliver 1968). Between these geographical extremes, they have radiated into nearly every habitat that is aquatic or wet including peripheral areas of the world's oceans (Oliver 1971). Even small, isolated islands support significant midge fauna (Beck 1976). Chironomids comprise major part of the benthic invertebrates in prealpine and
alpine lakes (Gerstmeier 1989). As a general rule, the number of species of Chironominae increase towards the equatorial regions with decreasing latitude and with reducing current speed in flowing waters. They are the dominant group in lowland standing waters in tropical and subtropical areas of the globe. The cosmopolitan distribution of the Chironomidae gives the family the capacity to be a truly international and intercontinental monitoring group.

Chironomids are truly ubiquitous and are adapted to a wide variety of habitats, the range of which is unparalleled among other insect groups. Majority of them occur in freshwater habitats (lentic and lotic) and some inhabit brackish (e.g. *Dicrotendipes inouei* Hashimoto and *D. lobus* (Beck); Epler 1988) and marine waters (e.g. *Chironomus salinarius* Kieffer). Their abode includes the littoral and benthic regions of marine waters, estuaries, glacial meltwater, waterfalls, hot (44.5-50°C) and cold springs, rapid and cool mountain streams, fast and slow-flowing rivers, lakes, lagoons, ponds, temporary rain-pools, temporary or permanent ditches, shallow stagnant waters, ricefields, puddles, seeps, aquatic macrophytes, plant-held water (or phytotelmata), seasonally flooded tree-holes, bromeliads, leaf moulds, hollow stumps of bamboo, water-filled axils of
plants, water-filled flowers of insectivorous plants (e.g. *Nepenthes* sp., *Drosera* sp. etc.). Other types of habitats include algal layer on stones, within colonies of blue-green algae or sponges, leaves and stems of macrophytes, bogs, marshes, swamps, peaty soils among mosses and higher plants, soil of meadows and woodlands, saturated dead wood, under bark, cowdung, carrion, fallen fruit, dense forests and in living tissues. Hudson (1987) tabulated 9 categories of unusual larval habitats of Chironomids including hygro-petric, riparian (bank, floodplain, upland), hyporheic, symbiotic, and intertidal; others live in water held in plants or mine into unusual substrates. Even man-made habitats such as sewage and waste water treatment plants, municipal water supply tanks, irrigation ditches and canals, fish pools and bird baths are also exploited by Chironomids. Bass (1982) found that certain species showed distinct preferences for a particular substrate (leaf debris, wood debris, or sand), which insisted him (1986) to postulate the concept of micro-habitat preference for Chironomids. Stones, pebbles, logs, sand, vegetation etc. are preferred micro-habitats especially in lotic waters. Whitman & Clark (1984) found 21 species in the interstitial sand habitat of a woodland stream. Madicolous biotopes consisting of thin water films (2 mm or less) flowing over diverse substrates including rocks are occupied by several Chironomid larvae.
(Oliver & Sinclair 1989). A lotic moss, *Platyhypnidium riparioides* provides a prominent micro-habitat in the form of moss-cushions for several species and genera of larval Chironomids (Nolte 1989). Ferrington (1993) found that Chironomid larvae selectively utilize five well-defined habitats within a spring which differ in substrate, depth, velocity, vegetation and detritus: they are categorized as follows — spring, spring run, pool at base of spring run, splash zone and saturated soil and seeps. Epler (1987) found *Dicrotendipes leucoscelis* larva from the water in a bromeliad from Florida. Aquatic macrophytes offer favourable living and feeding site for many Chironomid larvae (Berg 1950; McGaha 1952, Driver 1977). Epler (1988) studied *Dicrotendipes septemmaculatus* larvae collected on *Hydrilla* occurring in Burma, Indonesia and Malaysia. Some Chironomine midges mine in the aquatic macrophyte, *Nuphar lutea* (L.) (Nymphaeaceae) at different stages in the growing season. They are reported to damage floating and folded leaves, petioles and peduncles. *Endochironomus lepidus* (Meigen) appeared to be an obligate phytophage and a real miner. *Glyptotendipes pallens* (Meigen) is a facultative phytophage, seston-eater and secondary miner like *Pentapedilum sordens* (van der Wulp) (van der Velde & Hiddink 1987). *Endochironomus tendens* (Fabricius) larvae are miners in
leaves and stems of *Typha latifolia* and they also mine in air bubbles of *Trapa natans* (Michailova 1991). The larvae of *Glyptotendipes viridis* (Macquart) and *Pentapedilum sordens* (van der Wulp) live mainly within the stems of *Nymphoides indica* and the petioles of *Trapa japonica*. Some larvae of *P. sordens* were also found on the stems of *Phragmites communis* (Kondo & Hamashima 1993). *Pentapedilum tigrinum* Hashimoto, a typical aquatic macrophyte dweller (Hashimoto 1983) and a secondary miner (Kondo et al. 1989), especially an occupant of the floating plants (Kondo & Hamashima 1985), are found to occur on the surface of or inside the floating leaves of *Nymphoides indica* and *Trapa japonica* or sometimes in association with another aquatic macrophyte, *Cabomba caroliniana* (Kondo & Hamashima 1993). *Stenochironomus nelumbus* prefers the floating leaves of *lotus, Nelumbo nucifera* (Tokunaga & Kuroda 1935, 1936; Yokogi & Ueno 1971; Ishihara 1972). *Xenochironomus xenolabis* lives in trumpet-like cases made out of sponge spicules. The larvae of *Dicrotendipes pelochloris* (Kieffer) have been reported from hot springs (40°C) from Sumatra (Lenz 1937). Moriya (1991) recorded several species of *Chironomus* and *Polypedilum* from the highly acid hot springs in Japan. The maximum temperature tolerance appears to be 40°C and the lowest pH range recorded was 1.7.
The extraordinary ecological range of the Chironomidae ensures that they will have representatives in all functional groups within their communities (Dayton 1986). Inhabitants of temporary habitats such as fallen fruit, dead wood, carrion, the dung of vertebrates and rainpools are regularly exposed to extreme crowding as their habitat diminishes in size because it is consumed or evaporates. Under such circumstances, a reduction in body size usually occurs, which is thought to be an adaptive response to increase in competition for food and space (Arthur 1984).

Larvae of the subfamily Chironominae are widespread in distribution, occurring in all sorts of limnic habitats. This amazing success has been attributed to their remarkable power of adaptability (Brundin 1966, Bass 1986, Warwick 1990). Most of them are essentially thermophilous (Oliver 1971; Beck 1977, — ) and are adapted to sustain in lentic water though some do occur in cold habitats and in lotic environments (Oliver 1971). They are very abundant in the warmer parts of Holarctic and decrease in numbers with increasing latitude or its climatological equivalent. The Chironominae are generally burrowers or clingers in habit and feed as collector-gatherers or collector-filterers (Coffman 1978). In general, Chironomini larvae are tube-
dwellers and prefer highly organic sediments (Oliver and Roussel 1983) that are characteristic of shallow and open-water areas. The larvae of Chironomus tolerate a broad range of environmental conditions (Beck 1977) from pristine to polluted water bodies and are typically grazers on detritus or are filter-feeders predominantly in soft sediments of standing water, seldom in flowing waters (Pinder & Reiss 1983, 1986). Some species are more abundant in oligotrophic to dystrophic standing waters and are tolerant of acidic conditions (Cranston et al 1989). A few species are halophilous or halobiontic (Pinder & Reiss 1983). Cold stenothermic larvae are rare and are characteristics of both in ultra oligotrophic lakes and in the deeper layers of eutrophic lakes as long as the oxygen deficiency is not too severe (Saether 1970, 1972). Cryptochironomus larvae occur in a wide variety of habitats including streams, larger rivers and lakes (Pinder & Reiss 1983, 1986; Cranston et al. 1989). Cryptochironomus fulvus is typically found in both lentic and lotic waters, usually those with a slightly alkaline pH (Beck 1977), but they also occur in acidic waters (Bass 1986). Larvae of Demicryptochironomus inhabit soft sediments of lakes and rivers (Pinder & Reiss 1983, 1986; Cranston et al 1989). They are predatory, especially on Oligochaetes (Pinder &
Immature stages of *Dicrotendipes* occur principally in littoral sediments of a wide variety of standing waters including marginal sediments of pools in lotic waters (Pinder & Reiss 1983, 1986; Cranston et al. 1989). Majority of them are "clingers" and/or "Sprawlers" that are found on the surface of aquatic vegetation, and among or on the vegetation or "Aufwuchs" on rocks, logs, or similar substrata. The larvae construct silken tubes being attached to the substrate. *Dicrotendipes* larvae feed on algae, detritus, or the micro-organisms associated with it (Epler 1988). At least three species of *Dicrotendipes* inhabit brackish water salt marshes (Epler 1987, Hashimoto 1984, Prat 1981). Larvae of *Einfeldia* live in littoral, soft sediments of small lakes, ponds, old river beds and small water bodies with a tendency towards eutrophic conditions. *Einfeldia* is apparently absent from flowing waters (Pinder & Reiss 1983, 1986). Larvae of *Endochironomus* inhabit "Aufwuchs" of living and dead substrata including facultative leaf miners of aquatic macrophytes, predominantly in standing, but occasionally in slow flowing waters. Some species overwinter in cocoons (Pinder & Reiss 1983, 1986; Cranston et al. 1989). Similarly larvae of *Glyptotendipes* occur free-living in detritus-rich littoral sediments and in "Aufwuchs" of lakes, ponds, small water
bodies and running water. Many species are miners or "semi-miners" in submerged wood and plants. Harnischia larvae are found in soft sediments of lakes and characteristically in larger slow-flowing rivers (Pinder & Reiss 1983, 1986; Cranston et al 1989). The larvae display unique adaptations to life in the continuously moving bottom sediments (Reiss 1989) or shifting sand (Rossaro 1991). Larvae of Kiefferulus inhabit sediments of predominantly small, lentic bodies of water (Coffman 1978, Pinder & Reiss 1983, 1986; Cranston et al 1989) and seem to be restricted to a more specific habitat (e.g. temporary pool, rice puddle etc.), which underscores the remarkable adaptability of Chironomid larvae (Bass 1986). Larvae of Microchironomus occur in lakes, rivers, ditches and other freshwater habitats. They are also known from brackish waters (Pinder & Reiss 1983, 1986; Cranston et al 1989). Juveniles of Paracladopelma usually inhabit sandy substrata in lakes and streams and also in soft profundal sediments of deep lakes. They tend to be relatively cold stenothermic and intolerant of eutrophication (Pinder & Reiss 1983, 1986; Bass 1986; Cranston et al 1989). Immatures of Paratendipes are tolerant to a wide variety of environmental conditions (Beck 1977) and are found in soft, fine and sandy sediments in both running and standing waters (Pinder & Reiss
1983, 1986; Bass 1986; Cranston et al 1989); these worms build tubes and feed as collectors (Coffman 1978). Some species are reported to tolerate high water temperatures (Cranston et al 1989). The immature stages of the genus Polypedilum consists of eurytopic species, occurring in all kinds of standing and flowing waters except those at high latitude and altitude. Sediments are the preferred substratum (Pinder & Reiss 1983, 1986; Bass 1986; Cranston et al 1989). The larvae build short, loose sand tubes (Lindegaard - Petersen 1972) and feed as herbivores, collectors, or predators (Coffman 1978), a few species mine wood or graze epilignic and epilithic surfaces (Cranston et al 1989). Larvae of Stictochironomus live in profundal soft sediments or littoral sandy substrates in lakes and in slow flowing rivers (Pinder & Reiss 1983, 1986; Bass 1986; Cranston et al 1989). They build tubes and are herbivorous collectors and shredders (Coffman 1978). Larvae of Xenochironomus are obligate miners of freshwater sponges in both standing and flowing waters (Pinder & Reiss 1983, 1986; Cranston et al 1989).

Despite their non-biting habits, Chironomid midges are implicated in a variety of nuisance problems, health hazards, human disease and economic problems. Public
remaining within the flight and dispersal range of these midges suffer a lot of nuisance problems (Lavalle 1976; Ali 1980; Ali & Fowler 1983; Tabaru et al 1987; Tabaru 1991). Adults frequently emerge in phenomenal numbers and swarm in huge quantity, particularly at dusk near water and cause much inconvenience to the waterfront residents or workers. Dense swarms of midges often preclude outdoor human activity since the adults are inhaled or fly into the mouth, eyes and ears of an individual and in extreme cases may cause asphyxia (Cranston et al 1983). The nature of problems caused by adult midges include severe annoyance, nuisance, discomfort, clogging of air-conditioning units, soiling of automobiles, drapes, furniture and laundry, defacing of indoor walls and ceilings, staining of stucco and paints, traffic hazards by covering the headlights and wind shields, and suffocation of livestock. They also pose problem for plastic, paint, pharmaceutical, dairy and food processing industries where hoardes of adult midges fly into the final products. The short-lived adult midges congregate at lighted windows where they die, pile up on window ledges and give off a stench similar to rotting fish. This odour persists in damp weather for several days even after the insects have been removed. Accumulation of dead midges and the unsightly spider webs in which midges are trapped, require frequent washing and maintenance
of properties. Hotels suffer economic losses because tourists find these insects objectionable. It has been reported that just one lakefront business, the Holiday Inn, Sanford, spends nearly $50,000 each year on property maintenance and control attempts of these nuisance midges (Ali & Lord 1980). At times, the dead adults accumulate on the roads or bridges in such numbers that their littered remains make those situations too slippery for safe driving (Ali 1980, Beck & Beck 1969).

In recent years, both larval and adult Chironomid midges have been reported to be involved in human allergic disease causing type I allergic reactions such as bronchial asthma, conjunctivitis, hay fever, seasonal rhinitis and skin hypersensitivity (Freeman 1950; Lewis 1956; Cranston et al 1981, 1983; Cranston 1988; Sasa 1985a; Igarashi et al 1985, 1987; Kawai & Konishi 1986, 1988; Ito et al 1986, 1987; Tee et al 1985, 1987; McHugh et al 1988; Yamashita et al 1989; Edahiro et al 1989). They are considered as significant potential environmental and occupational allergens. The 'green nimitti' midges, Cladotanytarsus lewisi Freeman is an important and widespread cause of immediate-type immunoglobin E (IgE) mediated hypersensitivity with associated human allergic symptoms like bronchial asthma and rhinitis amongst the nilotic people of
Sudan (Freeman 1950; Kirk 1952, 1953; Lewis 1956; Kay et al 1978, 1982; Cranston et al 1981; Tee et al 1985). This Chironomid induced allergy have been identified also in Egypt (Cranston et al 1983), U.S.A. (Kagen et al 1984), Sweden (Eriksson et al 1985), Japan (Sasa 1985; Ito et al 1986; Kino et al 1987; Yamashita et al 1987, 1989) and England (McHugh et al 1988). Some aquatic Chironomid larvae, used commercially as fish food, are sources of occupational allergy in Sweden (Eriksson et al 1984), Italy and particularly in Germany (Baur et al 1982, 1983). The principal allergens have been shown to be larval haemoglobins, which are retained in the adult midge (Baur 1982; Tee et al 1985; Baur et al 1986; Prelicz et al 1986). Exposure to midge allergens is thought to be either by direct contact with midges, causing immediate hypersensitivity reactions, or by inhalation of allergenic fragments in dust, resulting in immediate and delayed respiratory tract and mucosal reactions. Mizukami et al (1986) reported a case of bronchial asthma in a girl induced by direct inhalation of a Chironomid Tanytarsus oyamai Sasa 1979 in Japan. Chironomid antigens are currently one of the important allergens for bronchial asthma in Japan (Edahiro et al 1989). Antigens from midges (e.g. Tokunagayusuriya akamushi Tokunaga) seem to be the second important allergens
(next to mites) in the metropolis of Tokyo (Ito et al. 1986). These midges swarm and die. The dead bodies accumulate on the ground, break up and might be inhaled. Igarashi et al. (1985) and Sasa & Igarashi (1985) demonstrated that *Poly-pedilum kyotoense* (Tokunaga) was liable to an important allergen causing bronchial asthma among people of Japan. The radioallergosorbent inhibition test (RAST) suggested that there may be no or only very low cross-reactivity between midge allergens and mite, house dust (HD), silk, shrimp, or mosquito allergens. Thus, midges have allergenicities distinct from other common allergens (Yamashita et al. 1989). Yamashita et al. (1989) have shown that the midge allergens are able to release histamine from leukocytes via IgE-mediated mechanism from asthmatic patients who were positive to midge RAST.

The Chironomid larvae, some of which popularly known as "red or blood worms" (though the term is a misnomer) serve to bridge the gap between biologists and non-biologists. The worms occasionally turn up in water supplies thereby causing considerable concern to persons who notice red worms in their drinking or bathing water. They have achieved true public health significance by spreading high blood pressure amongst municipal water superintendents
and plant operators (Beck 1976). The larvae pass through all the stages of the water treatment including chlorination and thus act as potential biological hindrances in the water supply system (Zintchenko 1989). On account of the presence of polytene chromosomes in their salivary glands, the larval Chironomids have been extensively used in studying various aspects of Cytogenetics such as polytenic cell differentiation, Karyosystematics, Cytochemistry and gene amplification (Keyl 1962; Grossbach 1977; Martin 1979, 1991; Wülker 1980; Wülker et al 1984, 1989; Michailova 1987, 1989; Devai et al 1989; Kerkis et al 1989; Hankeln et al 1989; Petrova 1989; Filippova 1991; Istomina et al 1993). Very recently Chironomus has proved to be a "state-of-the-art" animal in the field of molecular biology (Schmidt 1989). The larvae are also used as popular experimental material in various divisions of Life Sciences including Agronomy, immunology and, limnology, in particular. Since Brundin's (1966) work on transantarctic relationships, Chironomids have become "test animals" of phylogeny and zoogeography. Phylogenetic and zoogeographic studies have advanced not only Chironomidology but the science of Systematics and Zoogeography as a whole (Saether 1978). Chironomidae have been essential components of multidisciplinary, palaeolimnological reconstructions of past
climate change (Rosenberg 1993). Attributes of fossil Chironomidae as palaeoecological indicators are now well known (Walker 1987). Fossil remains of Chironomids have been used to trace the palaeoproductivity of lake systems (Deevey 1942; Stahl 1959; Bryce 1962), to assess anthropogenic eutrophication (Carter 1977; Warwick 1980; Wiederholm 1979; Wiederholm & Eriksson 1979) and acidification (Henrickson et al. 1982), and to monitor the impact of salinity fluctuations (Paterson & Walker 1974; Clair & Paterson 1976) and climatic variations (Walker & Mathewes 1989; Walker et al. 1991). Underwater sediments often act as a sink for trace metals. Consequently, benthic Chironomids confront an environment high in trace metal levels. Timmermans & Walker (1989) showed that Chironomids were suitable for trace metal transfer research, as the larvae accumulate trace metals from sediments, and both eliminate and transfer substantial amounts during moult or metamorphosis. Timmermans & Davids (1989) showed that filter feeders have lower concentrations of Cd and Pb in their body than the deposit feeders or opportunistic feeders. The concentrations of Zn and Cu show no significant differences in the feeding categories. Moreover, it has been demonstrated that a distinction between essential (e.g. Zinc, Copper) and non-essential (e.g. Cadmium, Lead) metals can be made by
Chironomid larvae. The former can be regulated and the range of internal concentrations is mostly between narrow margins, the later are readily accumulated and can not be regulated, and, as a result, may reach very high levels. It has been indicated that long term (chronic/sublethal) effects of trace metal accumulation may result in alteration of behaviour or delay in development and emergence (Timmermans et al 1991). Quite interestingly, the Chironomids have been reported to initiate the study of 'aquatic forensic entomology' (Haskell et al 1989). The Chironomid larvae form an integral link in aquatic food chains and constitute a biological connection between aquatic and terrestrial habitat (Mason 1973); and ostensibly, humans are intimately and ultimately linked to these same systems (Warwick 1990). Many Chironomid larvae are primary grazers and feed directly on organic detritus, on microbially conditioned detritus, or on the microbial communities themselves (Pinder 1986). Chironomids form one of the most important functional groups in soft bottom communities and fulfil all the categories identified by Dayton (1986), including a few additional ones. The exact terminology, based mainly on feeding regime, varies among authors (Oliver 1971, Smock 1983, Pinder 1986), but these categories include: (1) deposit feeders, (2) omnivores,
(3) filter-feeders, (4) carnivores, (5) surface feeders, (6) leaf miners, (7) parasitic species (Warwick 1990). Lindegaard (1989) showed that Chironomids contribute 20-25% of the secondary production in oligotrophic lakes and about 95% in shallow highly eutrophic lakes. Chironomid production in running waters ranges from 2 to 600 KJ/m²/yr. Production of Chironomidae can reach 1600 KJ/m²/yr in streams heavily polluted with organic matter. Biomass and production of profundal Chironomid larvae are strictly connected with seasonal changes in the abundance, size, and phenology of the corresponding species (Gerstmeier 1989). It is interesting to note that aquatic macrophytes may influence the composition of the Chironomid fauna (Learner et al 1989). Chironomid larvae, in turn, form an integral part of the natural diet for fish (Dendy & Sublette 1959; Beck & Beck 1959; Assman 1960; Jonasson 1965; Korinkova 1967; Løgner & Medved 1973; Lellak 1974; Guziur 1976; Spataru 1976; McLarney et al 1977; Mackey 1977; Lindegaard & Jonasson 1975; Zur 1980; Willassen & Björklund 1989; Palavesam & MuthuKrishnan 1992; Mbahinzireki 1991) and food base for dabbling or diving ducks. They are among the most abundant aquatic insects in freshwater marshes (Wrublesky 1987) which makes them important food for water fowl (e.g. Krapu 1974; Swanson et al 1974;
Swanson 1977; Connelly & Chesemore 1980; Sjöberg & Danell 1982; Woodin & Swanson 1989; Wrubleski & Rosenberg 1990). Chironomids along with other aquatic invertebrates are a source of protein necessary for successful egg development by hens (Krapu 1979, 1981) and for growth of young ducklings (Sugden 1973; Street 1977, 1978). The abundance and availability of Chironomidae may even influence marsh use by waterfowl (Mcknight & Low 1969; Swanson 1977, Danell & Sjöberg 1982, Talent et al 1982). Intertidal Chironomids of British Columbia, Canada spend their larval stage among green algae such as Ulva, Enteromorpha and Cladophora. Intertidal Chironomids, in turn, are preyed upon in the larval stage by young pink, Chum and spring salmon (2-4" in length) just as they are beginning their migration from freshwater, by marine mites; by intertidal staphylinid beetles; and by intertidal sculpins (e.g. Oligocottus). The adult midges are preyed upon heavily by swallows and martins (Ring 1989).

Chironomids are widely recognized by limnologists as indicators of lake trophic state. The usefulness of Chironomid communities in environmental assessment has been demonstrated in the lake classification system. The development of this system began with the early work of
Thienemann (1913, 1922, 1931) and Naumann (1917, 1929) and evolved into a relatively sophisticated system for classifying trophic conditions in lakes, and for use in monitoring lake pollution (Brundin 1949, 1956; Saether 1975, 1979; Hashimoto 1976; Wiederholm 1976, 1980, 1981; Lenat et al 1979; Warwick 1980a; Oliver 1981; Aagaard 1986; Wang 1987; Kawai et al 1989; Cranston 1990; Rosenberg 1993; Verdonschot et al 1993). The system is based primarily on the response of Chironomid communities to changes in oxygen supply, food availability, temperature, sedimentation patterns, and other environmental parameters that effect changes in the composition and relative abundance of species in the community (Warwick 1988). Use of Chironomidae as indicators of water quality in running waters was developed relatively recently (Learner et al 1971; Wilson & Bright 1973; Wilson & McGill 1977, 1979; Morris & Brooker 1980; Armitage & Blackburn 1985; Ruse & Wilson 1984, 1991; Bazerque et al 1989; Wilson 1987, 1989, 1993). Chironomid indicator communities are useful in pinpointing localized pollution within a particular area of water (Saether 1979). Chironomids are exposed directly to contaminants arriving at the mud/water interface throughout the longest, most critical, and metabolically active stage of their life cycle - the larval stage. The worms are considered as
important bio-monitoring tool for the assessment of ambient conditions in the environment (Warwick 1989, 1990). They have been used successfully at population, community and ecosystem levels, and in laboratory and field toxicity testing. Some species of Chironomidae are ideal organisms for acute and chronic, single species, toxicity testing because they are easy to culture and they provide readily measured and sensitive responses (Rosenberg 1993). Life-history variables such as survival, growth, and reproduction of Chironomids are valuable indicators of the effects of organic and inorganic pollutants (Rosenberg 1993). The morphological deformities in Chironomidae larvae now-a-day are utilized as a biological screening tool for detecting and assessing the nature, extent and significance of toxic chemicals in freshwater ecosystems (Hamilton & Saether 1971; Kosalwat & Knight 1987; Warwick 1985, 1988, 1989, 1990; Madden et al 1993). Deformities were observed in several Chironomine larvae in the structures like ligulae, antennae, dorsomenta, mandibles, menta, labral lammellae, epipharyngeal pecten, premandibles and paraligulae in response to serious contamination by industrial pollutants like PCBs (Polychlorinated biphenyls) and heavy metals. Warwick (1985) presented an indexing scheme for classifying antennal deformations in the genus Chironomus. To date, frameworks
for categorizing deformities in several major and rarer taxa have been formulated and indices established to gauge the severity of response (Warwick 1990). The worms are also believed to play important role in indicating radioactive pollution (Curry 1960). It has been reported that *Nilotanypus fimbriatus* (Walker), *Cricotopus bicinctus* and *C. varipes* individually or as a group indicate contamination to oil and petroleum products (Rosenberg & Wiens 1976). Like larvae the floating Chironomid pupal exuviae may conveniently be used as tools in the biological classification of lakes and rivers, which appears to be important both for fisheries management and for the monitoring and control of pollution (Wilson & Bright 1973; Wilson & McGill 1977, 1979; Wilson 1976-1982, 1987, 1989, 1991; Ruse & Wilson 1984, 1991; Bazerque et al 1989; Ferrington & Crisp 1989; Bitušik 1991; Frantzen 1993). Collections of drifting exuviae may not be able to pinpoint sources of pollution in short reaches in the same way as sampling of benthos. However, exuviae could be used for fast preliminary monitoring to identify polluted areas and this could be followed by more intensive bottom fauna studies (Armitage & Blackburn 1985). It has been demonstrated that highly polluted river sites are dominated by Chironomini (Ferrington & Crisp 1989). Chironomidae, when included in a biotic index or score system, have usually
been treated at family or sub-family level because of taxonomic difficulties (Woodiwiss 1964; Chandler 1970; Armitage et al 1983). Biological monitoring requires species level identification of the Chironomid fauna under study (Resh & Unzicker 1975). Three prevalent methods have been used to alleviate the need for universal species-level identification: selection of indicator taxa, taxonomic reduction of the total data, and allocation of biotic components to functional groups (Cranston 1990). Warwick (1991) suggested that the interaction between trophic and contaminant effects constitute a classic example of the setback or deflection in the trajectory of ecological succession of Chironomid communities hypothesized by Odum (1981, 1985). Chironomidae also have been included in ecosystem-level experimental manipulations that have examined the effects of anthropogenic perturbations of freshwater lakes such as acidification and insecticide application (Rosenberg 1993). Sokolova et al (1993) suggested that the larvae of Chironomus piger str. widespread in small rivers and canals polluted with domestic sewage have got some role in the self purification of river. They retain seston and use it for eating as well as for tube construction. In the zone of maximum larval concentration assimilation of organic matter was significant.
The midge larvae might often serve as mechanical carrier of pathogens causing diseases from polluted water (Lysenko 1957; Steinhaus & Brinley 1957). It has been suggested (Pastoris et al 1989) that Chironomid larvae harbour legionellas and are involved in their maintenance and dissemination, thereby acting as natural reservoirs of these micro-organisms. Chironomids may also affect horses (Burrill 1913) and cattle (Bonell and Mote 1941). The swarming adults, when inhaled in large numbers by cattle, are liable to cause death of these animals. Owing to their high protein content (Yurkowsky & Tabachek 1979), lyophilized larvae are normally fed to fish in some European fish farms (Ceretti et al 1987).

Chironomidae were first reported as causing an agricultural nuisance when Patch (1917) observed mining in growing potatoes in Maine, USA, by larvae of *Bryophaenocladius furcatus* (Kieffer). Sporadic reports refer to larval Chironomids causing sub-soil damage in commercial horticulture or to stored crops. Recently, larvae of Chironomid midges e.g. *B. furcatus* (Kieffer) have been implicated as glasshouse crop pests (Cranston 1987) causing serious damage to indoor horticultural crops, particularly lettuce and young tomatoes. Lettuce crops are mostly damaged in the seedling stage. Larvae of some Orthocladiid midges injure roots of Japanese horse-radish (Tokunaga & Kuroda 1935, 1936;
Yokogi & Ueno 1971; Ishihara 1972). Wang & Yizuo (1989) recorded that the leaves of Brasenia schreberi Gmel., an aquatic plant and a Chinese favourite dish, destroyed by the Chironomid larvae. Damage to rice crops and seedlings by members of the subfamily Chironominae (particularly Chironomini) has now been well documented (Tokunaga & Kuroda 1935, 1936; Risbec 1952; Bogner 1958; Darby 1962; Jones 1968; Yokogi & Ueno 1971; Ishihara 1972; Yasumatsu et al 1979; Hashimoto et al 1981; Sasa & Kikuchi 1986; Chaudhuri & Chattopadhyay 1990, 1991; Ferrarese 1993). They also serve as alternate prey for predators of rice pest (Hashimoto et al 1981). Jones (1968) recorded Chironomus tepperi Skuse as a pest of rice in Australia. Darby (1962) made a list of 36 species from the rice-fields and its vicinities in California (USA) and accounted 30 of them actually harbouring the paddies. Hashimoto et al (1981) gave a brief description on the adult morphology of 32 species of Chironomids in the rice fields of Thailand. Sasa & Kikuchi (1986) made an account of 34 species from the ricefields of Japan and stated that at least 40 species of Chironomids were found to be breeding in the rice paddy areas of Japan. Ferrarese (1993) studied the Chironomids of the Italian rice fields and found Harnischia falcata, to be an important pest of paddy. Chaudhuri & Chattopadhyay (1990) recorded 53 species of
Chironomidae from the rice fields of West Bengal, India. At present, there are 58 species belonging to 20 different genera collected from the rice paddies of India (Chaudhuri & Chattopadhyay 1991). Still other larval Chironomidae have been suspected of damaging field crops including winter wheat and maize. However, it is not clear if these larvae actually cause damage or are secondary invaders following attack by invertebrate and fungal plant pathogens. More careful observations on damaged crops are necessary before the significance of other Chironomidae species can be determined (Cranston 1987). It is notable that parthenogenicity occurs quite widely amongst the Chironomid pest species.

Owing to their ubiquity, abundance, diversity, variety of breeding habits and an exceptionally wide range of environmental tolerance, formulation of control methods of these nuisance and pestiferous midges has got many restraints. Control of Chironomids may be achieved by employing physical, cultural, biological or chemical means, depending upon the nature of the breeding source (Ali & Mulla 1979; Ali 1980). A majority of control studies of Chironomids has been focussed on chemical control by using botanical insecticides like pyrethrins and rotenone (Felton 1940); synthetic pyrethroids like cypermethrin, permethrin etc.
(Ali et al. 1985); organochlorines such as DDT, DDD, dieldrin (Anderson et al. 1964); organophosphate insecticides like chlorpyriphos, temephos, fenithion, fenitrothion, malathion etc.; insect growth regulators (IGRs) and juvenile hormone analogues (JHA) such as methoprene, diflubenzuron, Bay SIR-8514, Stauffer NV-678 (Hilsenhoff 1960, 1962; Mulla & Khasawinah 1969; Ali & Mulla 1976, 1977a,b, 1979; Mulla et al. 1971, 1974, 1975; Ali et al. 1978; Ali & Lord 1980; Ali et al. 1985; Tabaru 1991). However, the toxicity and dilution problems of organochlorines to fishes and other invertebrates (Hunt & Bischoff 1960) including the predatory fishes regulating midge larval populations (Bay & Anderson 1965; Murray 1976), lower safety index of lethal chemicals to nontarget micro- and macro-invertebrates and fishes (Cope 1965; Johnson 1968; Muirhead - Thompson 1971; Ali & Mulla 1978a,c; Mulla et al. 1979; Ali & Lord 1980) and the development of resistance in midges (Lieux & Mulrehan 1956; Pelsue & McFarland 1971; Ali & Mulla 1977a, 1978c) discouraged the use of chemicals. Since the existing midge control by physical and cultural methods such as crop rotation, rotational flooding and drying of partial areas of breeding sources (Anderson et al. 1964) or artificial flooding of lakes which are part of a river system to displace phytoplankton or larval food (Ali 1991), or habitat depth
increase (Ali & Mulla 1976c) or substrate removal by mecha-
nical means or by natural factors such as rainfall (Ali
et al 1976, 1977), are not economic, biological control
through the use of predators, parasites and pathogens has
been evolved. Predators of midges include flatworms
(Legner, Yu, Medved & Badgley 1975), planarians e.g. Dugesia
dorotocephala (Legner, Yu, Medved & Badgley 1975; Ali &
Mulla, unpublished ref., Ali 1980), tanypodine midges (e.g.
Coelotanypus Kieffer, Bay 1964; Procladius Skuse, Dusoge
1980), dytiscid beetles (Bay 1964), dragon fly nymphs
(Pritchard 1964), water mites e.g. Hygrobates (Winkel &
Davids 1987), leeches (Bay 1964), and a variety of fishes
like breams, blue gills, redear and long ear sunfishes, cat-
fishes, desert pupfish, young Bass, goldfish, carp, tilapia,
guppy or mosquito fish etc. (Cook et al 1964; Bay & Ander-
son 1965, 1966; Legner, Yu, Medved & Hauser 1975; Murray
1976; Spataru 1976; McLarney et al 1977; Zur 1980; Ceretti
Chironomids have been stated to act as hosts of some mer-
mithid nematodes (Johnson 1963, 1965; Parenti 1966; Poinar
1964, 1968; Welch & Poinar 1965). In California (USA) rice-
fields, Pardosa romulosa (Araneae : Lycosidae) has been
tried against midges (Oraze & Albert 1989). The protozoan
parasites of Chironomids are the microsporidia (Weiser 1961;
Hunter 1968) and the ciliophores (Corliss 1960). The pathogens include viruses such as entomopoxvirus (Anthony 1975; Harkrider & Hall 1975, 1978, 1979; Majori et al 1986), cytoplasmic polyhedrosis virus (Federici et al 1973) etc., rickettsiae (Götz 1972; Federici et al 1976) and fungi, especially of the genus Coelomomyces (Weiser 1976; Weiser & McCauley 1971). Various industrial formulations of the biocide, Bacillus thuringiensis var. israelensis de Barjac, which are highly effective against several species of mosquito larvae and Simuliid larvae, have been successfully tried against several species of Chironomine midges (Garcia & Goldberg 1977; Ali 1981; Ali et al 1981, 1985). Such bacterial insecticides are more useful in small habitats. The potential of this bacterial entomopathogen as an effective microbial insecticide for the bio-control of the Chironomid midges needs further trial. However, it may be generalized that parasites and pathogens are less effective for midge control. More researches on cultural and biological control techniques with minimum dependence on chemical measures are needed for the integrated control of nuisance Chironomids (Tabaru et al 1987). Basic informations on the biology, ecology, behaviour, seasonal changes, and population dynamics of the pest species would be helpful in formulating control strategies.
Chironomini Macquart (1838) (=Tendipedini Grünberg, 1910) is the most well defined tribe in the subfamily Chironominae Macquart, 1838 (=Tendipedinae Grünberg, 1910). Kieffer was the first to split up the old genera Chironomus and Tanytarsus. The primary character Kieffer used to diagnose the "Groupe Chironomus", presence of bare wings, however, has become subsidiary now-a-days. The most acceptable character used to designate Chironomini is the possession of 2-3 pairs of volsellae in the male hypopygium. Other important characters of the tribe are cross vein MCu being absent, RM definitely oblique to the direction of R_{4+5}', squama fringed; mid and hind tibiae with the spurs modified into "combs", fore basitarsus longer than the fore tibia or rarely slightly shorter, gonostylus of male genitalia directed rigidly backwards rarely with a terminal spine.

This tribe has now been more or less regularly studied in the Indian subcontinent. Altogether as many as 79 valid genera have been recognized in the tribe (Ashe 1983) of which only 25 such as Beckidia Saether, Chironomus Meigen, Cladopelma Kieffer, Cryptochironomus Kieffer, Demicryptochironomus Lenz, Dicrotendipes Kieffer, Einfeldia Kieffer, Endochironomus Kieffer, Gillotia Kieffer, Glyptotendipes Kieffer, Harnischia Kieffer, Kiefferulus.
Goetghebuer, **Kribiocosmus** Kieffer, **Lauterborniella** Thienemann & Bause, **Microchironomus** Kieffer, **Microtendipes** Kieffer, **Nilodorum** Kieffer, **Paracladopelma** Harnisch, **Paratendipes** Kieffer, **Pentapedilum** Kieffer, **Polypedilum** Kieffer, **Stenochironomus** Kieffer, **Stictochironomus** Kieffer, **Trichotendipes** Guha, **Das**, Chaudhuri & Choudhuri and **Xenochironomous** Kieffer are recorded from India.

A large number of species has been described by Kieffer (1910, 1911a, b, 1913a, 1914, 1918, 1919, 1921c, 1925) from the Orient including India and many of them are either placed under the "unplaced" series (Sublette & Sublette 1973) or are treated as "Nomina Dubia" (Sublette & Sublette 1973, Chaudhuri & Guha 1987). Singh (1958), Singh & Kulshrestha (1976), Kulshrestha (1979) have added 5 species viz., **Chironomus bharati** Singh & Kulshrestha (=**Chironomus circumdatus** Kieffer), **C. uttarpradeshensis** Singh & Kulshrestha, **Dicrotendipes septemmaculatus** (Becker) (as **rajastrhani**, Singh & Kulshrestha), **Pentapedilum kuluensis** Kulshrestha and **Paratendipes lahulensis** (Singh) to the tribe from India. Since then, the studies of Chironomini were in a state of diapause. This vacuole has been filled up by the extensive works of Chaudhuri and his collaborators who rejuvenated it from the later half of the Seventies. Chaudhuri et al (1981), Guha et al (1982), Guha et al

*Chironomus* is one of the most well defined and widespread genera in the family Chironomidae. It was erected by Meigen (1803) on the basis of *Tipula plumosa* Linnaeus (1758), which was subsequently designated as the type of the genus (Latreille, 1810). *Chironomus* is a junior synonym of *Tendipes* Meigen (1800) ([Tendipes suppressed by the I.C.Z.N. (Opinion 678: 339, 1963) in favour of Chironomus]). At the species level it is taxonomically one of the most confused genus and approximately 1,300 species have been assigned to *Chironomus* (Ashe 1983). Many of the species originally recognized as *Chironomus* are now assigned not only to many different genera but also to different subfamilies (Ashe 1983). Edwards (1929) considered *Chironomus* Meigen as a very broad genus involving as many as 10 subgenera under it and the subgenus *Chironomus* s. str. includes 5 species Groups (A, B, C, D and E) of which group B includes 3 series and group E includes 4 series; *Chironomus* s. str.
comes under Group B series 1. Townes (1945) aired the ancient controversy once again and preferred to use the generic name *Tendipes* Meigen (1800) in place of *Chironomus* Meigen (1803) and included 5 subgenera in it. Freeman (1957, 1961) defined the genus in the manner of Goetghhebuer (1937) and included all the species placed by Edwards (1929) in his subgenus *Chironomus* s. str. Further, Freeman did not restrict the definition of genus as done by Townes (1945) because he considered male hypopygeal characters as the best ones for generic diagnosis. Sublette & Sublette (1973) preferred to maintain the generic status for almost all the subgenera of Freeman (1957, 1958) and this has been supported by most of the present-day workers such as Lindberg & Wiederholm (1979), Freeman & Cranston (1980), Ashe (1983), Cranston & Judd (1989), Cranston & Martin (1989), Cranston et al (1989) etc. The study of *Chironomus* in India and even in Orient is not at all satisfactory. Hashimoto et al (1981) reported 9 species of *Chironomus* from the rice fields of Thailand. Kieffer (1910, 1911a, b, 1913, 1916 and 1924) described about 84 species and Edwards (1932) added 1 species in the list of *Chironomus* from India. Sublette & Sublette (1973) catalogued 25 species of *Chironomus* from the Orient and confirmed or placed only 5 species, *Chironomus dolichotomus, C. longivalvis*. 
C. macrogaster, C. nepalensis and C. validus (var. lobaticeps) described earlier by Kieffer (1910, 1911, and 1913) from India and kept as many as 59 species under "unplaced species" of Chironomini and 19 species under "nomina dubia" due to inadequate descriptions and illustrations. Afterwards, two more species such as, C. bharati (=C. circumdatus) and C. uttarpradeshensis have been added from India by Singh & Kulshrestha (1976). Guha et al (1985) described another species C. brevistylus from Andaman Is., India. Chaudhuri & Guha (1987) recorded 18 species under genus Chironomus Meigen and 5 unidentified species from the Indian subcontinent. Chaudhuri & Chattopadhyay (1990) enriched the directory of Indian Chironomus by adding 3 more species viz. C. circumdatus (Kieffer), C. javanus Kieffer and C. samoensis Edwards from the rice paddy areas of West Bengal, India. Very recently, Chaudhuri, Das & Sublette (1992) added 4 more species to the list, namely C. niger n. sp., C. ramosus n. sp., C. fortistylus n. sp. and C. pulcher Wiedemann. At present, 25 species of Chironomus are known from the Indian subcontinent inclusive of C. sinuosus Guha & Chaudhuri from Tibet.

Kieffer (1918a) introduced the concept of Cryptochironomus as subgenus of Chironomus Meigen (1803). Recent authors like Reiss (1968b), Ashe (1983) revalidated
the generic status of *Cryptochironomus* recognizing *Chironomus* (*Cryptochironomus*) *chlorolobus* Kieffer (1918) \[ = *Chironomus supplicans* Meigen (1830) \] as its type. Edwards (1929) did not consider *Cryptochironomus* Kieffer (1918) distinctive enough to reckon it a subgenus but relegated it to his Group E of subgenus *Chironomus* including about 24 British species in 4 series. Goetghebuer (1937) and Freeman (1957) maintained a subgeneric status of *Cryptochironomus* including all species of the genus *Chironomus* in which inferior volsella of the male hypopygium is greatly reduced or rudimentary or absent. Townes (1945) recognized *Cryptochironomus* as a genus. There had been number of attempts for splitting *Cryptochironomus* into further genera and subgenera but Freeman (1957) did not find this idea practical. *Cryptochironomus* has now been considered as a member of the *Harnischia* complex (Saether 1977). Tokunaga (1964) and Sublette & Sublette (1965) maintained the subgeneric status of *Cryptochironomus* following Freeman (1957). Sublette & Sublette (1973) reaffirmed the generic status of *Cryptochironomus* and identified 5 species from the Orient. The Single Indian species, *Tendipes polius* Kieffer (1911) was placed under genus *Cryptochironomus* by Sublette & Sublette (1973). Unfortunately, the type specimens could not be traced in the National Zoological Collections at the Zoological Survey of India, Calcutta. The four other valid
species from the Orient catalogued by them are *Tendipes apicalis* Kieffer (1924), *T. javae* Kieffer (1924), *T. viridiclavus* Kieffer (1927) and *T. distractus* (Johannsen).


At present 11 species of *Cryptochironomus* are known from India, inclusive of *C. acuminatus* n. sp., *C. curryi* Mason, *C. gracilis* n. sp., and *C. ramus* Mason.

Lenz (1941a) proposed the genus *Demicryptochironomus* after the type-species, *Chironomus vulneratus* Zetterstedt (1838) from the British isles (Saether 1977). *Demicryptochironomus* is a junior synonym of *Schadinia* Lipina (1939). *Demicryptochironomus* is now a well established name in the taxonomic and ecological literature whereas *Schadinia* is practically unknown to most workers. In the interest of stability it is recommended that *Demicryptochironomus* be used instead of *Schadinia* until a ruling on the problem is given by the I.C.Z.N. (Ashe 1983). This is a very least
known genus throughout the world. Edwards (1929) recorded *Chironomus vulneratus* Zett. under series 4, Group E, subgenus *Chironomus* s. str. of genus *Chironomus* which was later placed under *Demicryptochironomus* by Pinder (1978). Saether (1977) recognized 6 species of *Demicryptochironomus* namely, *D. curtivalvus* (Kieff.) n. comb. (Australia) (Freeman 1961), *D. vulneratus* (Zett.) (Palaearctic) (Lehmann 1971), *D. ploenensis* Lenz (Palaearctic) (Lenz 1960), *D. cinereithorax* (Goetgh.) n. comb. (Ethiopian) (Freeman 1957), *D. cuneatus* (Town.) n. comb. (Nearctic) and *D. fastigatus* (Town.) n. comb. (Nearctic) (Townes 1945). In this study, *D. vulneratus* (Zett.) has been recorded as the only known species from India. The Japanese species, *D. chuzeguartus* Sasa (1984) have now been proposed as a synonym with the widely known species, *D. vulneratus* (Zett.).

Kieffer (1913 b: 23) established the genus *Dicrotendipes* after the east african species, *Dicrotendipes pictipennis* Kieffer which automatically became its type. The genus differs from all others in that the inferior volsellae of the male hypopygium are bifurcated or forked. The next available names for the type species were *quatuordecimpunctatum* Goetghebuer (1936), *pilosimanus* Kieffer (1914) (Freeman 1957), and *septemmaculatus* (Becker 1908) Cranston & Armitage (1988). The correct name for
the type - species of the genus has now been stated as
*Dicrotendipes septemmaculatus* (Becker 1908), which is one
of the most widely distributed members of this genus in the
world (Epler 1988). Edwards (1929) recognized *Dicrotendipes*
Kieffer as *Limnochironomus* in his Group C under subgenus
*Chironomus* s. str. of the genus *Chironomus*. Goetghebuer
(1936) considered it as a subgenus *Limnochironomus* under the
genus *Chironomus* and fixed one of his species, *Dicrotendipes*
*quaturodecimpunctatum* as subspecies of the type separately.
Townes (1945) considered *Limnochironomus* as a subgenus of
*Tendipes* (=*Chironomus*). Freeman (1957) relegated *Dicroten-
dipes* to subgeneric status within *Chironomus* and synonymized
*Limnochironomus* Kieffer (1920), *Calochironomus* Kieffer (1921)
and *Carteria* Kieffer (1921) [= *Carteronica* Strand, 1928] with
*Chironomus* (*Dicrotendipes*). Later *Dicrotendipes* was
elevated back to the genus level by Hamilton et al. (1969) and
has been followed by next workers like Sublette & Sublette
(1973), Freeman & Cranston (1980), Ashe (1983), Chaudhuri &
Guha (1987), Epler (1988), Cranston & Martin (1989), and
in the genus *Dicrotendipes* from different zoogeographical
regions of the world. Hashimoto et al. (1981) recognized 3
species from Thailand viz. *D. formosanus* Kieffer [= *D. sep-
temmaculatus* (Becker)], *D. niveicauda* (Kieffer) [= *D. pel-
ochloris* (Kieffer)] and *D. flexus* (Johannsen). Three
Indian species, punctatipennis, semiviridis and tenuiforceps described by Kieffer (1910, 1911 and 1913) under the genus Chironomus/Tendipes have been placed under genus Dicrotendipes by Sublette & Sublette (1973). They also listed 6 more Oriental species Chironomus flexus Johannsen 1932, C. inferior (Johannsen 1932) [= D. pelochloris Kieffer], Limnochironomus niveicauda (Kieffer 1921) [= D. pelochloris (Kieffer)], Dicrotendipes formosanus Kieffer (1916) [= D. septemmaculatus (Becker)], D. frontalis Kieffer (1916) [= D. septemmaculatus (Becker)] and D. pilosimanus Kieffer (1914) [= D. septemmaculatus (Becker)] under this genus. Later on, 1 more Indian species, D. rajasthani [= D. septemmaculatus (Becker)] has been added by Singh & Kulshres tha (1977). Chaudhuri & Guha (1987) recorded 9 species of Dicrotendipes from the Indian subcontinent of which only 3 species are now valid, namely D. arcistylus Guha, Das, Chaudhuri & Choudhuri, D. canitibialis Guha, Das, Chaudhuri & Choudhuri and D. semiviridis (Kieffer 1911) (Sublette & Sublette 1973). Chaudhuri & Chattopadhyay (1990) recorded 2 more species, D. pelochloris (Kieffer) and D. septemmaculatus (Becker) from the rice field of West Bengal, India. Hence, altogether 5 species of Dicrotendipes are now known from India.
*Einfeldia* was erected as a genus by Kieffer (1924b) indicating *Einfeldia pectoralis* Kieffer as its type-species. Edwards (1929) placed it in his Group B under subgenus *Chironomus* of genus *Chironomus* Meigen. Townes (1945) treated it as a subgenus of *Tendipes* Meigen. Ashe (1983) placed *Benthalia* Lipina (1939) as a synonym of *Einfeldia* Kieffer. *Einfeldia* is yet to be recorded from the Afrotropical region and is very poorly represented from the Orient. Prior to this study, the genus *Einfeldia* was known only in 1 species, *E. loriipes* (Chaudhuri & Guha 1987) from the Orient (India) which has now been synonymized with *Dicrotendipes pelochloris* (Kieffer) (Chaudhuri & Chattopadhyay 1990). At present, the genus *Einfeldia* is represented by 3 species from India: *E. ocellata* Hashimoto, *E. pagana* (Meigen) and *E. synchrona* Oliver recorded during this investigation.

*Endochironomus* was established by Kieffer (1918) from the Palaearctic species of *Chironomus alismatis* Kieffer (=*Tipula tendens* Fabricius 1775) which obviously serves as the type of the genus. Edwards (1929) used it as a subgenus of the genus *Chironomus* and considered two lobed pronotum as the most important character for the subgenus which was accepted by Sublette & Sublette (1965). Kruseman (1933)
and Goetghebuer (1937) recognized *Endochironomus* and *Demeijerea* as full genera, while Townes (1945) placed *Endochironomus* and *Demeijerea* as distinct subgenera under the genus *Tanytarsus* and *Glyptotendipes* respectively and Freeman (1957, 1959 and 1961) placed these subgenera of Townes (1945) under *Endochironomus*. Freeman (1957) and Tokunaga (1964) followed the classification of Edwards (1929) and maintained the subgeneric status of *Endochironomus* under genus *Chironomus*, while Dendy & Sublette (1959) kept it as subgenus in genus *Tendipes*. Sublette & Sublette (1973) reaffirmed the generic status of *Endochironomus* with inclusion of only 1 species, *Tendipes pekanus* Kieffer (1916) from Formosa. Chaudhuri & Guha (1987) registered *E. brunetti* (Kieffer) from India and Chaudhuri & Chattopadhyay (1990) recorded *E. pekanus* (Kieffer) from the rice fields of West Bengal, India. At present, 4 species of this genus are recognised from India including *E. ampliceps* n. sp. and *E. effusa* n. sp. stated in this thesis.

*Glyptotendipes* was erected as a genus by Kieffer (1913a) and *Glyptotendipes sigillatus* Kieffer (1922) [\*? = *Glyptotendipes foliicola* Kieffer 1918] was designated as its type. Although, *G. sigillatus* was selected as the type-species in the original work by Kieffer, the species was not described until 1922. Edwards (1929) relegated
Glyptotendipes Kieffer to subgeneric status within genus Chironomus Meigen. Goetghebuer (1937) synonymized Phytochironomus Kieffer (1921) with Glyptotendipes Kieffer (1913) and Ashe (1983) synonymized Tendochironomus Lenz (1937) with the latter. Townes (1945) recognized 3 subgenera: Demeijerea Kruseman, Phytotendipes Goetghebuer and Glyptotendipes Kieffer under genus Glyptotendipes; of which Demeijerea is now a full genus. The genus is least represented from the Afrotropics, Micronesia, Australia and Oceania. Sublette & Sublette (1973) confirmed 6 species in this genus namely, G. brevilobus (Kieffer), G. formosae Kieffer, G. melanostolus (Kieffer), G. philippinarum (Kieffer), G. tumidus (Johannsen) and G. verrucosus (Kieffer) from the Orient. Chaudhuri & Guha (1987) recognised 4 species, G. barbipes (Staeger), G. melanostolus (Kieffer), G. oriplanus (Kieffer) and G. verrucosus (Kieffer) from India raising the number of Indian species to five including G. pilosus n. sp. described in this thesis.

Kieffer (1921c) erected the genus Harnischia on the basis of monotypic species Harnischia fuscimana Kieffer (1921). Edwards (1929) placed Harnischia in his series 4 of group E of the subgenus Chironomus of genus Chironomus Meigen with inclusion of 10 British species. Goetghebuer (1937) kept Group Harnischia under subgenus Cryptochironomus.

Goetghebuer (1922) established the genus *Kiefferulus* with the type-species *Tanytarsus tendipediformis* Goetghebuer (1921) by original designation. Edwards (1929) treated it

Kieffer (1921c) recognised *Kribiocosmus* as a genus indicating *Kribiocosmus ornatipes* as its type species which is probably lost. Freeman & Cranston (1980) listed it as the only species from the Afrotropical region. Though this
genus shares many common features with Polypedilum Kieffer. Ashe (1983) considered it as a valid genus. Prior to this study, no report about this monotypic genus was made from anywhere in the world. The only species known from India and the Orient, *Kribiocosmus tumulus* n. sp. is now described and illustrated in this account.

**Microchironomonas** was described by Kieffer (1918a) as a subgenus of *Chironomus* Meigen with *Chironomus* (*Microchironomonas*) *lendli* Kieffer as its type species. Lenz (1960) raised it to the generic status and synonymized *Leptochironomonas* Pagast (1931) with the genus *Microchironomonas*. The idea of Lenz has been followed by later workers [Saether 1977, Freeman & Cranston 1980, Ashe 1983, Chaudhuri & Guha 1987, Cranston & Martin 1989]. Saether (1977) placed the genus *Cladopelma* Kieffer (1924) in synonymy with *Microchironomonas*. This little known genus belonging to the *Harnischia* complex is poorly represented from the Holarctic, Afrotropics and the Orient (Lehman 1971, Saether 1977, Freeman & Cranston 1980, Laville & Serra - Tosio 1987, Azzouzi & Laville 1987, Cranston & Judd 1989, Cranston & Martin 1989). Chaudhuri & Guha (1987) recognized 3 species from India namely, *M. clarilatus* Guha & Chaudhuri (1981b), *M. fuscitarsus* (Guha & Chaudhuri 1979: 85, as *Cryptochironomonas*) and *M. tener* (Kieffer 1918), the last two were
also identified from the rice paddy areas of West Bengal, India by Chaudhuri & Chattopadhyay (1990). At present, the genus *Microchironomus* Kieffer is represented by 3 species from India and the Orient.

Harnisch (1923) coined the genus *Paracladopelma* fixing *Tendipes camptolabis* Kieffer (1913) as its genotype. Edwards (1929) placed it in Group D (along with *Cladopelma* Kieffer) of the subgenus *Chironomus* of genus *Chironomus* Meigen and included 2 British species under it. Goetgherbuer (1937, 1954) supported Edwards in respect to the systematic status which was in use for sometime. Townes (1945) treated *Paracladopelma* Harnisch as a synonym of the subgenus *Cladopelma* Kieffer of genus *Harnischia* and described 10 Nearctic species, many of which now clearly belong to *Paracladopelma*. Saether (1977) reverted *Paracladopelma* to the generic status, which has now been followed by present authors (Jackson 1977, Ashe 1983, Cranston et al 1989 etc.). *Paracladopelma* is well represented in the Holarctic (Townes 1945, Lehman 1971, Jackson 1977, Pinder 1978, Laville & Vincon 1986, Caspers & Reiss 1987, Laville & Serra-Tosio 1987) and Afrotropics (Freeman & Cranston 1980, Azzouzi & Laville 1987), but is yet to be represented in significant numbers from Australasia, Oceania (Cranston & Martin 1989) and the Orient. Chaudhuri & Chattopadhyay
(1990) enriched the directory of Indian *Paracladopelma* by adding 3 species, *P. bulbosa* Bhattacharya, Dutta & Chaudhuri, *P. aratra* and *P. sacculifera*. At present, there are 4 species known from India including *P. diutinistyla* n. sp. stated in this thesis.

*Paratendipes* is one of the well defined genus of tribe Chironomini, and was established by Kieffer (1911) on the basis of a monotypic species *Chironomus albimanus* Meigen (1918). Edwards (1929) treated it as subgenus *Paratendipes* Kieffer under genus *Chironomus* Meigen. Townes (1945) reverted *Paratendipes* Kieffer back to the genus level and synonymized *Synparatendipes* Thienemann & Bause (1913) with it. Freeman (1957) supported the opinion of Townes (1945) and placed *Kribiodoxa* Kieffer (1921) in synonymy with *Paratendipes* Kieffer. Sublette & Sublette (1973) registered 7 Oriental species, *Paratendipes bifascipennis* (Tokunaga), *P. digraphis* (Kieffer), *P. dolens* (Kieffer), *P. inarmatus* Freeman, *P. lahaulensis* (Singh), *P. melanothorax* (Kieffer) and *P. pelargus* Kieffer. Chaudhuri & Guha (1987) listed 5 species from India viz. *P. digraphis* (Kieffer), *P. dolens* (Kieffer), *P. lahulensis* (Singh), *P. hirsutus* Guha & Chaudhuri and *P. pelargus* Kieffer. Chattopadhyay & Chaudhuri (1991) added 1 more species, *P. unimaculipennis* from Shillong, India. With the inclusion of *P. maculipennis* n. sp. and
P. penicilliceps n. sp. described in this work, the present number of species from the Indian subcontinent comes to eight.

Kieffer (1913b) erected the genus Pentapedilum with Pentapedilum stratiotale Kieffer [= Chironomus tritus Walker 1856] as the type of the genus (Edwards 1929). Edwards (1929) considered Pentapedilum Kieffer distinctive enough to reckon it as a "full genus" and recognized 4 subgenera under it, Pentapedilum Kieff., Sergentia Kieff., Kiefferulus Goet., and Phaenopsectra Kieff., and included 4 British species under subgenus Pentapedilum Kieffer. Edwards (1931) corrected his previous stand and treated Pentapedilum Kieff. as a subgenus under the genus Chironomus Meigen. Goetghebuer (1938) maintained the generic status of Pentapedilum Kieff. until Townes (1945) took it as a subgenus of Polypedilum Kieff. Freeman (1954, 1955) kept Pentapedilum Kieff. as a separate genus until 1958, when he preferred the concept of Townes (1945) and synonymized Kribiopelma Kieffer (1921) and Rosenia Kieffer (1921, 1923) with the subgenus Pentapedilum Kieff.

Kieffer. or mostly of the genus **Polypedilum** Kieffer. However, several authors like Johannsen (1932), Sublette & Sublette (1973), Saether (1977), Pinder (1978), Freeman & Cranston (1980), Hashimoto (1983), Sasa (1979, 1983 and 1985), Sasa & Hasegawa (1983), Guha & Chaudhuri (1985), Sasa & Kikuchi (1986), Chaudhuri & Guha (1987), Ree & Kim (1988), Chaudhuri & Chattopadhyay (1990) preferred to recognize **Pentapedilum** Kieffer. as a valid and useful genus. In the present text, the classification adopted by later workers has been followed. **Pentapedilum** Kieffer. is now a very well represented genus throughout the world. Johannsen (1932) described 2 species from the Malayan subregion of the Dutch East Indies namely, **Pentapedilum convexum** John. from Sumatra and Caroline Islands and **P. nodosum** John. from Marina Islands (Java). Sublette and Sublette (1973) confirmed these 2 species from the Orient. Chaudhuri & Guha (1987) catalogued 4 species namely, **P. convexum** Johannsen, **P. kuluensis** Kulshrestha, **P. macrotrichium** Guha & Chaudhuri and **P. robusticeps** Guha & Chaudhuri from India. Chaudhuri & Chattopadhyay (1990) added 1 more species, **P. uncinatum** (Goetghebuer) from the rice fields of India.

**Polypedilum**, a well defined and older genus in the tribe Chironomini, was established by Kieffer (1921b) designating **Polypedilum emarginatum** Kieffer 1913 \(=\) **Chironomus nubeculosum** Meign 1818 as its type-species. Subsequently,
Ashe (1981) selected a new type-species *Polypedilum pelo-stolum* Kieffer 1912 \(\equiv Chironomus nubifer\) Skuse 1889 after discovery of an earlier date for the genus *Polypedilum*. Edwards (1929, 1931) treated it as subgenus *Polypedilum* Kieff. of the genus *Chironomus* Meigen. Goetghebuer (1936, 1937) while accepting the idea of Kieffer fixed *Chironomus nubeculosus* Meigen as its genotype in place of *Polypedilum emarginatum* Kieffer. Later, both the species were found to be similar. Townes (1945) considered *Polypedilum* as a broad genus with 3 subgenera, *Pentapedilum* Kieffer (1913), *Polypedilum* s. str. and *Tripodura* Townes (1945). Freeman (1958, 1961) accepted the view of Townes (1945) and synonymized a large number of genera with genus *Polypedilum*. Subsequent authors including Tokunaga (1964), Ashe (1983), Cranston & Armitage (1988), Cranston & Judd (1989), Cranston & Martin (1989), Cranston et al (1989) preferred to follow Townes (1945). The generic status of *Polypedilum* Kieff. was re-established by Sublette & Sublette (1973) and this concept was followed by Pinder (1978), Freeman & Cranston (1980), Sasa (1979-1985), Sasa & Hasegawa (1983), Hashimoto et al (1981), Ree & Kim (1981, 1988), Sasa & Kikuchi (1986), Chaudhuri & Guha (1987), Chaudhuri & Chattopadhyay (1990). In the present work, the classification adopted by above workers has been followed. *Polypedilum* is a most well represented genus throughout the world. Johannsen (1932) clearly described 10 species of
Po~dilum from the Malayan subregion of the Dutch East Indies. Sublette & Sublette (1973) placed 38 species from the Oriental region in this genus including 8 species from India and kept many more species, "unplaced" for obvious reasons. Hashimoto et al (1981) recorded 4 species of Polypedilum from the rice fields of Thailand. Kieffer (1910, 1911, 1913) described 7 species of Polypedilum from India. Prior to this study, 34 species of Polypedilum have been confirmed from India. Chaudhuri & Guha (1987) catalogued 31 species from India, of which Polypedilum obscurum Guha & Chaudhuri (1983) has now been recombined as Stictochironomus obscurus (Guha & Chaudhuri). Chaudhuri & Chattopadhyay (1990) added 4 more species, Polypedilum circulum Chaudhuri & Chattopadhyay, P. medivittatum Tokunaga, P. suturalis (Johannsen) and P. yapensis Tokunaga from the rice fields of India. At present, 37 species of Polypedilum are known to occur in India, which includes P. edensis Ree & Kim, P. seorsum (Skuse) and P. insignum n. sp. stated here.

Stictochironomus was raised as a genus by Kieffer (1919) and the type-species Chironomus pictulus Meigen (1830) was fixed subsequently by Townes (1945). Edwards (1929) considered it as a subgenus of genus Chironomus Meigen, which was okayed by Johannsen (1932), Townes (1945)
suggested an interesting alteration in relationships by placing this genus along with Endochironomus and Tanytarsus as subgenera of a single genus, which took the oldest name Tanytarsus v.d. Wulp, following the type fixation of Coquillett (1910). Freeman (1958) revalidated the generic status of Stictochironomus Kieff. and synonymized Kribiocallis Kieffer (1921) with it. Shilova (1964) placed Allochironomus Kieffer (1921) in synonymy with Stictochironomus Kieff. The view of Freeman (1958) got support from the subsequent workers like Tokunaga (1964), Sublette & Sublette (1973), Freeman & Cranston (1980), Ashe (1983), Cranston & Judd (1989), Cranston & Martin (1989) and Cranston et al (1989). Johannsen (1932) described 2 species Chironomus (Stictochironomus) affinis John. and C. (S.) translucens John. from the Malayan sub Region. Sublette & Sublette (1973) registered only 1 species from the Orient, Stictochironomus translucens (Johannsen). Ali, Chaudhuri & Guha (1987) described S. affinis (Johannsen) from India. Chaudhuri & Chattopadhyay (1990) described 1 more species S. obscurus (Guha & Chaudhuri) along with this species from the rice fields of West Bengal, India. Thus, at present, Stictochironomus Kieffer is represented by 2 species from India.
The genus *Xenochironomus* was erected by Kieffer (1921c) and the type-species was later fixed as *Chironomus xenolabis* Kieffer (1916) by Goetghebuer (1937). Edwards (1929) placed *Xenochironomus* in his series 3 of Group B of Subgenus *Chironomus* under genus *Chironomus* Meigen. Goetghebuer (1937) treated it as a subgenus of *Chironomus* Meigen, while Townes (1945) considered *Xenochironomus* Kieffer as a genus. Freeman (1955, 1957) kept *Xenochironomus* Kieffer as a subgenus under genus *Chironomus* Meigen and he (1957) considered the subgenus to be intermediate between the subgenera, *Cryptochironomus* and *Dicrotendipes*. *Xenochironomus* was retrieved to the generic rank by Sublette & Sublette (1973) which have since been used by most workers like Freeman & Cranston (1980), Hashimoto et al (1981), Ashe (1983), Cranston & Martin (1989) and Cranston et al (1989). Sublette & Sublette (1973) recorded the single oriental species, *Xenochironomus trochanteratus* (Thomson 1869) from Philippines. Hashimoto et al (1981) identified 2 species, *X. xenolabis* (Kieffer) and *X. nigricaudus* Hashimoto from the rice fields of Thailand. Chaudhuri & Guha (1987) registered 2 species, *X. flaviventris* (Kieffer) and *X. longicrus* (Kieffer) n. comb. from India. Chaudhuri & Chattopadhyay (1990) also described *X. flaviventris* (Kieffer) from the rice fields of West Bengal, India. The genus is at present documented by 4 species including *X. tenuiforceps* (Kieffer) n.comb. and *X. lacertus* n. sp. in India.