I. INTRODUCTION

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The genus Culicoides, erected by Latreille in 1809, is included in the family Ceratopogonidae (= Heleidae), suborder Nematocera, order Diptera of the class Insecta. For many years it was treated as one of the genera of the subfamily Ceratopogoninae. Recognition of the family Ceratopogonidae, raising the subfamily into a family taxon, was made in 1917 and since then the status has been maintained in all pertinent literature including the common entomological books (Borror and Delong, 1963; Imms, 1977). Today, the family Ceratopogonidae includes 78 valid genera and subgenera within its 4 subfamilies on a global basis (Wirth et al. 1974)

The blood-sucking insects of the genus Culicoides are commonly referred to as biting midges or gnats and are well known to the laymen in different parts of the world in various colloquial names, such as, "machhri" in Bombay area, "outki" in Assam and Bengal area of India (Patel, 1921), "jejens" in South America (Hill, 1947), "brulots" in French Canada and "punkies" and "no-see-ums" in the forested regions of America (Jamnback, 1965). The genus has recently received much attention from the taxonomists all over the world because of its species having economic importance as disease vectors and pests of man and farm animals (Kremer et al. 1965, 1974; Braverman and Galun, 1973).

A) Economic importance of Culicoides

Acclaimed as a menace in pestiferous forms retarding development of the otherwise favourable resorts in many coastal areas for their avid anthropophilic and zoophilic habits in many species, the biting midges throughout their distributional range may act as vectors of filarial worms, malaria-like protozoons and some groups of viruses affecting man as well as the domesticated and wild animals and birds. Their ability to inflict some damage in fruit-cultivation, to affect pollination of tropical economic plants and their occasional entomophagous habit add to their further importance.

The females of many species of the three ceratopogonid genera - Culicoides, Leptoconops and Lasiohelea are long known to feed on warm-blooded vertebrates (birds and mammals). Culicoides may be more troublesome than mosquitoes and according to an observation (Hopkins, 1952), a biting rate by them exceeding 2000/hour can be withstood only for a few minutes. Such a rate can be responsible for entomophobial symptoms in man although the usual effects of a bite show up as provisional local swelling with irritation. They have long been suspected as the possible arthropod-vectors of many a disease-agents. Thus, Patton (1913) quotes Townsend who connected some Lasiohelea as carriers of "Utah" (= Oriental sore) in the South Andean. Culicoides have been suspected as vectors of a type of child fever in Korea and a type of horse-sickness in South Africa and China.

In India, their abundance in damp, humid conditions characteristic of the Kala-azar belts was noted and Roy (1928) observed that a Leptoconops species (referred by him as "Eye-flies") had an identical seasonal incidence with that of "Naga" sore and epidemic conjunctivitis. That a fever of several days' duration may follow from Culicoides bites in many tropical and subtropical countries was long suspected and Boyd and Lee (1961) from their observations in Australia concluded that those insects were potential vectors of diseases between flying fox, bird and man in that country.

The real incrimination of biting midges as the vectors in nature started with Sharp (1927, 1928) who showed that a Culicoides was the carrier of the human filarial worm, Acanthocheilonema perstans in West Africa. A complete development of the worm Mansonella ozzardi in a Culicoides, fed on infected persons in West Indies, was noted by Buckley (1938) who also incriminated a Culicoides as the vector of cattle onchocerciasis in Malaya. Earlier, Steward (1933) in England showed spread of this disease in horses through Culicoides and the same was confirmed to be the case in France as well by Boigneux (1952). Natural microfilarial infection in Culicoides in Algeria, Mexico, Venezuela and in Thailand were recorded by Sergent et al. (1933), Dampf (1936), Mirza et al. (1952) and Causey (1938) respectively. Bergner and Jachowski (1968) traced the development of a filarial parasite of monkeys in Culicoides in

Taiwan, while Robinson (1971) showed a Culicoides as the vector of the filarial parasite Chandlerella of grackles. The transmission of malaria like protozoon parasites by Culicoides were reported thus : Akiba (1960) incriminating C. arakawai as the vector of Leucocytozoon of chickens in Japan, Fallis and Bennet (1961) detecting some Culicoides as the vector of Haemoproteus (= Parahaemoproteus) of crows and finches in Canada and Garnham et al. (1961, 1962) showing conclusively two Culicoides as vectors of Hepatocystis parasites in African monkeys. There have been further reports of such cases from these countries, and in India, Dasgupta and Pal (1976) report natural infection of malarial oocysts in Culicoides of Darjeeling. The status of transmission of such nonviral disease agents by Culicoides in recent years is reviewed very aptly in recent years by Greiner and Bennett (1977) and by Lourie et al. (1977).

The most important vectorial role played by Culicoides seems to be in their dissemination of several viral bodies, that of the blue-tongue diseases of sheep and cattle populations in South Africa, the New World countries and Australia being the long-known focal point in this respect (Du Toit 1962; Price and his collaborator 1954 and 1963; Foster et al. 1968; Downe 1973; Downe et al. 1964; Lee et al. 1974; Sinha, Dyce and Standfast 1979), and it was found that the specimens of the schultzei-oryctoma complex, C. peregrinus and C. actoni which occurred widely in India

harboured the BT virus in Israel (Braverman and Galun, 1973), Nigeria (Lee *et al.* 1974) and Australia (St. George *et al.* 1984). The spread of the buttonwillow virus by *Culicoides* in the U.S.A. was demonstrated by Reeves *et al.* (1970). The *Culicoides* species are also proven vectors of African horse sickness and it is presumed that the dispersal of these infected midges may have been responsible for spread of this disease from one to another country in different years including the same from Pakistan to India during 1960 onwards (Boorman 1979). It is also long suggested that the *Culicoides* play a role in the transmission of viruses of fowl-pox in Japan and of avian synovitis in the U.S.A.

From a scrutiny of literature, it appears that the habit of having a blood meal by female *Culicoides* from mammalian hosts is yet not known very critically though this habit is intimately connected with their role as transmitters of various disease agents in addition to their nuisance value in a locality. The haematophagous *Culicoides* show a fair amount of host specificity and the anthropophilic species of India were *actoni*, *anophelis*, *flaviscutatus*, *huffi*, *peregrinus*, *oxystoma* and *palpalis*. Some of these avidly attacked cattle populations and other warmblooded mammals and birds. From several spot studies, in and around Calcutta, Dasgupta (1964) contended that *C. anophelis* and *C. palpifer* do not readily attack such hosts while *C. circumscriptus* was anthropophilic

and the readily zoophilic species were schultzei, peraccrinus, innoxius and turgidus, which also fed on man in captivity.

B) Review of literature on Indian Culicoides and scope of the present study.

The first taxonomic study on the Culicoides fauna of India started with Kieffer (1910) who later enriched our knowledge by a few more contributions (1911 a-b; 1913; 1914). This was followed by Patton (1913), Dover (1921), Edwards (1922), Smith (1929), Mukerji (1931), Smith and Swaminath (1932), and Macfie (1932). After a long interval, Sen and Das Gupta (1959a) attempted a comprehensive study on the Indian Culicoides mainly on the basis of materials collectedin and around Calcutta. Their study furnished descriptions of many a new species, redescriptions of a few known species and corrections of some previous taxonomic errors. Das Gupta (1962b, 1963 a-c) and Wirth and Hubert (1959) described a few more species from other parts of India and Sikkim. Das Gupta (1964) in a revisionary study of the ceratopogonid fauna reported the existence of 42 valid species of Culicoides within the territory of India and Sikkim. Subsequently, Majumdar and Dasgupta(1972) exploring to some extent the eastern India locations, found that 70 species of Culicoides were extant in India. They found 28 of these as new to science and they could accommodate all known Indian species of Culicoides in 23 species groups under 11 subgenera, 14 of the species groups being newly proposed by them.

The intensive taxonomic studies on Culicoides of many Afro-Asian countries, and Australia and adjoining countries made during all past years by various specialists abroad had a both direct and indirect bearing on any appraisal of Culicoides of India since it was becoming increasingly clearer that several species did have either a continuous distribution range or sporadic, isolated occurrence in two or more countries. Thus the recent work on African Culicoides by Clastrier and his collaborators (1959-'61), Dipeolu and his collaborators (1974-'77), Boorman and his collaborators (1979) and Cornet and his collaborators (1970 and '74) were indispensible; similarly important were the findings on (i) the Culicoides of Arab countries, Egypt and Israel in the middle east by Megaty and Morsy (1959-'61), by Naval and her collaborator (1965-'71), and by Braverman and his collaborators (1970-1977), (ii) the Culicoides fauna of South east Asiatic countries including China by Wirth and his collaborators (1959-1981), by Chen and his collaborators (1962 & 1982), Chu (1977), by Kitaoka and his collaborator (1963-1974), by Cho (1974), by Wada (1977-1979) and by Kitaoka (1963 & 1983), (iii) the Culicoides of Soviet Asia by Gutsevich (1973) and (iv) the Culicoides of Australia by Dyce and his collaborators (1979-1983). Many valuable reappraisals of previously known species extent in several countries including India were reported in these papers as a result of which our confusions about synonymic cases were dispelled to some extent, and our knowledge about the species distribution increased.

In this connection, the monographic works of earlier times on Culicoidea of various zoogeographical realms were also found necessary and liberal consultation of Carter et al. (1920,1921), Edwards (1926), Causey (1938), Lee and Reye (1953), Arnaud (1956), Anosova (1957), Wirth and Blanton (1959), Tokunaga (1959), Gutsevich (1959,1960), Campbell and Pelham-Clinton (1960), Delfinado (1961), Jamnback (1965) etc., were also necessary.

As for having the basic conception of the species-groups and the subgenera of Culicoidea, the work of Fox (1948), Vargas (1953 a-b, 1973a-b), Wirth and his collaborators (1959-1974), Delfinado (1961) etc. are useful. A checklist of Oriental Culicoidea by Wirth (1973) aptly sums up the position though the unpublished data in this respect by Majumdar and Dasgupta (1972) showing Indian species at that time could not be included in the same.

From a perusal of literature reported above it appears that there has been a tremendous progress in the general taxonomic knowledge of Culicoidea on global basis during last twelve years from now. The genus Culicoidea is known to be represented by more than 1500 species, over 50 species groups and 22 subgenera. The old conception of the subgenera and the species groups underwent a substantial change requiring reappraisal of the Culicoidea fauna of various countries. The same necessitated inter-subgeneric and inter-species group changes and consequent rearrangement of the

valid species of a country including redefinition of species characteristics in many cases, and while such exercises were taken up by the concerned scholars in respect of most of the countries elsewhere, the case for India practically remained stagnant at 1972 level, as per the work of Majumdar and Dasgupta (1972). It was thus necessary to re-assess the data of those authors in light of recent findings elsewhere on various sections of Culicoides and to work out modifications as due. Moreover, as was evident from literature, the explorations of Culicoides fauna in different parts of India were still in a rather elementary stage, the diverse eco-systems in different parts of the country hardly being yet touched in any worthy manner. So the scope for undertaking repeated explorations and study of Culicoides collected thereby was always there. It was amidst such backdrops that the present study involving fresh explorations of Culicoides in the State of West Bengal, India was undertaken. The richness of the Culicoides speciation and their abundance in different parts of the study area justified not to cover more areas of India outside the State of West Bengal. It is presumed, species listed now as extant in the study area will be found fairly distributed in other parts of India as well; in that way, the present study will act as the latest available, updated taxonomic work of Culicoides of India for any future reference.