Title: "The true flies (Diptera) of the Western Ghats : knowledge status and richness estimates" *In:* Invertebrate Diversity and its Conservation on the Western Ghats. ATREE, Bangalore.
Running head: Flies (Diptera) of the Western Ghats, India
Author: Kumar Ghorpadé
Address: Post-Graduate Teacher and Research Associate, Department of Agricultural Entomology, University of Agricultural Sciences, Krishi Nagar, Dharwar 580 005, India.
E-mail: kumar.ghorpade@yahoo.in
Keywords: Peninsular India, Diptera species diversity, flies, gnats, mosquitoes.

The true flies (Diptera) of the Western Ghats : knowledge status and richness estimates

Kumar Ghorpadé
Post-Graduate Teacher and Research Associate, Department of Agricultural Entomology, University of Agricultural Sciences, Krishi Nagar, Dharwar 580 005, India. E-MAIL: kumar.ghorpade@yahoo.in

Keywords : Peninsular India, Diptera species diversity, flies, gnats, mosquitoes.

"Simplicity is attained after learning,
Lack of this profound knowledge creates confusion."

Abstract : This article summarizes knowledge about the true, two-winged, flies known to occur in the Western Ghats biogeographical sub-area, ranked 7th among the 25 global "Hot Spots." Numbers of genera and species of each family of Diptera known to occur on the continental island of Ceylon ("Sri Lanka," politically), as well as in the biogeographical area of Peninsular India—Ceylon, and in the Indian sub-continent, are also presented, for perspective. A map showing the biogeographical areas and their sub-areas in the Indian subregion (= sub-continent) is included, with a brief account in the text. The sequence used for families is the latest one researched and adopted by the Biosystematic Database of World Diptera, created and updated at the United States National Museum of Natural History, Washington, DC, U.S.A. The data presented are from the author's research files maintained since 1973 and based on original catalogues, checklists, monographs, revisions, and annual compilations by the abstracting periodical, the *Zoological Record* (*Insecta*). The Western Ghats (portions called *Sahyadri* in Maharashtra and *Malnaad* in Karnataka), a north—south mountain range running down south of the river Tapti (Tapi), where the Dangs occur in Gujarat, to Cape Comorin (Kanyakumari) where the Ashambu and Papanasam Hills of Kerala—Tamil Nadu exist, contains some 1,262 known, described and here recorded fly species belonging to 534 genera placed in 64 families (*vide* Delfinado and Hardy 1973-1977, and some updates). Perhaps an additional 825 to 950 or more species, at the very least, may still be flying and inhabiting the Western Ghats, but are yet not collected, named and described, or are other known species currently un-recorded from this hill range. Statistical inference suggests that the Western Ghats possesses some 52 % (or ≈ 50-70 %) of all Dipteran species found in the Peninsular India—Ceylon biogeographical area, but only 15 % (or ≈ 15-25 %) of the fauna in the Indian sub-continent, an area almost coincidental with the Indian subregion of the Oriental biogeographical region (the Western Ghats having ≈ 7-10 % of species found in the Oriental Region and ≈ 2-4 % of the Diptera found on earth). Comparison of databases available on plants, birds and butterflies on the Western Ghats is made to place its Dipteran diversity in context and point out information lacunae that still exist. That the fauna and flora (biota) of the Western Ghats has most probably been initially sourced from the older hills in the east—centre of Peninsular India, mostly isolated hill outcrops and smaller ranges that are collectively, somewhat inappropriately, termed the "Eastern Ghats" is hypothesized here. From this initial invasion of the newly uplifted and then still rising Western Ghats (by faulting; see Mani, 1974), more new species evolved by adapting to the higher altitudes as and when these microniches opened up in geological time over the past 50 million years or more. The lower leeward foothills and slopes of the Western Ghats still have this ancient, drier forest and scrub habitat and their associated biota which are a feature of these ancient Eastern "Ghats." It is hence argued that even these Eastern Droogs (proposed alternative name, meaning hill peaks) and their biota form other, dissected, "Hot Spots" that must also be protected and "conserved," as what have been fundamental "source areas" and gene pools for the colonization of the young emergent Western Ghats mountain range niches. In fact, a fairly rich diversity inhabits these eastern droogs e.g., the Biligirirangan, Shevaroy, Horsley, Palkonda—Seshachalam, and Nallamala—Velikonda, and they represent examples of these other, perhaps minor, hotspots that are being ignored by conservationists (see Mani, 1974 for geological history of the Western Ghats and Eastern Droogs) ! Only by protecting (and restoring) ***all remaining pristine and minimally disturbed habitats*** in India (*ca* 3% remaining ?) by legal and military force can its biota be hopefully saved for posterity and our environmental good health.

Introduction

The Western Ghats are a north—south oriented mountain range located from just south of the river Tapti (Tapi) in Gujarat State, where the "Surat Dangs" occur, and then descending down some 1,600 km as the highest altitudinal aspect in southern India through the States and Union Territories of Daman, Dadra—Nagar Haveli, Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala to what are called the Ashambu and Papanasam Hills straddling the Tamil Nadu—Kerala political border near Cape Comorin (Kanyakumari). Some portions of these high hills are also locally termed the *Sahyadris* in Maharashtra and the *Malnaad* in Karnataka. The precipitation on these hills ranges from some 1,000 to 7,000 millimeters per annum and the highest peaks soar to over 2,500 metres height. Some peaks from north to south are Kalsubai (1,646m) and Mahabaleshwar (1,438m) in Maharashtra, Bababudangiri (1,892m) and Kudremukh (2,027m) in Karnataka, Dodabetta (2,633m) in Tamil Nadu and the highest, Anaimudi (2,695m) in Kerala. Of the 182,500 sq. km of original forest area, less than 7% (12,450 sq. km) now remains on the Western Ghats.

There are some 4,780 species of plants on the Western Ghats of which 2,180 (46 %) are currently found to be endemic here. Of the 1,073 vertebrate species on these mountains, some one-third (*ca* 30 %) are endemic. Of these vertebrates, 38 (27 %) of the 140 species of mammals, 40 (8 %) of 528 bird species (this endemism proportion needs to be re-evaluated), 161 (62 %) of 259 reptile species, 204 (76%) of 269 land snail species, 116 (80%) of 146 amphibian species, and 111 (46%) of 238 freshwater fish species are also endemics on the Western Ghats, which is ranked 7th among the 25 global hotspots in relation to endemic plants and vertebrate endemism, their area ratios, and percentages of remnant vegetation to original extent. For more information on these ghats the following may also be consulted—Bhimachar 1945; Champion and Seth 1968; Croizat 1968; Mani 1974; Meher-Homji 1983; Nayar and Sastry 1987; Pascal 1988; Gadgil 1996a; Chandran 1997.

I also appreciate the *geographical scope* of this book—the Western Ghats—which is a *major re-focus on natural areas*, rather than continue with the otherwise political (Country, State, District) units selected for scientific documentation (of plants or animals) that I consider are highly artificial and irrelevant (except politically) in biogeographical, evolutionary, or purely scientific terms. It is therefore recommended here that we need to identify and study the fauna and flora of these individual *biogeographical areas*, rather than do those of political units.

THE FLORA AND BIOGEOGRAPHY OF THE WESTERN GHATS :

Subramanyam and Nayar (1974) provided a very important database on the flora of the Western Ghats. They wrote (p. 178-182) that "…..the vegetation is influenced more by the abundance and distribution of the seasonal rainfall than the atmospheric temperature" and that "…..the flora of the leeward side of the Western Ghats merges with the floristic elements of Deccan [also of the Eastern Droogs *q.v., vide infra*—K.G.]. The exact boundaries of the botanical provinces of Malabar [the Western Ghats sub-area of mine, see Map, Fig. 1] and Deccan [Deccan Plateau and Eastern Ghats—Carnatic sub-areas of mine, *q.v.* Fig. 1] are not sharp, as large number of spurs of Western Ghats enter into Deccan and merge with the mountains of the Eastern Ghats. So also in the north the Vindhya and Satpura ranges, Mahadeo Hills carry some of the deciduous floristic elements to Central India." They also stated that the Western Ghats flora is distinctive in the primary presence of the plant families Bambusae [now Poaceae—K.G], Dipterocarpaceae, Guttiferae [Clusiaceae], Myristicaceae and Palmae [Arecaceae]. The "ten dominant Natural Orders [*sic !* actually botanical families—K.G.] are Gramineae [Poaceae], Leguminosae [Fabaceae], Acanthaceae, Orchidaceae, Compositae [Asteraceae], Euphorbiaceae, Rubiaceae, Asclepiadaceae, Geraniaceae and Labiatae [Lamiaceae]." The Western Ghats have some 1,500 endemic species they wrote, out of 2,045 endemic Dicotyledons in Peninsular India, in comparison to 3,169 endemic dicots on the Himalayas *vide* Chatterjee's paper in the *Journal of the Asiatic Society of Bengal* published in 1940. But Subramanyam and Nayar (1974) divided the Western Ghats into four, not three, "Phytogeographical regions" *i.e.*, —1. The ghats from the River Tapti to Goa, 2. The ghats from the R. Kalinadi to Coorg, 3. The Nilgiris, and 4. The Anaimalai, Palni and Cardamom Hills.

Three reasonably distinct geological and biological divisions of the Western Ghats (in India) are theorized based on studies of fish distribution by Bhimachar (1945) and subsequent research by other workers. What is now the geologically separated island of Ceylon (Sri Lanka, politically) was once part of the older Gondwanaland-originated and split "Greater Indian Plate," and the high country there, as the hilly area is popularly termed in Sri Lanka, is also biogeographically part of this significant, newly uplifted, north—south oriented, mountain range on this ancient land that has never lain under water (*vide* Forster 1924). Of the three divisions (a fourth in Ceylon), the first is what I have named the "Dangs—Konkan" biogeographical sub-sub-area (the "Northern Division" of Bhimachar 1945) from the Dangs in Gujarat south to all of Goa and to the Kalinadi River. The second is the "Canara—Malabar" (Central Division) from the Kalinadi River to the Nilgiris north of the Palghat Gap barrier. The third is the Travancore—Cochin sub-sub-area (Southern Division) from south of the Palghat Gap (Nelliampathy—Anaimalai Hills) to the extreme southern tip of India near Kanyakumari (Ashambu—Papanasam Hills).

These are also exactly the biogeographical sub-sub-areas of the Western Ghats that were earlier identified by me (see Ghorpadé 2001). Consult the Map (Fig. 1) here included also which gives the main biogeographical divisions of the Indian sub-continent that form the Indian subregion of the Oriental Region. Simply put, the Greater Indian Plate, which was once part of the southern hemisphere supercontinent Gondwanaland, now exists only as the Central Highlands and Peninsular India—Ceylon areas south of the Indo—Gangetic Plains. These latter plains are recently

formed land, overlaying the Tethys Sea that previously existed there. More of this Indian Plate now lies crumbled below the Arabian Sea and the Bay of Bengal, the latter being an important "node" (*vide* Croizat 1968) which divides what life occurs from Afghanistan to Sri Lanka (Indian subregion) from what does south of the Yangtze-Kiang River in China to the Malay Archipelago (Sino—Malayan subregion) in Malaysia and Indonesia. The Himalayas*, along with the Baluch—Afghan mountains and the Naga—Arakan Hills form the northern "mountain arcs" which are, mostly, the transition of Palaearctic (high elevations) and truly Oriental (lower altitudes) biota. The Irrawaddy River Valley in Burma (Myanmar) separates the Indian subregion to its west from the eastward Sino—Malayan subregion. The Sino—Malayan subregion includes areas in eastern Burma such as the Shan States and the Tenasserim Isthmus. The Andaman (and Nicobar ?) Islands are perhaps peaks of once high mountains that existed on the Greater Indian Plate of which a part has now sunk into this Bay. In the Peninsular India—Ceylon biogeographical area, which is the oldest surviving geological landmass in the subregion, it should be noted that both the Western Ghats and the Deccan Plateau sub-areas are recent formations, the former by faulting (see B.P. Radhakrishna, 1992, *J. Geol. Soc. India*, 40: 1-12) and the latter through gradual, fissured volcanic action, respectively, some 50 million or more years ago. Hence, the Eastern Ghats (Droogs)—Carnatic sub-area, or what still remains of it without human destruction or disturbance, is the oldest and most "Gondwanan" portion of this sub-continent, and contains the most ancient and relict surviving flora and fauna here. It is this land area of the eastern peninsula that has most probably sourced the new biota evolved on the Western Ghats and some that have adapted to the semi-arid Deccan Plateau as well. The Tapti and Godavari rivers (actually Tapti—Purna—Bemla—Wardha—Pranhita—Godavari) form the northern boundary of the Peninsular India—Ceylon biogeographical area and are a major distributional barrier, keeping distinct non-mobile fauna (like species of macaques and junglefowls, for example) and flora (?) on each side, isolated from that of the other.

Misled by the unique and special lifestyle adaptation by some migratory birds to escape life-threatening climatic changes in the winter months, it is being generally assumed that most other birds also "disperse" willingly, and easily (!), whenever they need good, sustainable habitats (for food or nesting). Croizat (1968) however emphasized that "land and life" *move and evolve together* and warned that some present living plants and animals *may be much older* than recent geologic changes. Current scientific thought leans more towards vicariance biogeography and this "dispersal" paradigm (e.g., Meher-Homji 1983, etc.) may be an inappropriate and untrue model applicable only to new ecosystems like oceanic islands rising above sea level, opening up virgin "empty" habitats (*cf* MacArthur and Wilson 1967; Quammen 1996) and then gradually being colonized, mostly by accidental or chance "invaders." Srinivasan and Prashanth's (2006) 'dispersal routes' to the Western Ghats appear to me inconclusive (see more appropriate and biogeographically proven, or hypothesized, theories in Karanth 2003 and Ghorpadé 2007). Hora's "Satpura Hypothesis" is dead and buried now, and my thought process tends to agree with Croizat's (1968; **not** "1949" *vide* Srinivasan and Prashanth 2006 !) analysis about the "fundamentals" of the Indian subregion's biogeographical history.

Gadgil and Meher-Homji (1982, 1986) gave the following nine forest types that make up the floristic diversity and ecosystems on the Western Ghats :

1. *Cullenia—Mesua—Palaquium* ecotone on the western slopes of these ghats in Kerala and some pockets in Tamil Nadu, like Kalakkad, Neyyar, Periyar, Silent valley, Agastyamalai, Sabarigiri, and western slopes of Nilgiris.
2. *Dipterocarpus—Mesua—Palaquium* ecotone on the Konkan—Canara Coast and on the ghats from 12° to 14° 40' N. latitude, like Someshwara, Makut and Agumbe.
3. *Persea—Holigarna—Diospyros* ecotone on the ghats in Shimoga, North Kanara, Belgaum and Goa.
4. *Elaeocarpus—Gordonia—Meliosma—Schefflera* montane sholahs on the high ranges of the Nilgiris, Palnis, Anaimalais, Bababudans and Kudremukh, like Bababudangiri, Upper Bhavani Plateau, Eravikulam Plateau and near Kodaikanal.
5. *Memecylon—Syzigium—Actinodaphne* ecotone in North Kanara, Belgaum, Ratnagiri, Kolhapur and Satara, like Radhanagari, Koyna Valley and Bhimashankar.
6. *Bridelia—Syzigium—Terminalia—Ficus* ecotone on the upper western slopes of the Maharashtra Sahyadris, like Karnala and Khandala.
7. *Tectona—Lagerstroemia—Dillenia—Terminalia* on the lower western slopes in Kerala, Goa, Maharashtra and eastern slopes of Karnataka, like Dandeli and in North Kanara.
8. *Tectona—Terminalia—Adina—Anogeissus* ecotone in Thana, Nasik, Surat Dangs, Bulsar and Nagar-Haveli, like Borivli and the Dangs forests.
9. *Anogeissus—Terminalia—Tectona* ecotone on lower altitudes on the leeward slopes, like Bandipur, Mudumalai and Nagerhole.

Nayar (1994) wrote on the hotspots of plant diversity in India and gave these specific locations in the southern peninsula—Agastyamalai, Kalakkad; Guderikal-Sabarigiri; Periyar, Varushanad, High Wavy Mountains; Anaimalais, Parambikulam; Silent Valley, Wynaad, Nilgiris; Coorg, Brahmagiri; Agumbe; Radhanagari; Koyna, Mahabaleshwar.

---

* In contrast to Mani (1974), I wish to bring to notice that the "Himalayas" are a composite combination of several distinct highland and valley portions, *viz.*, the Western Himalaya, Eastern Himalaya, Outer Himalaya, Kailas Range, Ladakh Range, Pir Panjal Range, Siwalik Range, Karakoram Range, Hindu-Kush Range, Northwest Himalaya, etc., and I prefer to retain the usual anglicized term Himalayas, instead of Himalaya in allusion to the Sanskrit source. Mani (1954: 13-14) had himself used "Himalayas" in his papers on the inspiring entomological surveys conducted by him and his party from 1952-1956 (about 40 papers published from 1954 to 1968) and recognized several "faunal belts" that together made up the great Himalayas, a west—east directed extensive mountain massif.

As "Centres of Endemism" he gave the Mahabaleshwar—Khandala ranges, Agumbe—Phonda ranges, Ratnagiri—Colaba ranges, Silent Valley, Nilgiris and Wynaad, Anaimalais, Palnis—Yercaud, and Agastyamalai—Kalakkad. I consider Coorg and the Bababudan Hills also as other Western Ghats hotspots but the latter were omitted by Nayar. These hotspots for *plant diversity* need to be compared to and corroborated by similar studies on the richness of the *faunal taxa* on these high mountains, including of its true two-winged flies, the Diptera.

Vats *et al.* (1999) gave a worrisome report on the scene in our sub-continent with our grass species, several of which may be on the verge of extinction. The sholah—grassland ecosystem on the high ranges of the Western Ghats, especially the central and southern divisions, needs to be studied and sampled for its Diptera (and other insects) that have adapted to the grass species that evolved here. Similarly, Henry *et al.* (1979) listed 224 species of flowering plants from "south India" of which a huge majority, 208 species, threatened in their native habitat, are found on these ghats.

Thapar (1977) gave a map showing the *socio-cultural* sub-regions in India inhabited by its human population, which I found interesting to compare with wildlife's disribution pattern. The Western Ghats are extant in eight of these : in Khandesh (southernmost Gujarat and northern Maharashtra), Konkan (western Maharashtra and Goa), Desh (eastern Maharashtra), Bombay Karnatak (southern Maharashtra and northwestern Karnataka), Old Mysore and *Malnaad* (southern Karnataka), Malabar (northern Kerala), Kongunad (western Tamil Nadu), and Kerala Coastal Plain (southern Kerala).

THE DIPTERA FAUNA IN THE INDIAN SUB-CONTINENT :

A preliminary appraisal of Diptera taxonomy in the Indian sub-continent was given by me (Ghorpadé 1998; see paragraphs quoted here below and summaries in Ghorpade 1986b, and Brown 2001) which provides a synoptic database on the true flies of India and adjacent countries. See also Oosterbroek (1998, 2006) for a good synopsis of Malayan and European families. Oldroyd (1964) is a "pleasure read" book on the natural history of true flies. Information in Ghorpadé (1998, *q.v.*) is not repeated in this paper, but ideas from it offer information on the economic importance of the Diptera and present a brief account of the history of research on our flies in the Indian sub-continent and elswhere :

"The major interest of man with flies has been in preventing or controlling diseases, of humans and their livestock or pets, transmitted by species of Diptera. Besides the Culicidae, members of the families of Calliphoridae, Ceratopogonidae, Gasterophilidae, Hippoboscidae, Muscidae, Nycteribiidae, Oestridae, Psychodidae (including Phlebotomidae), Sarcophagidae, Simuliidae, Streblidae and Tabanidae are involved. As crop pests, flies aren't as important as beetles, bugs or moths for example, but some serious injury to cultivated plants is caused by species of Agromyzidae, Anthomyiidae, Cecidomyiidae, Chloropidae, Muscidae and Tephritidae. The beneficial aspects of True Flies are connected mainly to their propensities either as predators or parasitoids of destructive insects or other animals, or as pollinators of economic or ornamental plants. The vast majority of the Diptera biodiversity is hardly thought useful to be sampled and studied, let alone be compartmentalized by us as 'harmful' or 'beneficial'. The ecology ('scientific' natural history) of Diptera is shamefully sidelined, even by Dipterists, they either choosing to pursue taxonomic research (with phylogenetic and evolutionary 'mirages' and 'flights of fancy' enlivening the mundane nitty-gritty of description of dead specimens), or opting for better funded microentomology, biotechnology, molecular biology, DNA-based studies, or even 'conservation,' now !"

"The history of Indian Dipterology has not been satisfactorily updated for the past 75 years, since Ronald Senior-White (1923) published his notes on the "Recent progress in our knowledge of Indian Diptera." Before him, Enrico Brunetti (the 'Father' of Indian Dipterology, without any doubt—see his Obituaries in Prashad, 1927 & Senior-White, 1927, and references to more of them in Thompson & Ghorpadé, 1992: 10) had written reviews on "Our knowledge of Oriental Diptera" in 1910 and 1919. Howlett (1909) had drawn up the first Indian overview of the Diptera in this sub-continent, at a time when an estimated 1,000 species of flies were known from here, this figure doubling W.T. Blanford's (1881, *Journal of the Asiatic Society of Bengal*, 50: 263) earliest (?) 'numerical enumeration' (see *Indian Insect Life*, pp. 14-15). T. Bainbrigge Fletcher (1920: 993-994), the Imperial Entomologist then, wrote that 'The Diptera were listed by myself in 1910 and the card catalogue made then is presumably still in the Imperial Pathological Entomologist's Section,' now at the Indian Agricultural Research Institute in Delhi. The first documentation, with a useful bibliography, of major works published before the 20th Century began, was by F.M. van der Wulp (1896) in his '*Catalogue of the described Diptera from South Asia*,' another century-old celebration now. Wulp gave a useful 'Review of the Literature on Oriental Dipterology' (pp. 4-10) which cited names of most Dipterists who worked on Oriental flies, from Carolus Linnaeus to Major E.E. Austen, a period of around 150 years. The '*Catalogue of the Diptera of the Oriental Region'* by J.M.F. Bigot (1891-1892) was the first ever for this biogeographical region, but was replete with errors and omissions which Wulp painfully corrected in his own work. M. Datta & P. Parui (see Jairajpuri, 1991: 373-417) attempted a 'Historical Resumé' (pre-1900 to 1990) of Indian work on Diptera, as well as an 'Estimation of Taxa' of most families in India, and were supported by similar 'State of the Art' summaries by A.N.T. Joseph (on Tipulidae), M. Datta (Simuliidae), C. Radhakrishnan (Tephritidae), S.K. Tandon (Agromyzidae), and P.T. Cherian (Chloropidae). The Zoological Survey of India Dipterists approximated 6093 species of True Flies as 'occurring in India' (see 1991: xxvi), which they calculated as being 6.31 % of the total World fauna, given by them as 96,600 fly species." **[Ghorpadé 1998: 3-5]**

Current State of Knowledge

Beyond information provided for the Western Ghats, for perspective, known numbers of genera and species of each family of Diptera occurring on the continental island of Ceylon, in the biogeographical area of Peninsular India—Ceylon, and in the Indian sub-continent are also provided (see Table 1). The sequence used for families listed in the Table is that adopted by the "Biosystematic Database of Diptera of the World," created and updated at the United States National Museum of Natural History, Washington, DC, U.S.A. But, the splitting of families like Tipulidae and Mycetophilidae, and the transference of others like Conopidae from the Brachycera to Cyclorrhapha, etc., is not followed here until more thorough sampling of the tropical fauna is done and phylogeny is then based on more extensive, complete databases offering a better understanding (see also Ghorpadé 1998: 4). The data presented below are from my research files (see also Ghorpadé 1979, 1997, 1998), kept and updated since 1973, and sourced from original catalogues, checklists, monographs and revisions. Moreover, the names in most of these were annually compiled by the abstracting periodical, *Zoological Record* (*Insecta*) which was also searched.

Table 1. FLIES KNOWN FROM SOME PARTS OF THE INDIAN SUB-CONTINENT.

TAXON	**W. Ghats**	**Ceylon**	**Pen. Ind.+Cey.**	**Indian Subc.**
Order DIPTERA	534—1,262	611—1,321	823—2,279	1,544—7,801
NEMATOCERA	144—416	156—400	223—795	423—3,110
Tipulomorpha				
Tipulidae	60—214	41—111	68—319	150—1,565
Psychodomorpha				
Psychodidae	11—19	7—21	13—40	23—99
Scatopsidae	1—1	2—2	2—3	4—5
Culicomorpha				
Dixidae	0—0	1—1	1—1	1—12
Chaoboridae	1—1	2—2	2—2	2—4
Culicidae	23—81	35—118	36—169	45—341
Ceratopogonidae	12—14	16—36	21—48	34—214
Chironomidae	2—10	5—29	7—40	32—236
Simuliidae	3—13	3—6	3—15	6—63
Blephariceromorpha				
Blephariceridae	2—2	1—2	3—4	6—23
Bibionomorpha				
Anisopodidae	0—0	2—4	2—4	2—11
Bibionidae	1—3	1—3	1—6	4—52
Mycetophilidae	2—2	21—38	21—39	39—114
Sciaridae	2—2	4—8	4—8	6—61
Cecidomyiidae	24—54	15—19	39—97	69—310
BRACHYCERA	70—224	98—233	118—396	247—1,464
Stratiomyomorpha				
Xylomyidae	1—1	1—1	1—3	3—27
Stratiomyidae	4—6	18—27	19—33	43—122

Tabanomorpha				
Rachiceridae	1—2	1—4	1—6	2—10
Tabanidae	7—41	10—35	12—73	18—191
Rhagionidae	2—5	2—6	3—13	4—51
Nemestrinidae	0—0	3—4	3—4	4—11
Acroceridae	1—1	2—3	2—4	10—18
Vermileonomorpha				
Vermileonidae	1—1	0—0	1—1	1—1
Asiloidea				
Therevidae	1—1	3—8	3—9	5—20
Scenopinidae	1—1	1—2	2—4	2—4
Mydidae	0—0	0—0	1—1	1—5
Asilidae	22—91	20—37	35—161	55—482
Bombyliidae	11—25	13—26	16—58	25—123
Empidoidea				
Empididae	5—5	8—25	11—29	42—185
Dolichopodidae	13—44	16—55	19—96	32—214
CYCLORRHAPHA	320—622	357—688	482—1,088	874—3,227
Aschiza				
Phoridae	12—18	8—11	18—29	38—134
Platypezidae	1—1	2—2	2—2	3—6
Pipunculidae	3—15	3—7	4—19	10—127
Syrphidae	30—59	35—73	38—99	80—355
Conopidae	5—6	5—10	6—16	12—57
Calyptratae				
Hippoboscidae	3—3	7—10	9—12	16—43
Nycteribiidae	7—13	8—13	8—18	8—40
Streblidae	3—4	2—6	4—9	4—12
Anthomyiidae	2—2	4—5	7—11	18—56
Fanniidae	1—2	2—2	2—3	2—7
Muscidae	32—121	35—131	36—179	57—363
Eginiidae	1—1	0—0	1—1	2—2
Calliphoridae	17—25	15—35	17—48	30—128
Sarcophagidae	24—44	23—39	34—71	60—248
Rhinophoridae	0—0	1—1	1—1	3—3
Tachinidae	50—71	47—67	81—125	160—333
Gasterophilidae	2—4	1—3	2—5	3—6
Oestridae	1—1	1—1	3—3	7—7
Acalyptratae				
Nerioidea				
Neriidae	0—0	4—4	4—4	4—6

Micropezidae	1—1	3—5	3—6	4—14
Megamerinidae	0—0	1—1	1—1	1—2
Diopsoidea				
Psilidae	1—1	1—1	1—1	4—14
Diopsidae	3—3	1—4	3—7	6—15
Tephritoidea				
Pyrgotidae	1—1	2—3	3—4	6—17
Tephritidae	27—39	39—62	49—92	97—306
Platystomatidae	3—9	7—19	10—29	21—80
Otitidae	1—1	1—2	1—2	2—6
Lonchaeidae	4—7	3—10	4—14	4—15
Lauxanioidea				
Lauxaniidae	8—12	14—25	16—32	20—55
Celyphidae	3—6	2—4	3—8	3—15
Chamaemyiidae	2—2	2—2	3—3	4—8
Sciomyzoidea				
Sciomyzidae	1—5	1—3	1—5	6—13
Sepsidae	5—13	6—10	6—16	8—21
Opomyzoidea				
Aulacigastridae	1—1	1—1	2—2	2—3
Asteiidae	1—1	1—1	2—2	3—4
Agromyzidae	12—38	7—15	12—44	19—184
Fergusoninidae	0—0	0—0	1—1	1—1
Carnoidea				
Milichiidae	2—3	1—3	2—5	3—10
Chloropidae	30—42	26—38	37—67	70—269
Canacidae	0—0	2—2	2—2	2—3
Cryptochetidae	0—0	1—1	1—1	2—2
Sphaeroceroidea				
Sphaeroceridae	1—1	6—9	7—10	12—42
Ephydroidea				
Ephydridae	9—15	11—16	15—26	28—51
Curtonotidae	0—0	2—2	2—2	2—4
Drosophilidae	10—31	13—29	18—51	27—140

NOTE : In **boldface** above are 11 families not recorded from the Western Ghats, though known from Ceylon, plus Mydidae known only from Tranquebar on the Coromandel Coast, and Fergusoninidae recorded from Hyderabad (in Andhra Deccan) and Bangalore (my unpublished data). Western Ghats totals have been updated for some families but figures for most others taken from Delfinado and Hardy (1973, 1975, 1977). Information on other families recorded from the Indian sub-continent, or from other subregions of the Oriental Region, but so far not found in Peninsular India—Ceylon, are given elsewhere (*vide infra*, p. 19).

BRIEF ACCOUNT OF DIPTERA FAMILIES FOUND ON THE WESTERN GHATS :

The 534 genera and 1,262 species of 64 families of Diptera known from the Western Ghats are given above (Table 1) as catalogued by Delfinado and Hardy (1973, 1975, 1977), with some updates of a few of these families, mainly on the Western Ghats (*cf* Ghorpadé 1998 also). I develop the information about these families below. I also maintain a

list of the localities on the Western Ghats, and the windward littoral coastline, that together circumscribe the Western Ghats biogeographical sub-sub-area. This list includes both localities where I collected specimens and where others have collected and trapped flies, as documented in publications. The fold-out map included in Gamble and Fischer (1915-1936) also gives localities where botanical specimens were taken in southern India, especially within the erstwhile Madras Presidency.

Though many fly families have species that occur in both tropical and temperate parts of the Orient (latter in the Baluch—Afghan, W & E Himalayan, and northernmost Assam—Burma biogeographical divisions of this sub-continent, see Fig. 1), some of these families are either predominantly tropical, or then only temperate, in their choice of environments, and this reflects their past history of evolution and diversification. The fly families presented here (which when compared with the total for this sub-continent), that have a low percentage of species on the Western Ghats, are almost all dominantly temperate in distribution. They occur (as currently known) only in preferred habitats on the northern "mountain arcs" of the Baluchi, Afghan, Himalayan, northern Burmese and Naga—Arakan mountain ranges. The dipterofauna (and other biota) of the Western Ghats is hence predominantly tropical, with some subtropical and temperate elements (*cf* Meher-Homji 1979) inhabiting the higher altitudes of this mountain range. The sholah—grassland montane habitat is peculiar to the Western Ghats (perhaps also present on the higher aspects of the Eastern Droogs, the Central Highlands, and probably also on the Garo—Khasi—Jaintia Hills in the Assam—Burma area ?) and evidently contains a singular Peninsular Indian and Ceylonese fauna and flora.

Tipulidae (60 genera—214 species on the Western Ghats) : This is one family that has been fairly well sampled and researched, just like the economically important Culicidae (*q.v., vide infra*; also for relative proportions of and among other families as given below and commented on). The relative diversity of these two groups of flies provides a reasonable measure of richness of most other taxa of Diptera on the Western Ghats, Peninsular India—Ceylon, Indian sub-continent, the Oriental Region, and the World. For instance, the Western Ghats contains some 15% of the tipulid species so far known from the Indian sub-continent (or subregion—this is roughly India and adjacent countries; and 40% of its genera). But as many as 70% of the species that occur in the Peninsular India—Ceylon biogeographical area are found on the Western Ghats. The Tipulidae of the Western Ghats make up some 7% of the Oriental Region Diptera fauna, but only 2% of the World's diversity of true flies. About 15,000 species of Tipulidae in some 300 recognized genera (many more "subgenera"; generic totals given in Table 1 include subgenera as well) are so far known from the world. My studies prompt me to theorize that the Indian sub-continent (subregion) generally posseses roughly 10% of this planet's species across most taxa. Hence, it may be possible that almost all of our sub-continent's species (1,565 known) of Tipulidae (Crane-flies, Daddy-long-legs) have been named and described. Using the same computation and using the estimate that the Western Ghats probably has 15% of this sub-continent's species diversity (*op. cit., vide supra*), it is here suggested that an additional 24-50 tipulid species (new and some known from other sub-areas) await discovery from the Western Ghats.

These primitive flies are called Crane-flies because of their extremely long legs (and wings) and they are perhaps good indicators of wet habitats (the adults), especially during the monsoons (rainy months) in forests or grasslands. Adult flies are easy to collect and usually large so are easily spotted in the wild. Larvae live in aquatic or semi-aquatic habitats or in decaying vegetation. Species are also flower visitors and potential pollinators (see Kevan and Baker 1983 for this and other Diptera families' data below, on flower visitation). Researchers will find this an excellent family of flies for comprehending the bio-ecology of wet habitats because tipulids are well documented and the taxonomy adequately studied, predominantly by Charles P. Alexander (U.S.A.), whose vast world collection (and types of more than 11,000 of his personally named species !) are housed in the U.S. National Museum of Natural History at Washington, DC. A.N.T. Joseph of the Zoological Survey of India, Calcutta had written a series of papers (Joseph 1971-1979) on the Enrico Brunetti tipulid types held in the Zoological Survey of India (see also Alexander 1961). The FAUNA OF BRITISH INDIA volume on Tipulidae was written by Brunetti (1912).

It may be pertinent and interesting to the reader for me to mention here some of the binomens that species of Indian Tipulidae have been christened with, e.g., patronyms honouring human individuals : *Pselliophora henryi* Alexander, 1921, was named for G.M. Henry who was an entomologist and Orthoptera specialist at the Colombo Museum (Sri Lanka) and an expert on birds who wrote an excellent regional field guide ("A Guide to the Birds of Ceylon" in 1955), with his beautiful colour paintings and pen-and-ink sketches. That book gifted to my family by late M. Krishnan, well-known naturalist, photographer and "elephant-man," set me, then 8 years old, walking the farmlands and wilds searching for species of the rich Indian avifauna ! *Tipulodina susainathani* Alexande, 1966, was named in honour of the late sugarcane entomologist P. Susai Nathan (additionally, a species of *Eriocera* and another of *Teucholabis* were also named after him) who worked at Coimbatore and was an expert field collector of insects and who passed on his collections to many foreign and Indian museums and specialists, both here and abroad, and hence made our insect life forms available for scientific study. *Schummelia hampsoni* Edwards (1927), was named after George F. Hampson, an English curator in the British Museum, London (U.K.), who wrote the very first four FAUNA OF BRITISH INDIA volumes ever published, these on our Moths (Lepidoptera), in the latter years of the 19th century (1893 to 1896) and contributed the earliest comprehensive faunistic paper on the butterflies of the Nilgiri Hills (Hampson 1889). *Limonia brunettii* (Alexander, 1921) was named after Enrico Brunetti (see Thompson and Ghorpadé 1992:10), who was undoubtedly the "Father" of Indian Dipterology. He was a career musician, of English and Italian parentage, but with

additional interest in the study of true flies. He wrote three FAUNA OF BRITISH INDIA volumes on our Diptera in the first half of the 20th century (in 1912, 1920 and 1923), besides many other important papers on several families of our flies. Nelson Annandale, the first Director of the Indian Museum, Calcutta (which later became the Zoological Survey of India) named a genus of moth-flies of the family Psychodidae, after this part-time dipterist working in the Calcutta museum, as *Brunettia* Annandale, 1910, for the type-species *annandalei* (Brunetti), 1908 (*vide infra*; and see Bravo and Amorim 1995). *Mitopeza kanagaraji* Alexander, 1952, was named after S. Kanakaraj David who was an aphid (Hemiptera: Aphididae) specialist working at the Agricultural College in Coimbatore and who identified for me several aphid prey of species of the Coccinellidae (Coleoptera) and Syrphidae (Diptera), and also co-authored a paper with me detailing new records of aphids from India in 1974. *Teucholabis pruthiana* Alexander, 1942, was named after Hem Singh Pruthi who was Director of the Indian Agricultural Research ("Pusa") Institute in New Delhi and an accomplished economic entomologist. Alexander also named genera like *Ramatipula* in 1971 and *Sivalimnobia* in 1963, besides also species like *Dicranomyia vamana* in 1952, *Gonomyia matsya* in 1954, *Oxyrhiza krisna* in 1957 and *Eriocera agni* in 1963, all after Hindu Gods.

Then, species named after geographical place and area names by other authors and Alexander include (only year described given below) *Nephrotoma bombayensis* (Macquart, 1855), *N. dodabettae* (1951), *N. kodaikanalensis* (1951), *Lechria coorgensis* (1960), *Indotipula palnica* Edwards (1932), *Antocha madrasensis* (1970), *Dicranomyia goana* (1927), *Protohelius nilgiricus* (1960), *Eriocera anamalaiana* (1949), *Teucholabis gudalurensis* (1950), *Eriocera walayarensis* (1951), *Schummelia dravidiana* (1961), *Tipulodina malabarensis* (1959), *Geranomyia deccanica* (1967), and *Eriocera nepalensis* (Westwood, 1835; initially in the genus *Caloptera*), which last could be the very first Indian Tipulidae ever named and described. Names were even coined after south Indian human tribes, like *Nephrotoma toda* Alexander (1951; from Wood Estate, Nilgiris) and *Baeoura irula* Alexander (1966; from Kodaikanal, Palnis).

Psychodidae (11—19) : These are called Moth-flies or Owl-midges and occur on vegetation in the vicinity of shady, moist habitats in forest, generally near a water source, lentic or lotic (subfamily Psychodinae). Specimens are small in size, very hairy and breed in marginal freshwater habitats and in water accumulated in tree holes and bases of leaves. In urban areas and human habitations they usually occur in toilet rooms. Larvae are saprophytic. Brunetti (1912) wrote the FAUNA OF BRITISH INDIA volume on this family. Lewis (1987) wrote the definitive work on the Sand-flies of the subfamily Phlebotominae (sometimes treated as a separate family) in this subregion which are terrestrial and ubiquitous in the drier tropics. Female sandflies suck blood and transmit diseases like visceral and dermal leishmaniasis (Kala-azar or Oriental sore) and sandfly fever. About 900 species of Psychodidae are currently known from the world, meaning that the 99 species now known from this sub-continent and the 19 species from the Western Ghats may constitute all there are and this family is probably fully known in the Indian subregion.

Scatopsidae (1—1) : These are small dark flies, resembling Bibionidae (*q.v.*, *vide infra*) and usually encountered in grassland. Larvae live in decaying plant matter and are commensals in nests of other insects and larger animals. Species are also flower visitors and potential pollinators. They are poorly known from our sub-continent and the Western Ghats; they seem to be dominantly temperate region inhabitants (*cf* Amorim 1994). At least another 20 species must occur in the Indian subregion and another 3 or so on the Western Ghats. Brunetti (1912) wrote the FAUNA OF BRITISH INDIA volume which also included this family.

Chaoboridae (1—1) : These are mosquito-like small flies called Phantom Midges, rarely found in habitats like streams, pools and ditches, where larvae live as predators of insects, including mosquitoes and their own kind, or other small organisms that they encounter. At least six more species remain to be recorded from this sub-continent and maybe one or two more from these ghats. Edwards in Barraud (1934) wrote the FAUNA OF BRITISH INDIA volume on this family.

Culicidae (23—81) : This is certainly the best known family of Diptera, the mosquitoes, but their taxonomy is complicated and revisions based on current phylogenetic philosophy, molecular biology analyses and better generic concepts (*cf* Kaur 2003) are sorely needed. After Senior-White (1923, see Ghorpadé 1998: 21) published a catalogue of Indian sub-continent Culicidae, Christophers (1933) and Barraud (1934) wrote two FAUNA OF BRITISH INDIA volumes on this family. Females of all species of the mainly tropical Anophelinae and Culicinae are blood feeders and a few species bite man and are carriers (vectors) of many diseases like malaria, dengue, filariasis, Japanese encephalitis and chikungunya. Oviposition is generally in stagnant water where the larvae of some large mosquitoes (Toxorhynchitinae) feed on other mosquito larvae. Species are also flower (also of orchids) visitors and potential pollinators. Mosquitoes, unlike other blood-feeding (haematophagous) flies, have adapted to human habitations and live and breed there in huge numbers, prompting these flies to be labeled as major pests of mankind and livestock, and they cause epidemics in some years. A minority of Indian sub-continent species prefer human blood, but most take that of other mammals, birds, frogs and other vertebrates. In comparison with the Tipulidae (*vide supra*) the Western Ghats have some 24% of species so far known from the Indian sub-continent (50% of their genera), and 48% of the Peninsular India—Ceylon biogeographical area species. Western Ghats Culicidae make up some 10% of the Oriental Region culicid fauna, and 4% of the World's mosquito diversity. Both in our subregion and on the Western Ghats we probably know all our mosquito species, which are relatively much better studied here than other Diptera families. But

there could still be some synonymies to be discovered and so may reduce the present number of our known mosquito species.

Ceratopogonidae (12—14) : These are very small flies called Biting Midges that also take blood of other animals, including man. Some are predacious or ectoparasitic on other insects. Adult flies are usually crepuscular, occurring in mesic or moist habitats, resting on leaves or flowers. Species are also flower visitors and potential pollinators, some of cocoa plants. Larvae are rarely terrestrial in wet wood but mainly found in damp or aquatic habitats, in moss and fungi, tree holes, moist soil and water tanks or lake margins, marshes or in decomposing plant matter like banana stalks and pineapple axils. Hardly half of the existing species in our sub-continent have probably been discovered and the Western Ghats should have around 50 more species ?

Chironomidae (2—10) : This is a fairly large family of non-biting midges, often mistaken by humans for mosquitoes and who then panic seeing the huge swarms that emerge from waterbodies (tanks, lakes, streams, *nullahs*, sewage pits and reservoirs) during the monsoon season, being attracted to artificial light sources. Their larvae are an important source of food for fishes and hence are economically important for humans doing commercial fish breeding or farming. Chironomid larvae feed on small plants or animals in water or are predacious in water or damp terrestrial environments rich in organic matter. This is another family which is poorly known here; the Indian subregion could have more than twice the number of species currently known and the Western Ghats at least 50-60 more. But there is a recent checklist published (Chaudhuri *et al.* 2001) which listed 313 Indian sub-continent species in 59 genera, but did not give distributions.

Simuliidae (3—12) : These small Black-flies are haematophagous like mosquitoes and some other fly families. They are of great medical and veterinary importance as blood-sucking pests of humans and domesticated animals, producing allergic reactions which could be very serious and result in death. As vectors they transmit onchocerciasis which is a serious filarial disease causing blindness in man (in Africa and South America). Species are also flower visitors and potential pollinators. This is another fly family that has been well researched for its taxonomy and M. Datta of the Zoological Survey of India has done extensive work in India on our simuliid fauna (see e.g., Datta 1980, 1984; Datta in Jairajpuri 1991; Datta in Alfred *et al.* 1998). Black-flies occur near flowing water, and are found in the smallest to the largest lotic habitats where the immatures live. This sub-continent could have another 50 or so species still unrecorded and the Western Ghats another 10 or so. Brunetti (1912) wrote the FAUNA OF BRITISH INDIA volume on this family.

Blephariceridae (2—2) : These are very curious looking flies with distinctive wings and wing patterns. They are called Net-veined (or net-winged) Midges and their immatures live only in cool, swift flowing mountain streams, near waterfalls (see Hora 1931). Male adult flies dance in small swarms high up above the waterfalls and females shelter under overhanging rocks or large boulders in the rapids below. Blephericerid flies also flutter slowly just above the water surface in the waterfall spray and occur in thick masses under overhanging rocks. These microniches also harbour other flies of the families Empididae and Tipulidae (*q.v.*). Larvae adhere to rocks in these lotic habitats by disc-like suckers on their mid-ventral region and breathe dissolved oxygen by variously arranged tufted gills. Adult flies are found near these habitats on vegetation. Brunetti (1912) wrote the FAUNA OF BRITISH INDIA volume on this family. The Western Ghats fauna may turn up a few more new species but these flies are better known from Himalayan water sources. This sub-continent could have at least another 6 species (meaning elsewhere) and the Western Ghats another 2 at most ?

Bibionidae (1—3) : These fairly medium-sized or largish flies are often quite un-Nematocera like, being stout, and are called March-flies. They are fairly hairy flie, usually dark in colour, some Indian species being black with red thoraces. They resemble Scatopsidae (*q.v.*) which are much smaller generally. Adult flies frequent grass meadows, grassy hillsides and decaying vegetable dumps, are very short-lived and hence little is known of their habits. Species are also flower visitors and potential pollinators. Larvae are scavengers of decaying organic matter but sometimes feed on roots and tubers of economically important crops (some vegetables and cereals) and may assume minor pest status. These flies also visit flowers for feeding on nectar or other plant juices and may be of some importance in the pollination of fruit trees and other plants; this activity needs further investigation. Himalayan species are fairly well known but the peninsular Indian fauna, especially on the Western Ghats, is poorly studied, not even six species being known. This sub-continent could have at least another 12-15 species and the Western Ghats another 5-6 at most ? Brunetti (1912) wrote the FAUNA OF BRITISH INDIA volume on this family.

Mycetophilidae (2—2) : This predominantly temperate region distributed family has recently been broken up into several families. It is a large, highly variable group of what are called Fungus-gnats and little work on the Indian fauna has been done. Brunetti (1912) wrote the FAUNA OF BRITISH INDIA volume on this family. The peninsular Indian fauna is hardly known, but the Ceylonese one is better studied (see Table 1 above). The Western Ghats diversity is almost unknown. Adults are usually nocturnal and this may be the problem with the limited collections of these flies which are found in damp, dark habitats, especially in forest undergrowth. Their minimal economic importance is another factor but these flies are biologically very interesting. Species are also flower visitors and potential pollinators.

The larvae are almost all mycophagous and many live in fleshy as well as in other fungi. Some larvae are also luminescent. This sub-continent could have 250 more species and the Western Ghats another 50 at least, if not more ?

Sciaridae (2—2) : These flies are related to the Mycetophilidae and were once treated as a subfamily of that family. They occur in a wide range of habitats, the larvae living in rotting wood, leaf litter and soil rich in humus, in fungi, animal excrement and decaying plant material. They also feed on roots of plants in pots and greenhouses and in mushroom beds where they sometimes assume pest status. Species are also flower visitors and potential pollinators. The sciarids are a difficult group whose taxonomy is poorly worked owing to limited usable diagnostic characters, and their supraspecific classification is still unsettled. Sciarids are little known from the Western Ghats and better sampling could result in the discovery of many unrecorded or new species here. This sub-continent already has a little more than the species diversity expected here, probably, but the Western Ghats could have about 10 more species ? Brunetti (1912) wrote the FAUNA OF BRITISH INDIA volume on this family.

Cecidomyiidae (24—54) : These frail flies are popularly known as Gall-midges and are of considerable economic importance. They are undoubtedly the most fragile and delicate of all Diptera and adult flies are taken in alcohol for slide preparation, or the dry fly specimens are almost impossible to process this way for study of their taxonomy which is still poorly studied. The primitive gall-midge species are not associated with vascular plants but live in soil and rotting wood, being mycophagous, also attacking mushrooms. Species are also flower visitors and potential pollinators. The specialized, recent species however have larvae living in vascular plants (stems, buds, seeds, bark and resin) and many form characteristic plant galls or live as inquilines in galls made by other insects. See Rao and Sharma (1977) for the host-plants and insect prey of our species. Late M.S. Mani, who died recently, began his career working on these gall flies and had carried out significant studies of these cecidomyiids and their galls, especially on the Western Himalaya where he undertook many important expeditions (*cf* Mani 1954). Prabha Grover of Allahabad University also continued taxonomic research, chiefly on the northern fauna (published chiefly in their *Cecidologia Indica* journal from Allahabad). Some species are also predacious or endoparasitic on Homoptera or Acari (mites) and a few could be of use in biological control of insect pests. It is a fascinating family to study for a Botanist—Entomologist team and many of our 15,000 or so flowering plants need to be examined in the field for any cecidomyiids (and other insects !) associated with each of them. This sub-continent could have at least another 150 species but the Western Ghats probably another 15-20 more (*cf* Sharma 1993, 1999). Senior-White (1923, see Ghorpadé 1998: 21) published a catalogue of Indian sub-continent Cecidomyiidae, and the FAUNA OF INDIA volume on this family was being written by late S. N. Prasad but is not yet published, if at all completed ?

Xylomyidae (1—1) : Earlier called the Solvidae, these "False soldier-flies" are colourful insects and resemble the true Soldier-flies, Stratiomyidae, in their habits but are less diverse and confined mostly to the tropics. Larvae are predacious or saprophagous under loose tree bark and in nests of *Bombus* bees. This family is best developed in the Oriental tropics (?) and this sub-continent could have at least another 5-6 species and the Western Ghats another 3 at least, if not more ? Brunetti (1920) wrote the FAUNA OF BRITISH INDIA volume on this family.

Stratiomyidae (4—6) : This is a family of evolutionary antiquity and a wide range of structural diversity. Some species of Soldier-flies are very bright and colourful, small to moderately large in size, sparsely haired, and often with shiny metallic reflections of the body with conspicuous markings resembling military uniform neatness, from whence the English name is derived. They are easily distinguished by their wing venation having radial veins crowded towards the anterior wing margin and the discal cell small and short, often pentagonal or hexagonal in shape. Even if of little or no economic importance, this family may be, like the Tipulidae (*op. cit.*), a good indicator of undisturbed forest habitats, especially near water sources and pools. Species are also flower visitors and potential pollinators. One accidental immigrant species from South America, *Hermetia illucens*, which has gained entry here through commercial shipments, is now breeding in poultry sheds, its larvae feeding on the chicken excreta there. Larvae of soldier-flies are scavengers mostly in aquatic habitats and also live under the bark of trees and inhabit decaying plant and animal material, sod and excrement. The larvae (also of Xylomyidae, *op.cit.*), exceptionally for Brachycera, pupate within the last larval skin, the "puparium." This sub-continent could at least have another 75 species and the Western Ghats another 25 at least, if not more ? Woodley (2001) published a catalogue of World species and Brunetti (1920) wrote the FAUNA OF BRITISH INDIA volume on this family.

Rachiceridae (1—2) : These are flies of moderate size and resembling the above two families but distinct in their many segmented large antennae with flagellum being serrate or pectinate. Forest dwelling and rare, their larvae are little known and could be predacious, living under leaf litter or loose tree bark. Perhaps this apparently plesiotypic (ancient) group of flies is dying out and is reduced in species number now ? The fauna in this sub-continent and on the Western Ghats is perhaps fully known (*cf* Nagatomi 1970) ?

Tabanidae (7—41) : This is a large family of blood-sucking flies of great economic importance as pests of domestic animals. The flies are medium to large sized and the females are haematophagous. Larvae are carnivorous or saprophagous and aquatic, so wetlands are necessary for the occurrence of these flies. Adults of several species have been implicated in the transmission of human or livestock diseases, e.g., *Surra* in India. Because of their importance to

man, and also their large size and colourful markings, these Horse-flies or Deer-flies are well studied taxonomically and even the Western Ghats fauna is much better documented. But males of many species are poorly known, since they are not usually found with females and around human habitations, but visiting flowers for nectar. This sub-continent could have at least another 100 species still undocumented and the Western Ghats another 5-6 species ? There is a recent catalogue published, after that of Datta (1985), by Vijay Veer (2004) which lists 311 species (in 21 genera) now known from the Indian subregion out of which some 80 or 85 species (in 7 or 8 genera) are documented from the Western Ghats. In spite of this being an economically important family there has never been a FAUNA volume published on it, though Senior-White had completed a catalogue in 1927 (see Ghorpadé 1998: 1) which was recently updated by Vijay Veer (*vide supra*). In the 1940s B.M. Hobby was working on a FAUNA OF BRITISH INDIA volume on Indian Tabanidae in England but then independence happened in India and it was then perhaps shelved ?

Rhagionidae (2—5) : These Snipe-flies are fairly small in size, slender, with a tapered abdomen and rather long legs. Adults are found in wooded areas near water sources and their behaviour is little known. Larvae are predacious and have been found in damp soil, rotting leaves and moss on the forest floor. This sub-continent perhaps has all its species known but the Western Ghats could turn up another 7-8 species ? Brunetti (1920) wrote the FAUNA OF BRITISH INDIA volume on this family.

Acroceridae (1—1) : These are called Small-headed flies or Spider-flies since their larvae are parasitoids of Spiders (Araneae). Their heads are round and being almost "all eyes" are small in comparison to the overall body, They are of rare occurrence but males of some genera in the right season are often found hovering above flowering bushes in some numbers. Another poorly known family in this sub-continent which may have at least another 25 species and the Westerm Ghats 7-8 more ? Brunetti (1920) wrote the FAUNA OF BRITISH INDIA volume on this family.

Vermileonidae (1—1) : Earlier 'clubbed' with the Rhagionidae (*q.v.*), these are very rare flies living like the neuropteroid Myrmeleontidae (Ant-lions) in conical pits in sandy soil (larvae) and being predacious on other insects, a remarkable example of convergent evolution ! Another little worked family in this region, so the fauna of this sub-continent and the Western Ghats is difficult to estimate.

Therevidae (1—1) : Called Stiletto-flies, therevids resemble Asilidae and are found in similar habitats, but adult flies are not predatory. Their snake-like larvae move about in sandy or loose soil, or in organic matter, and feed mainly on larvae of beetles , especially of the Elateridae, Scarabaeidae and Tenebrionidae. The Indian fauna is apparently rich but little collected and known. This sub-continent could have at least another 50 more species and the Western Ghats another 10 at least, if not more ? Brunetti (1920) wrote the FAUNA OF BRITISH INDIA volume on this family.

Scenopinidae (1—1) : These are very small black flies called Window-flies and their larvae are predacious on what are called carpet beetles (Dermestidae), but undoubtedly also on other household pest insects like fleas and lice, on stored food pests, and on termites. Usually taken more frequently in Malaise (tent) traps but otherwise generally not seen by the naked eye of the collector hunting with a net, and hence are rare in collections (*cf* Ghorpade 1981a). This sub-continent could have at least 30-40 more species and the Western Ghats another 5-6 at least ? Brunetti (1920) wrote the FAUNA OF BRITISH INDIA volume on this family.

Asilidae (22—91) : This one of the numerically largest and most abundant groups of Diptera in the field, called Robber-flies because all adults are predatory (raptorial, like birds of prey !) on other insects mainly. The adult flies are robust and very bristly with large eyes for good sight to capture their food prey in flight. One subfamily, the Leptogastrinae, are zygopterous and have slender, long abdomens and these elegant and graceful flies have a keen eyesight and instead of waiting for moving prey they search for and pounce on immobile, unsuspecting prey insects and spiders resting on vegetation. The prey of robber-flies is stabbed using the hypopharynx (tongue) and injected with paralyzing saliva. After the prey contents have liquefied, the body juices are sucked by the proboscis. This feeding resembles that of spiders. The face is exceptionally hairy in most robber-flies, giving the appearance of a moustache and beard. Larvae are also predacious found mainly in soil. The Indian fauna is well known now through the researches of A.N.T. Joseph and P. Parui of the Zoological Survey of India, Calcutta, who recently published their first Asilidae volume of the FAUNA OF INDIA recently (Joseph and Parui 1998). They also worked on my large collection of Asilidae and described many new species (see Joseph and Parui, 1984, 1997). Harold Oldroyd was engaged in writing up a FAUNA OF BRITISH INDIA volume in the 1940s but this was never published (*cf vide supra*). The catalogue authored by Rattan Lal (1961; see Ghorpadé 1998: 21) was mostly written up actually by M.G. Ramdas Menon (*pers. comm.*) at the Indian Agricultural Research Institute in New Delhi. This sub-continent's and the Western Ghats fauna may be fully known but this family is very diverse with species having a short flight period and phenology, relating to preferred seasons, and there are therefore real possibilities that more species still exist unrecognised (lumped ?), undescribed or unrecorded from here.

Bombyliidae (11—25) : The Bee-flies are another very large and diversified family of mostly delicate flies, generally preferring drier, relatively open habitats in the plains and at lower elevations, a few selectively adapted species inhabiting open woodland, jungle and moderately high altitudes. Adult flies are tiny to very large (are they polyphyletic ?) and usually with a long proboscis with which they take nectar from a variety of native floral species.

Some species are also potential pollinators. Some bee-flies that are frequently found in agroecosystems may be useful pollinators of our crops and need to be researched for confirmation and details. Larvae are parasitoids or hyperparasitoids of a wide variety of insects but especially of Coleoptera and Lepidoptera larvae. Some larvae are specific predators on grasshopper egg pods and carry out fairly effective reduction of locust pest populations. This family is also little researched in our sub-continent and could have at least another 250-300 unrecorded and new species and the Western Ghats another 50-60 more ? Senior-White (1923, see Ghorpadé 1998: 21) published a catalogue of the Indian sub-continent Bombyliidae after Brunetti (1920) had written the FAUNA OF BRITISH INDIA volume on this family. Banerjee *et al.* (2006) gave 27 genera and 81 bee-fly species as occurring on the Western Ghats. But their list is questionable and exaggerated with identities of doubt and no indications of actual localities on the Western Ghats for the species listed. The Bombyliidae are a dominantly arid habitat group and the Western Ghats may not posses such a large number of taxa adapted to this high rainfall, moist habitat usually not preferred by bee-flies.

Empididae (5—5) : These Dance-flies are more developed and diverse in the temperate regions and are rare in the tropics. The Indian sub-continent's fauna is very poorly sampled and known. Adults perform aerial dances before mating, flying in swarms, and males usually offer presents of an animal or vegetable nature to the females courted. Adults are predatory like small Asilidae and larvae are also carnivorous living in soil, decaying wood, and dung, or are aquatic. Species are also flower visitors and potential pollinators. A little worked family in this subregion and the Indian sub-continent could have at least another 120 species and the Western Ghats another 40, if not more ? Brunetti (1920) wrote the FAUNA OF BRITISH INDIA volume on this family.

Dolichopodidae (13—44) : These are small or moderately large, pretty, blue-green, pictured winged (some) "Long-legged Flies" occurring on leaves or on wet mud in forested and damp areas. Adults are predatory or scavenge on dead insects while larvae feed on Scolytidae beetle larvae or are leaf-miners of subaquatic plants. Species are also flower visitors and potential pollinators. The Indian fauna has been fairly adequately studied many years ago by Becker (1922; see also Ribeiro 1923) but the family is very diverse and many more species evidently remain to be discovered, also on the Western Ghats. Another minimally worked family here and this sub-continent could have at least another 300-400 species and the Western Ghats another 50, if not more ?

Phoridae (12—18) : These are small, dark or pale coloured Scuttle-flies with an unusual wing venation and a curious shuffling movement when at rest or on foot. It is a large and divergent group with varied larval habits, living in decaying vegetable or animal matter, mushrooms, in nests of social ants and termites, or being endoparasites of ants or cockroaches. Species are also flower visitors and potential pollinators. Father Thomas Borgmeier (1968, 1971) published a Catalogue (and a supplement) of World Phoridae. The Indian fauna is evidently large and a lot of work needs to be done to make all species of this sub-continent known which may have 150 more species and the Western Ghats another 20-30 at least ? This and subsequent families treated below belong to the Cyclorrhapha and Ferrar (1987) may be consulted for a good summary of the immature stages and breeding habits of these flies.

Platypezidae (1—1) : Another rarely encountered family of small flies in the field, called Flat-footed flies which occur in forested and damp areas. The adult flies move about on leaves in a jerky scuttling action and are also attracted to smoke from burning fires. Their larvae live in fungi. Our Indian species are still little known and sampled (*cf* Kessel and Clopton 1969). Little known family in this subregion, and the Indian sub-continent could have at least another 20 species and the Western Ghats 4-5 more ? Brunetti (1920) wrote the FAUNA OF BRITISH INDIA volume on this family.

Pipunculidae (3—15) : This is a moderately diverse family of small sized "Big-headed" or "Jassid-flies" of a pale colour and longish wings. The larvae are parasitoids of Homoptera, like leafhoppers (Cicadellidae), but prey relationships are little known here. The adult flies have a ragged and zig-zag flight, are difficult to spot in the field, some also come to flowers. V.C. Kapoor and his project team at the Punjab Agricultural University, Ludhiana, published a revision of "Indian Pipunculids" (Kapoor *et al.* 1987) but their material was sampled in only a select few areas of this huge sub-continent and many more pipuculids remain to be sampled elsewhere. The world fauna of these small, difficult to spot and collect flies is perhaps much more than what is currently known. This sub-continent probably has 20-30 more unknown or unrecorded species and the Western Ghats may have another 5-10 at least, if not more ? Brunetti (1923) wrote the FAUNA OF BRITISH INDIA volume on this family.

Syrphidae (30—59) : Like Asilidae, these hover-flies, or flower-flies, are one of the best studied and popular groups of Diptera by amateur entomologists in Europe and North America and elsewhere where the British tradition of the "hobby naturalist" persists. Syrphidae are a very large and highly varied group in their morphology and habits, being found from the equator to the high arctic and subantarctic islands. Some species are mimics of stinging Hymenoptera and almost all come freely to wild (and some cultivated) flowering plant species. Their close association with flowers makes them a potentially useful pollinator group, after the bees (Apoidea). Around one-third of the species (of the subfamily Syrphinae) are predacious, mainly on Aphidoidea (Homoptera) but also on other true bug families and insect orders (see Ghorpade 1981b for prey). The large majority of species (Eristalinae) are however saprophytic as larvae and many of these live in aquatic and semi-aquatic habitats, in rotting wood, in plant bulbs underground, and as inquilines in the nests of ants (the Microdontinae flies) and bees (Volucellini). The adults have a

spurious (false) vein in the wing by which almost all syrphid genera are easily identified as of this family, and many also hover in the air over flowers or for mating (especially male "swarms"), and this behaviour is characteristic of syrphids. I had selected this family for detailed study and have described two new Oriental genera and many new species, a few new ones also from the Western Ghats. I am in the process of revising every genus (some with collaborating specialists) occurring in India and the Orient, areas extending from Afghanistan east to the tropical Pacific Ocean islands and the high Himalayas south to Ceylon, and from the Yangtze-Kiang River south to the Lesser Sunda and Papuan islands (*cf* Thompson and Ghorpadé 1992; Ghorpadé 1994, Ghorpade 2007). The Indian sub-continent could have at least another 50-150 undescribed or unrecorded syrphid species and the Western Ghats a maximum of 20 more species ? Enrico Brunetti (1923) wrote the FAUNA OF BRITISH INDIA volume after publishing several other large papers on this family (see citations in Thompson and Ghorpadé, 1992, Ghorpadé 1994).

Conopidae (5—6) : Another peculiar and rarely field encountered family of Thick-headed flies whose larvae are solitary internal parasitoids of bumble bees (Bombidae) and wasps (Hymenoptera). One special genus (*Stylogaster*) has larvae that attack other Diptera. The adult fly deposits eggs on the prey body while in flight. The adult flies are thus fair mimics of wasps and of other dipteran wasp mimics such as the Syrphidae. They occur around flowers where they find their prey and the Indian fauna is still incompletely sampled and studied. Species are also potential pollinators. More species are known from the Himalayas than from the Western Ghats, where they are not very diverse in my field experience. Brunetti (1923) wrote the FAUNA OF BRITISH INDIA volume on this family. A minimally revised family here so this sub-continent could have at least another 20-25 species and the Western Ghats 5-6 more ? This family is now placed in the Cyclorrhapha—Conopoidea (near Superfamily Tephritoidea), removed from Brachycera as placed earlier, but this requires confirmation thtrough further study, based on more adequate material.

Hippoboscidae (3—3) : This is a small family of what are called Louse-flies which are stocky and flattened dorso-ventrally, with a leathery appearance. In some species the adults are without wings, being apterous or micropterous. Along with the Nycteribiidae and Streblidae (*q.v., vide infra*) they form a group known as Pupipara because eggs are never laid by females who nourish larvae within their abdomen (pseudoplacental viviparity) and these are only extruded just before pupation occurs. Both sexes of these louse-flies are haematophagous and are obligatory ectoparasites of birds and some mammals. This sub-continent invariably has most of its fauna documented but the Western Ghats should have twice the number of what are now known from these mountains ?

Nycteribiidae (7—13) : These are Bat-flies, small, wingless, dorsoventrally flattened, spider-like flies with rather long legs. The small head lies back on the mesonotum while at rest and is rotated forward and downward for feeding on bat blood. The prepupae are found adhered to bat perches. All species are obligate ectoparasites of bats and little is known of their biology. A great field of study lies here for a mammalogist—entomologist team. Hiregaudar and Bal did some pioneering work on the bat- and louse-flies (*vide supra et infra*) in India. This sub-continent and the Western Ghats perhaps have their entire fauna of these flies already documented and little remains unknown ?

Streblidae (3—4) : These are also bat-flies and are small, rather setose and either laterally compressed, like fleas, or strongly flattened dorsoventrally, or with a more typical convex body form. In this family most species have wings but a few are either brachypterous, stenopterous or apterous. Adult males and females are blood-suckers of bats, the prepupae occur on substrates in the vicinity of bat roosts. This sub-continent could have at least another 10 species, but the fauna of the Western Ghats is perhaps almost fully known ?

Anthomyiidae (2—2) : These flies are very closely related to those of the Muscidae (*q.v., vide infra*) and Scathophagidae (Himalayan only here) and are restricted to montane cool temperate habitats, flying in moist woodland and nearby areas and around lakes, streams, bogs, swamps and the like. Species are also flower visitors and potential pollinators. They are called Root maggot-flies and adults are anthophilous, feeding at flowers, their larvae being phytophagous, saprophagous or coprophagous, some species in the Holarctic regions being serious pests of cultivated and flowering plants there. It is a large family in temperate climes where a vast variety of lifestyles have evolved: larvae living in dry sandy habitats, fleshy fungi, as inquilines or commensals in wild bee or wasp nests, and in nests of rodents. Little is known of the Indian sub-region fauna and the montane sholahs of the central and southern Western Ghats may harbour an interesting fauna. Masaaki Suwa (1977, 1981) published papers on preliminary samplings of the Himalayan and Western Ghats faunae. Another little-known family here and the Indian sub-continent could have at least another 70-75 unrecorded species and the Western Ghats another 10 at least, if not more ?

Fanniidae (1—2) : This is another Muscidae-like family recently separated from that after van Emden's (1965) FAUNA volume was published. Little studied since and the flies are mainly arboreal and their larvae saprophagous or coprophagous. This sub-continent could have at least another 20 species and the Western Ghats another 4-5 at least, if not more ?

Muscidae (32—121) : Perhaps members of this large, cosmopolitan family come first to mind when one says "fly." These muscid flies are especially well evolved and diversified in the high arctic (also sub-arctic), like some other flies, e.g., the Chironomidae (*vide supra*). Adult House-fly like species are mainly saprophagous and some that occur around human habitation carry germs from filth to food and encourage diseases of man and domestic animals. A few are also haematophagous biting flies (e.g., *Stomoxys*) while others are serious stem-borers of foodgrain crops (e.g., *Atherigona*) but the vast majority occur near larval food sources like dung, refuse, garbage, decaying vegetation, rotting

wood, decaying fruit, forest litter and rich organic soil. Species are also flower visitors and potential pollinators. Much work has been carried out on this family in our sub-continent but not everything is known about our rich fauna, especially those occurring on the higher slopes of the Western Ghats. The Western Ghats muscid fauna is apparently better known than any family after the Culicidae and Tipulidae, as stated earlier. The Indian sub-continent could then have almost as many species as are now known but the Western Ghats probably a little more ? Van Emden (1965) completed a first FAUNA OF INDIA volume on this family, treating the subfamilies Muscinae, Phaoniinae and Stomoxydinae.

Eginiidae (1—1) : Again a very small and rare fly family related to the Muscidae but little is known about habits of adult flies or their larvae. Hard to say if our fauna of this family is well known or not.

Calliphoridae (10—15) : This is an interesting family of Calyptrate flies exhibiting much variation in lifestyles, habits and behaviour, and so being recently "split" into several smaller families. These are fairly large metallic blue, green, orange or black flies which occur around decaying animal matter, garbage, flowers or excrement. Species are also flower visitors and potential pollinators. Like the Muscidae, some of these species are also guilty of spreading disease and infections in us humans. Some are also pests of livestock causing subcutaneous myiasis in wild animals too. On the other hand, many flies of this family are beneficial as scavengers on animal carcasses and refuse. The Blow-flies or Bluebottle-flies are familiar around human habitations in garbage pits or waste dumps especially on rotting meat on which they lay eggs. Larvae of such species are called screw-worms. Some genera (*Bengalia, s. lat.*) have adult flies that pounce on ants or termites and snatch the larvae they carry on these trails ! Others are obligate parasites of earthworms, snails and other small animals. Senior-White *et al.* (1940) published a FAUNA OF BRITISH INDIA volume on this family and B.C. Nandi (2004) has just come out with an updated checklist. This sub-continent probably has its fauna almost fully documented and the Western Ghats probably have only 5 species to be added ?

Sarcophagidae (24—44) : This is a family related to the Calliphoridae and Tachinidae and most species are of a remarkably uniform colour pattern: medium or large grey flies with black stripes on the thorax and a black-and-grey checkerboard pattern on the abdominal terga. There is one small subfamily, the Miltogramminae, which are tinier flies that "tail" fossorial wasps especially and lay eggs in their nests, which are mainly holes in the ground, or on their prey provisions there. The larger flies (*Sarcophaga, s. lat.*) breed in decaying animal and plant material but some larvae are parasites or parasitoids of Orthoptera, Hemiptera and Lepidoptera. Females are larviparous and their association with humans have gotten them medical importance as synanthropic flies. Senior-White *et al.*'s (1940) FAUNA OF BRITISH INDIA volume treated the Indian and Oriental fauna and recently Nandi (2002) published an updated FAUNA OF INDIA volume. A world catalogue was published by Thomas Pape (1996). Though these flies are better known than most economically unimportant fly families in India, much still remains to be done and documented and more undescribed species await capture and study. Species are also flower visitors and potential pollinators. This sub-continent could have 50 more species and the Western Ghats another 5 at least, if not more ? Nandi's FAUNA volume gives 46 species in 29 genus-group taxa (genera and subgenera) from the Western Ghats, but Pape's (1996) catalogue lists only 44 species in 24 genus-groups. This is a substantial increase from what was known in the late 1970s (*op. cit., vide* Delfinado and Hardy 1977) and this fact is a good indicator of how little of our fly fauna was catalogued then and how much more remains to be discovered in many fly families in this subregion.

Tachinidae (50—71) : These are specialist parasitoid flies and a very large and complex, widely diversified family. The larvae are obligate parasitoids of other insects and a few related arthropods and many are important in the regulation of host populations and hence economically important for us as biological control agents. Most tachinids attack Lepidoptera larvae, others parasitize sawfly (Hymenoptera) larvae, and both larvae and adults of Coleoptera, especially the Scarabaeidae and Chrysomelidae. Tachinids also attack Hemiptera, Orthoptera, Dermaptera, Embioptera, other Diptera, Formicidae (ants), centipedes and scorpions. Adults are very active, fast flying flies and visit flowers and honeydew sources (aphid or coccid colonies) or are looking for suitable hosts (female flies). Species are also potential pollinators. Some tachinids have become a problem in Sericulture (e.g., *Exorista bombycis*; *cf* Ghorpade 1986) as they attack the silkworm larvae and reduce yields of raw silk ! This family is predominantly tropical in distribution and cold habitats do not have a large tachinid diversity. Maybe their place is taken over there by some other temperate groups e.g., Anthomyiidae (*q.v., vide supra*). The Indian sub-continent is very rich in tachinids but is little worked, and though a good catalogue exists (Crosskey, 1976) there is great need for a lot of biosystematics research on our fauna. This sub-continent could have at least 500 more species and the Western Ghats another 150-200 at least, if not more ?

Gasterophilidae (2—4) : These are called Bot-flies but scarcely seen as adults which have only a brief flying period. Their larvae live as parasites in the alimentary tracts of elephants, horses, donkeys, mules and their wild relatives. Some species have become pests of domestic livestock. The Indian sub-continent and the Western Ghats probably have their entire fauna of these flies known ?

Oestridae (1—1) : These are called Warble-flies and like Oestridae the larvae live in subcutaneous tissues of mammals. Some species are pests of domestic animals. Adult flies are also rarely encountered in the field. Like the above related family, this sub-continent and the Western Ghats probably have their entire fauna known ? Brunetti (1923) wrote the FAUNA OF BRITISH INDIA volume on this family.

Micropezidae (1—1) : These Stilt legged-flies are elongate insects with very long legs. They frequent wet habitats and sometimes occur on tree wounds and on excrement. Larvae are saprophagous. This sub-continent could have at least another 35 more species and the Western Ghats 5-6 more ? Incidentally, Willi Hennig, the initiator and promoter of the systematics analytical philosophy of Cladistics, initially used this family of flies for his research and analyses.

Psilidae (1—1) : These are also mostly slender and long legged flies found in wet places and shady forest habitats. Called Rust-flies, adults inhabit dark shaded woods with an abundance of lush vegetation on which these flies usually rest and are hidden from view. Larvae live in roots and stems of plants and under tree bark. At least one species in North America is a serious pest of cultivated carrots and celery. This sub-continent's fauna is perhaps all documented except maybe for 1-2 more species and the Western Ghats may have just another, if not more ?

Diopsidae (3—3) : Extremely bizarre in appearance, these are Stalk-eyed flies whose eyes are borne on short or long stalks. These stalks on their heads, like in deer or some similarly horn-endowed beetles (Scarabaeidae, Lucanidae, etc.), are used for fighting, as I had observed them doing on one of my field trips to the Nilgiris along with visiting American and Canadian colleagues. Adults are found in herbage near streams or pools and populations of species of *Sphryacephala* are huge, near water sources. Larvae are either saprophaous or phytophagous. This sub-continent could have at least another 5-6 species and the Western Ghats another 2-3 more ?

Pyrgotidae (1—1) : These are very interesting and peculiar flies whose larvae are internal parasitoids of adult scarabaeid beetles. Adult flies (females) have a strong visible ovipositor and fly by night so they can find their hosts for oviposition on their bodies. Therefore, many pyrgotids do come to light at night, even to houses. Some adult flies have marked wings and others may lack ocelli. Our fauna, especially in well forested areas, could be fairly large and diverse (since we have a large scarabaeid beetle fauna) but little sampling has been done. This sub-continent could have at least another 15-20 more species and the Western Ghats another 5 at least, if not more ?

Tephritidae (27—39) : A large family of primarily medium-sized phytophagous flies and of great economic importance. Several of our fruit and flower crops are affected by species of Tephritidae (which were known as Trypetidae or Trypaneidae in earlier literature). The Indian fauna is fairly well known but much more careful taxonomic research needs to be done, especially in the Dacini which have many agricultural and horticultural crop pests, and *Dacus* (*s. lat.*) species-complexes. Further field collecting of the diverse forest inhabiting genera is also required. It is a family most developed and diverse in the tropics and subtropics, though temperate regions also have a good fauna. The Fruit-fly larvae practically infest all plant parts, like fleshy fruit, flower heads, leaves and stems (which they mine), and also form galls on various parts of plants. Many species are host species-specific. Species are also flower visitors and potential pollinators. Tephritidae are highly ornamented flies with sharply contrasting colour patterns on their bodies and wings, which latter have the subcostal vein bent sharply at a right angle. They are usually seen strutting about on their host plants, waving their often pictured wings rhythmically. Agarwal and Sueyoshi (2005) have recently published a catalogue of Tephritidae recorded from India which listed 243 species in 79 genera. The Western Ghats fauna is undoubtedly rich with many endemic or restricted species but how much is really known ? Drew and Raghu (2002) wrote on the Subfamily Dacinae known from the Western Ghats. A fascinating and huge research lacuna with great scope is to check each of our wild flora species and see if and what Tephritidae (and other insects, obviously, if one has time) are associated with them. Kapoor (1993) and his team have worked extensively on our fruit-flies and also borrowed study material from me who had pointed out some lacunae in my review (Ghorpade 1982), and given suggestions about the kind of research that was then required. This sub-continent could have at least 150 more species and the Western Ghats another 30 at least ? Senior-White (see Ghorpadé 1998: 21) published a catalogue in 1924 and Kapoor (*cf* Kapoor 1993) published a couple more updated ones since then with the host plants of some tephritid species given as well.

Platystomatidae (3—9) : These are also fruit-fly like species with pictured wings which they vibrate when sexually excited. Adults are usually found resting on low vegetation or visiting flowers, fungi and tree wounds. Their larvae are found in decaying plant matter. The Indian fauna is scarcely known and here lie investigative research possibilites on these tephritoid flies adapted and evolved on the Western Ghats, with an indigenous (several endemic ?) subregion fauna. This sub-continent could have at least 20-30 more species and the Western Ghats another 5-6 at least, if not more ?

Otitidae (1—1) : Similar to the Platystomatidae, the otitids are poorly evolved in India and the Western Ghats, hardly half a dozen species being known so far. Perhaps this is not really a tropics adapted family ? The single species that occurs here is fairly ubiquitous on dense vegetation, even in agro-ecosystems, and its larvae scavenge. It is difficult

to make species richness estimates of this family but this sub-continent could have at least another 10-20 more species and the Western Ghats another 2-4 or more, on higher altitudes ? The family name Ulidiidae is now preferred for these flies on basis of nomenclatural priority.

Lonchaeidae (4—7) : These are called Lance-flies and are smallish, usually metallic blue-black flies with flattened abdomens, unmarked wings and black halteres. Females have lance-like, piercing ovipositors to lay eggs in dead or dying trees where the larvae live, as also in decaying fruits and vegetables. Male flies often swarm in large hovering groups in shafts of sunlight streaming through openings in jungle. This sub-continent could have at least 30-35 more species and the Western Ghats another 7-8, if not more ?

Lauxaniidae (8—12) : This is another interesting fly family (no "Common name" invented) well developed in the tropics but not really studied properly in India again. Flies are usually small, yellowish or brownish flies, frequently with spotted, milky coloured wings. Adults occur in a wide range of habitats, from rain forests to grasslands and sand dunes. They usually rest on low vegetation and a few have specialized to be riparian by choice, occurring on stones in swift flowing streams. Species are also flower visitors and potential pollinators. Larvae are mainly sapropagous in leaf litter and plant debris. The Western Ghats has a rich fauna obviously but more sampling needs to be done as is also required for almost all our fly families. This sub-continent could have at least 100 more species and the Western Ghats another 20-25 at least, if not more ?

Celyphidae (3—6) : These Beetle-flies are a bizarre morph of true flies found predominantly in the Oriental and Afrotropical Regions. India and the Western Ghats have a diverse, but little-studied fauna. The scutellum of the adult is enlarged and modified to cover the abdomen and wings, like elytra of beetles ! Adults prefer moist habitats along streams, ponds or rivers and in grassy areas, and larvae live in decaying vegetation. The flies are small to moderately sized and some are beautifully coloured in purple, shiny green or blue. There was a revision of the Oriental species by Tenorio (1972), but this work is due for a further expansion using the additional material of specimens that have accrued in museum collections. I have a fairly good collection and am still looking for these peculiar flies which fly mainly in the monsoon season (June to November). This sub-continent and the Western Ghats have their fauna fairly well studied but perhaps a few more species remain unrecorded ?

Chamaemyiidae (2—2) : A frequently found family of small flies in agro-ecosystems where these Silver-flies have larvae that are predators of aphids, adelgids coccids, and perhaps aleyrodids, and so are beneficial to the farmer. Flies are silvery grey in colour, small to minute, their bodies coated with silvery pruinescence and abdomens often marked with paired black spots. A few promising species have been tried as biological control agents in some situations. This sub-continent could have 8-10 more species and the Western Ghats another 2 at most ?

Sciomyzidae (1—5) : Often called Marsh flies or Snail-killing flies this is a highly specialized group of flies whose larvae are specific parasitoids or predators of freshwater and terrestrial snails or slugs, mainly. This is a case of flies more divergent in temperate climes than in the tropics and only one genus, *Sepedon*, has speciated in the latter but is not adapted yet to all aquatic habitats like marshes, flowing streams and nullahs besides river banks, ponds and tanks. The Himalayas have a better fauna but I have found the Western Ghats not at all diverse in sciomyzids. Even high altitudes of the Western Ghats have failed to turn up unknown species of *Sepedon* and maybe only the Himalayas and the Assam—Burma area in our sub-continent have a still undiscovered fauna. Species of sciomyzids are being investigated for possible biological control of snails and slugs which are intermediate hosts of pathogenic diseases like schistosomiasis, bilharziasis, elephantiasis, and are also agricultural pests. Lush paddyfields have become artificial habitats of species of *Sepedon* and adult flies are usually found sitting head down on rice plant blades. I am making a special study of these flies in India and the Orient (*cf* Ghorpadé *et al*. 1999, Knutson and Ghorpadé 2004), along with collaborators, and have major revisions of genera under way. The Indian sub-continent could have at least another 10-12 species and the Western Ghats only a couple more, at most.

Sepsidae (5—13) : A group of flies that the field collector is familiar with, a bunch of active, wing waving, fast walking flies on cow pats and other animal dung. Called Ant-flies or Scavenger flies these are small elongate black or brown coloured with narrow, clear wings. Like the adults the larvae live in excrement and decaying organic matter. The Indian fauna is possibly rich and fairly well researched, though more needs to be done. The Western Ghats fauna is perhaps well known but this sub-continent may have 4-5 more species elsewhere.

Aulacigastridae (1—1) : This family, like the next one, have very rare flies which look like Dwarf fruit-flies, the Drosophilidae. They are most frequently found around "bleeding" tree wounds, stumps and fungi where their larvae apparently live. This sub-continent's and these ghats' fauna is perhaps fully known ?

Asteiidae (1—1) : See notes under the above family. Adults are rarely found in shady woods where the larvae also apparently live. This sub-continent could have at least another 5-6 species and the Western Ghats another 1-2 more ?

Agromyzidae (12—38) : Another of the few economically important and large groups of flies that are mainly phytophagous and often pests of man's crops, especially ornamentals. This family has been fairly well investigated by

researchers in St John's College, Agra, with the help of a United States PL-480 project some 30 years ago, but the fauna of southern India is relatively less known. Spencer (1986) gave an overview of work done so far on Indian species. These fly larvae are leaf-miners, a vast majority of species, but some other species attack any other plant part. Adult flies are small and stocky, fast moving on substrates and coloured black, brown or yellow, with clear wings. They are often found in sunny locations on the leaves of herbaceous plants. Some species are highly host-plant specific but others are polyphagous. Being connected to agro-ecosystems the cultivated habitat fauna has been better studied but the forest and other natural ecosystem fauna of these flies may still be awaiting discovery ! This sub-continent could have 70 more species but the Western Ghats fauna is mostly all known ?

Milichiidae (2—3) : Like for many small and uncommon families of flies these have yet no "Common name" coined for their members. Milichiids are usually shining black, small flies with either milky or clear wings. They have relatively long mouthparts and adults are often found on flowers. Their larvae are saprophagous or coprophagous and have been reared from manure, compost, garbage and other rotting organic matter. The Indian sub-continent and Western Ghats fauna is probably not extensive but needs careful survey, sampling and study, like many other relatively rarely encountered species of other families. Adults of some genera are often found in small huddled and moving groups on bodies of prey being sucked by their predators such as spiders and assassin bugs, where they partake, somewhat hyaena-like, of the body-fluids of killed and being eaten prey. Other taxa are associated with ants or live in nests of birds. Here is a group well worth a good look at, both for taxonomy and biology. This sub-continent could have at least another 10-12 species and the Western Ghats 1-2 more ?

Chloropidae (30—42) : These are called Frit-flies in temperate climes and are another potentially economically important family of flies in both tropical and temperate regions. They are small, variously shaped flies, with singular antennae, and a large plate-like ocellar triangle, being common on all kinds of vegetation. Species are also flower visitors and potential pollinators. Larvae of many species feed within young shoots and stems of grass and dicot plants. Some species like our *Acletoxenus* are predacious on aphids (Aphidoidea) and white-flies (Aleyrodidae). P.T. Cherian (2002) has completed one FAUNA OF INDIA volume (he has also borrowed my Chloropidae collection for study) on our Indian species and published many other papers, so some databases are available on this family here. This sub-continent's and the Western Ghats fauna are perhaps both well known ?

Sphaeroceridae (1—1) : These are Dung-flies that are small and blackish and have the first segment of the hind tarsus shorter and more swollen than the second. Larvae are scavengers and live in excrement and in decaying organic matter. Adult flies abound in the same situations and occasionally become pests in septic tanks and similar waste disposal sites. Species are also flower visitors and potential pollinators. A few species are apterous, lacking wings, others are seashore inhabitants. The fauna in India is hardly worked and a lot remains to be done**.** This sub-continent could have at least 30 more species and the Western Ghats another 10 at least, if not more.

Ephydridae (9—15) : These are called Shore-flies and are highly gregarious groups inhabiting aquatic habitats of all kinds and are probably important in the food chains of waterfowl and fishes. Larvae are mostly aquatic but some species inhabit stems and shoots of plants. Others live in grassland even far from water but most are found in marshy places, banks of lotic and lentic habitats resting and running about on mud or even on the water surface. A world catalogue was published by Mathis and Zatwarnicki (1995). I have made a special attempt to sample the fauna in India and intends jointly working up the data with collaborating specialist (*cf* Mathis and Ghorpade 1985). This sub-continent could have at least 75-80 more species and the Western Ghats another 20 at least, if not more ?

Drosophilidae (10—31) : Adult flies of this family (called Dwarf fruit-flies, Yeast-flies, Pomace-flies) are mostly yellowish or brownish in colour and have clear wings. Larvae feed on yeasts in fermenting organic matter and adults occur commonly about garbage, in rotting fruits and vegetables. They are often found in homes in kitchens on such food matter kept open and uncovered. Flies also occur on flux deposits on tree wounds, bleeding stumps, fungi and excrement. Some species are used as laboratory animals for research on genetics and physiology. A few species could become a nuisance (pests) in stores, breweries, bakeries and food-processing plants. Species are also flower visitors and potential pollinators. The Western Ghats and southern Indian fauna has been researched mainly at Mysore University, but much more is out there and needs to be searched for, captured and studied. The northern Indian fauna has mainly been worked by S. N. Prasad and his team at the Benares Hindu University in Varanasi. This sub-continent could have at least 150 more species and the Western Ghats another 15 at least, if not more ?

Of the eleven families known from the Indian sub-continent, but not yet confirmed in formal publications as occurring on the Western Ghats (see Table 1), my personal collection includes specimens of some of these (sampled by me or by other collectors), except perhaps of the Dixidae, Anisopodidae, Rhinophoridae, and Megamerinidae (not searched for yet in my unsorted, uncurated samples, both dry in papers and wet in alcohol) and, perhaps also the Canacidae as well ? Papers recording species of these families from the Western Ghats, and/or other areas in

Peninsular India, will be published shortly. My Diptera collection material (of over 100,000 specimens) is available for research to make our fauna better studied and understood.

In closing this attempt at updating the database on the 64 families of true flies found so far on the Western Ghats (Ceylon has 71 and Peninsular India—Ceylon has 75 families), it may be mentioned that from 825-950 more Diptera species could be occuring on the Western Ghats, but which remain unknown or unrecorded so far (uncollected or unsorted and studied). The absolute maximum diversity of flies that could be occurring on the Western Ghats is estimated here to be about 3,000 species. There are 22 other families of Diptera that have been found to occur in the Indian subregion (= sub-continent) which are mostly north temperate in their habitat choice, but some of them could occur at least on the crests and peaks of the Western Ghats, or even elsewhere in "Dravidia" (Peninsular India—Ceylon and the Central Highlands). These familes are : Trichoceridae (3 genera and 21 species in the Indian sub-continent), Tanyderidae (1—3), Ptychopteridae (1—10), Nymphomyiidae (1—1), Deuterophlebiidae (1—2), Thaumaleidae (1—15) [all NEMATOCERA]; Coenomyiidae (1—2), Lonchopteridae (1—12) [BRACHYCERA]; Cypselosomatidae (1—2), Strongylophthalmyiidae (1—7), Megamerinidae (1—2), Nothybidae (1—1), Dryomyzidae (1—1), Piophilidae (1—21), Teratomyzidae (1—1), Clusiidae (9—15), Anthomyziae (1—1), Odiniidae (1—1), Carnidae (2—4), Diastatidae (2—6), Heliomyzidae (1—1), and Scathophagidae (6—7) [all CYCLORRHAPHA]. Six other families, that are known from the further east located Sino—Malayan and Papuan—Pacific subregions of the Oriental Region, have not yet been recorded from the Indian subregion. These families are : Pachyneuridae (1 genus and 1 species known from the Oriental Region) [NEMATOCERA]; Apioceridae (1—1) [BRACHYCERA]; Pseudopomyzidae (1—1), Chyromyiidae (2—3), Heteromyzidae (1—2), and Tethinidae (3—7) [CYCLORRHAPHA].

Incidentally, the fauna of the island of Ceylon (which was once, or several times, connected to the Indian mainland in geological history; see Ripley 1949) perhaps has 25-30% of the biota of this entire mountain range, and is currently better sampled and studied than the fauna of the Western Ghats in southern India. A 11-year Smithsonian Institution, Washington, DC (U.S.A.) project, where I was a Postdoctoral Fellow in 1982 and 1983, surveyed and sampled the Ceylonese insect fauna under the supervision of the late Karl Krombein, which is still being worked up by international specialists (Krombein 1981 *et seq*.). Museum specialists in some other countries (like Switzerland and Sweden) have also made their own surveys of Sri Lankan insects. A similar international project, running at least for a decade, and involving collaboration with several countries' museums (institutions), and their working specialists, is ***urgently required*** here (at least sampling Dravidia) if our entomofauna is to be properly surveyed and researched for valuable collections and databases. Speaking of the Indian subregion (sub-continent) as a whole, the 7,000 to 8,000 currently known and named species could be swelled by the discovery of at least another 5,000 unrecorded species, making a total of about 12,500 Indian subregion Diptera in all. But, as a maximum, I estimate that a total of some 20,000 species of Diptera could actually be flying in the Indian sub-continent, after our forest canopies are also well sampled. The Diptera species diversity estimate of Peninsular India—Ceylon and the Central Highlands ("Dravidia," together) could be anything between 6,000 and 9,000 species of true flies. However, if the Western Ghats have only about 15% of the total Indian fauna, then there should therefore be at least 5-6 more such hotspots in our subregion holding the remaining 85% of our total fauna. But, only the Western (?) and Eastern Himalayas and the Andaman—Nicobar islands have been currently so identified, leaving the other areas (and habitats) unmentioned and underrated ! Something is wrong somewhere…..

Knowledge Gaps

From my perspective, seven major gaps in our knowledge of true flies (Diptera) of the Western Ghats exist; they may apply similarly to other faunal taxa :

1. (Bio)geographic distributional ranges of taxa need to be fully mapped.
2. Phenology or seasonal occurrence and local movements ('migration') of species to be determined.
3. Host plant, prey, saprophytic food, etc., of species to be investigated.
4. Life-histories and bioecology, including pollination efficiency of flower visitors, to be studied.
5. Parasitoids, parasites and predators of fly species to be documented.
6. Economic significance for humans, beneficial or harmful, to be analysed.
7. Survey and sampling of remaining undisturbed habitats for species diversity is a major and primary need, and requires to be undertaken in urgency, before these surviving pristine habitats fall to "development," population expansion, and other human exploitations.

In brief therefore, we need to survey and inventory the Diptera on the Western Ghats and intensively study their biology and ecology on this mountain range. Other needs on our Diptera research and some "Working Plan" suggestions were given by me earlier (see Ghorpadé 1998: 5-6). Alfred *et al.* (1998: 485) had named only 19 specialist Dipterists, including myself, currently researching Indian sub-continent flies and as possible sources for help with identifications and information on our flies. I welcome any offers of joint researches on Indian Diptera taxa or requests for their study or identifications by specialists.

A major gap in our knowledge of the biodiversity of the Western Ghats is the comparative lack of planned surveys done in the northern (longest) section, *i.e.*, from the Surat Dangs to the Kalinadi River, in Gujarat, Daman, Dadra &

Nagar Haveli, Maharashtra, and Goa. Sālim Ali carried out bird surveys in this section and ornithological databases do exist, as do some on this section's butterflies (*vide infra*), but many of these ghat areas, called *Sahyadris* in Maharashtra, and also especially the west—east spurs from the Western Ghats crestline eastward onto and into the Deccan Plateau, are hardly known for what may be "source areas" for the certainly diminished diversity of the *Sahyadris*, caused by fissured volcanic eruptions which destroyed most of the evolved and adapted biota and created a new geology, leading to a stunted, depauperate, flora here. My limited surveys of the *Sahyadris* and the Dangs has actually turned up quite a few surprises in Diptera species and genera there, as well as in the avifauna. This northern section of the Western Ghats also has "narrow" endemics in birds, like the now un-lumped Sykes' or Vigors' Sunbird (better called Sahyadris Sunbird, *Aethopyga vigorsii*), and the still lumped Bombay Babbler [*Turdoides* (*striatus*) *somervillei*] to cite glaring examples, which should be, or are, present in other groups also, if distributional patterns and even "minor" morphological differences are tested for congruence. Prakash Gole (1998) had edited a useful special issue on the birds, snakes, mammals, turtles, lizards, plus rare and endemic plants of the Sahyadris, which is a starting point for further studies on this peculiar, little-known, northern section of the Western Ghats.

It may be mentioned here that our joint paper (Pearson and Ghorpade 1989), on Tiger Beetle (Coleoptera: Cicindelidae) biogeography here, now needs more data based on further field sampling in still poorly surveyed biogeographic divisions of this sub-continent (*viz*., Andaman—Nicobar Islands, Assam—Burma, Central Highlands, Deccan Plateau, Eastern Ghats—Carnatic), for a better, thorough analysis based on more complete databases, and a refined taxonomy using an "omnispective" approach (*cf* Blackwelder 1964; Borgmeier 1957).

Unless a holistic, well-documented analysis is initiated by biologists to study nature and build factual databases of its floral and faunal diversity *together*, only chipping away at its "bits-and-pieces," by odd taxon or subject specialists, who are unable to coordinate their research findings on a biogeographical, if not global scale (certainly **not** political), is hardly going to enable us to understand and then protect and restore our wilderness heritage. The *whole* is certainly greater and more complex than the sum of its parts, and is critical to our understanding of nature, its still untapped resources and how *we can fit into her natural balance*.

Hence, the Western Ghats diversity can **not** be fathomed in isolation, from that of the Deccan Plateau and the Eastern Ghats (Droogs)—Carnatic sub-areas of the Peninsular India—Ceylon biogeographical area, at least. Just as social insects and their lives are incomprehensible, if studied in seclusion. A minimal "Birds—Butterflies—Botany" (Vertebrates, Invertebrates, Plants) approach is here recommended, especially as an integrated group activity, involving specialist scientists (taxonomists) interacting with tribal and 'grass roots' locals in the field, whether in natural wildernesses or agro-ecosystems.

Our inventory of the natural genetic resources that have evolved in this sub-continent is very far from being even half complete and our claims of "endemic" species are therefore flawed, with little scientific backup based on poor data. Gadgil's (1996a) proposed LIFESCAPE project deserves wholesale, nationwide, collaboration of biosystematists, field biologists and students (*cf* Gadgil 1996b) who need to be provided with adequate funding (actually easily affordable now !) and logistical support by government departments and national/international funding agencies. What we desperately require, sooner than later, are long-term scientific explorations (like those made in the last two centuries, by pioneering, indefatigable, foreign explorers !) to sample our biodiversity in the rapidly disappearing undisturbed or minimally human-encroached habitats, as well as make detailed inventories of museum collections of biological material from the Indian sub-continent, held in institutions of this country and those abroad.

Unless we know what we possess and publicize this heritage of ours internationally, no government or private individual/institution is going to become aware of the "real value" of the natural treasures and their wild inhabitants we still have, besides also seriously thinking about carefully restoring our artificial environments (some *man-made* "wastelands") in rural and urban areas, especially in the plantation properties on the Western Ghats (some on the Eastern Droogs as well).

Conclusions on Western Ghats Biodiversity and Conservation

Specific lacunae in our knowledge and understanding of each fly family on the Western Ghats has been indicated in the brief synopis given for each family above (*q.v.*). In connection with the all important "human selection" decision of conservation hotspots (see Collar 1997 and Quammen 1996) I wish to make the following studied observations with particular reference to Peninsular India—Ceylon and its sole hotspot identified for biodiversity protection in southern India : the Western Ghats. Since this book also covers conservation of the invertebrate diversity of the Western Ghats, it seems to me important and appropriate to deal a little seriously with this aspect and go into other available databases on the biota of these mountains. As I have quoted in my recent revision of the Oriental Syrphidae genus *Agnisyrphus* (Ghorpadé 2007: 25), Vane-Wright (1993) citing May (1990) had emphasized that "in some very real sense, taxonomy may affect the destiny of species." So, we need also to be made aware of the species or habitats we ignore or undervalue now which then are destined to a "slow death," being bereft of conservation focus !

First, though these Western Ghats have been a popular focus of field biologists owing to their abundant habitats and comparatively rich biota, we still do not know and understand much about this recent geological—botanical—zoological ecosystem and its entire biodiversity. The widely inconsistent percentages of endemic species of different taxa, e.g., flowering plants 38% (Nayar 1994), land snails 75% (Aravind *et al.*, 2005), amphibians 78%, reptiles 62%, mammals 12%, birds 4% (all Kunte, this book, but *vide infra*), dragonflies and damselflies 38% (Subramanian and

Sivaramakrishnan 2002), and the variation among several families of Diptera as cited in this paper, are proof of insufficient research and study, and based on inefficient sampling and observation in the remaining undisturbed habitats still existing on this mountain range, from the Dangs in Gujarat to the Ceylonese highlands. For example, the poor (4%) endemism, as believed, of birds on the Western Ghats is a complication created out of the "lumping" of distinct, allopatric (even if externally minutely distinguishable) populations that were separated earlier as ***distinct species*** by both resident and overseas based foreign taxonomists (mainly European) during the British Raj period through careful, painstaking, field and museum research. In fact, Myers ***et al.***, in ***Nature***, journal issue of 24th February 2000, gave 8% bird endemism (double !) in the Western Ghats, and 27% here for mammals, 46% for plants, 62% for reptiles and 79% for amphibians ! This embarrassing muddle and mix-up gained entry after the formal recognition of the subspecies (or "race") as a nomenclatural category below the ***species***, especially in Ornithology. I am convinced that the species is still the lowest useable, relevant, nomenclatural category that identifies reproductively isolated (mostly through allopatry or ecological niche choice; geographical species concept) populations that are bound together by a unique "life-cycle" which keeps them reproductively and phylogenetically separate in life even from their nearest "relations" or sibling species (***cf*** Ghorpadé 2002).

BIRD DIVERSITY

My own analysis of the Western Ghats avifauna some 10 years ago (unpublished data) made me list some 60 bird species (11%) as "R-E-D" (Restricted, Endemic or Disjunct). Species recognized as restricted are those that, though certainly evolved and endemic in the Western Ghats sub-area, also wander or sometimes even breed outside of this hill range. Examples are the Yellow-browed Bulbul (***Iole indica***) and the Malabar Whistling Thrush (***Myophonus horsfieldii***). Endemics are of course intimately connected to the Western Ghats and incapable of surviving elsewhere outside of their special habitat range where they evolved, like the Small Sunbird (***Leptocoma minima***), Great Pied Hornbill (***Buceros bicornis***—the north-east Indian population is a distinct species, ***B. homrai***; my unpublished data), Black-and-orange Flycatcher (***Ficedula nigrorufa***), and others. But the interesting and highly important question is about "species" that are disjunct. My own taxonomic training and experience leads me to separate these widely (or even less widely) distinct taxa as disjunct ***species***, not as races or "subspecies." Karanth (2003) raised this intriguing point in a well drafted paper and Rasmussen (2005) summarized the "conservation implications" of such taxonomic decisions in an appropriately titled recent paper. On the Western Ghats such disjunct and "lumped" species are, for example, the Malabar Pied Hornbill (***Anthracoceros coronatus***), Crested Goshawk (***Accipiter trivirgatus***) and Large Wood Shrike (***Tephrodornis gularis***) which latter has now been "split," correctly, into two distinct species, the Malabar Wood Shrike (***T. sylvicola***) being the endemic Western Ghats species [see also others unlumped in Rasmussen (2005), like the Ruby-throated Bulbul, ***Pycnonotus gularis***]. Hence, unless research on taxonomy of our unique and rich biota is adequately funded and necessary permissions given by the Ministry of Environment and Forests—the recent ban on sampling in Protected Areas, for ***bona fide*** scientists, without a "permit" is a seriously retrograde Parliament decision—to both native and foreign specialists, we will be unable to fully know what the endemic quotient of our biodiversity (each animal and plant group) is. Hence, before we are shown what we need to protect as our unique heritage, industrial and consumer greed will destroy the less than 3% of natural ecosystems still surviving that have evolved in this sub-continent and are our responsibility to protect, preserve and study. The late M. Krishnan had written in despair, a little before he died, a small note titled "India—A Wildlifer's apprehensions" published in the Bombay Natural History Society's now bimonthly Bulletin ***Hornbill*** (see also extract in ***Indian Journal of Biodiversity***, 1: 197-199; 1997), giving his "convictions of a lifetime on our country." He lamented, rightly, that "If we cannot meet the needs of our peoples with 90% of the land then there is something seriously wrong with our administrative efficiency" !

BUTTERFLY DIVERSITY

Having looked at the Ornithology of the Western Ghats in a synoptic manner, I would now like to focus on the most popular and best studied (and therefore known) group of the overwhelmingly dominant animals on earth (which are the insects; see Ghorpade 1986b, 1997 for summaries)—meaning the Butterflies (Lepidoptera: Rhopalocera; see DeVries 2001: 559). Harish Gaonkar is undoubtedly the most experienced current specialist scientist on Indian butterflies and his comprehension of the database on these beautiful insects is vast and impressive. I spent almost two years (1995-1996) assisting him in the documentation of his report (Gaonkar 1996), on the Western Ghats butterflies, and can vouch for his immense, but sadly still unpublished, information ranging from accurate taxonomy to their biology, habitats, history and names, besides much more. He wrote (Gaonkar 1996: 7): "A unique feature of the Western Ghats is that, an area with rich butterfly diversity is also an area that is rich in all other faunal and floral diversity." He also opined that butterflies are better known than any other faunal group, except perhaps birds, and hoped that his study of the butterflies of the Western Ghats would "be consulted as a model by researchers using other animal and plant groups for biodiversity assessment." Gaonkar gave 16,823 or so butterfly species so far named and described from the World and estimated around 1,500 species existing in the Indian sub-continent. I however believe that, like in birds (***vide supra***), there are ***almost twice the actual number of existing species*** of butterflies (as were documented before this "subspecies concept" was ushered in at the turn of the 19th century) and precise distributional ranges and endemic percentages are far from known. Hence, I have consciously chosen **not** to attempt any wild guesses at percentage endemism of true flies here, until they are almost completely researched and documented. Gaonkar's list of Western Ghats butterfly species and recent updates (Kunte, this book) give a total of 333 species on the Western Ghats, placed

in 165 genera, of which 63 (19%) are endemic. From the island of Ceylon Gaonkar listed 243 species (21 endemic, 9%) in 127 genera. But, as I consider biogeographically and evohistorically more appropriate (see notes in Ghorpadé 2007: 14-25), this mountain range must be looked at in its ***complete*** geographical entity and include the Ceylonese highlands biota also as a fourth section of these ghats. This way, the total stretch of these Peninsular India—Ceylon highlands possesses a total of 359 butterfly species (84 endemic, 23%) belonging to 166 genera. Even if this percentage is a little lower than actuals, according to my taxonomic and scientific reasoning, incorrect "lumping" of distinct, allopatric, species is the reason. The numbers and percentages for birds is highly skewed and needs immediate taxonomic investigation and revisions by expert systematic ornithologists. Distinct endemic species of these ghats that are currently "lumped" as the same as distantly allopatric species found in north-east India, or eastern Central Higlands, may therefore be unfortunately and incorrectly ignored in our conservation evaluation ! In butterflies also the R-E-D species need closer study and, like the recently rediscovered Spot Puffin on the Western Ghats (***Appias lalage***; correct identity ?), after 100 years (Nalini and Lomov 1993; Soubadra Devy 1998; Kunte, this book), hugely disjunct from other known populations in north-east India (!; taxonomy needs investigation), many more such little collected and apparently disjunct species (as "subspecies") need to be evaluated for their correct taxonomic status and "un-lumped" forthwith. So, even for very popular and relatively well studied groups like flowering plants (almost 50-60 % are endemic here, in reality !), birds and butterflies, the knowledge status is not at all satisfactory, so one can imagine the status for the majority of other animal groups, like for example these, the true flies ! When is this basic "***in vivo***" research and "***in vitro***" documentation going to happen ? After the jungles are all gone ?

TRUE FLY DIVERSITY

The database available on our Diptera has been presented in this paper, originating mainly from the Catalog of Oriental Diptera (Delfinado and Hardy 1973, 1975, 1977) published three decades ago. I have included updates of a few families (e.g., Syrphidae, Asilidae, Sarcophagidae) but need more time and funding for assistance and mobility to complete a thorough revised catalogue (or at least an annotated check-list) of the true flies of the Indian sub-continent. Under the familial notes above for Tipulidae, Culicidae, Syrphidae and Sciomyzidae, the Western Ghats is estimated to possess anything from 50-70% (only, and not more as is generally believed—hence this hotspot labeling) of the Diptera species so far known from the Peninsular India—Ceylon biogeographical area. And the Western Ghats possibly have from 15-25% of species of true flies from the entire Indian subregion. So, it may be safe to presume that the Western Ghats have approximately three-fifths to two-thirds or less of the Peninsular India—Ceylon biota and up to one-fourth of the Indian sub-continent flora and fauna. These percentages could also apply to all other taxa except for specially adapted groups (these will have higher %) or those preferring more arid habitats (these will have lesser %). In birds and butterflies (except for the "lumping syndrome" and resulting skewed figures) the fauna of the island of Ceylon and the Western Ghats in peninsular India are perhaps the best known geographical areas in the Indian sub-continent. The Eastern Ghats—Carnatic and Deccan Plateau biota are still poorly surveyed and documented !

SOURCE AREAS

From the initial invasion of the newly uplifted and then still rising (?) Western Ghats, more new species evolved by then extant species adapting to the higher altitudes as and when these microniches opened up in geological time over the past 50 million years or more. The lower leeward foothills and slopes of the Western Ghats still have this ancient, drier forest and scrub habitat flora and fauna which are a feature of these ancient eastern droogs. It is hence argued that even these Eastern Droogs and their biota form other, dissected, hotspots that must also be protected and conserved, as what were fundamental "source areas" and gene pools for the colonization of the young Western Ghats mountain range niches opening up. In fact, still fairly rich diversity possessing eastern droogs e.g., the Biligirirangan, Kollaimalai, Pacchaimalai, Bodamalai, Kalrayan, Chitteri, Melagiri, Shevaroy, Javadi, Bannerghatta, Nandi, Devarayadurga, Sandur, Horsley, Palkonda—Seshachalam, and Nallamala—Velikonda, Lankamala, Erramala, etc. (*cf* Legris and Meher-Homji 1977), are examples of these other hotspots, even if considered minor, that are being sadly ignored by conservationists ! Even the Deccan Plateau has some fairly well vegetated hill ranges, like the Balaghat, Chandor, Ajanta, Nirmal, Jalna, Badami, Homnabad, Kakatiya, Amrabad, Medak and Satmala, which have hardly been explored for their biota.

The Central Highlands biogeographical area (see Fig. 1; also Forsyth 1889) is a huge, ancient portion of the once Greater Indian Plate that still has been little surveyed, sampled and documented (Rudyard Kipling's classic "Jungle Book" was based on a location in this area). The highlands in eastern Madhya Pradesh (now Bastar and Chhattisgarh), northeastern Andhra Pradesh (Northern Circars of yore), Orissa (Kalinga) and southern Bihar (now Jharkhand), in E. Central Highlands (see Map), have biota that show phylogenetic links with what now occur on the Himalayas (at least eastern) and, in my opinion, are crying out for such recognition and further research on them ! The Garo—Khasi—Jaintia Hills, in Meghalaya State, may also be an ancient Gondwanaland "splinter," now separated from "Dravidia" by the recently formed Ganges—Brahmaputra river basin delta, and could be another "source area" for the new eastern Himalayan biota ? The hill ranges of the Central Highlands that need more survey and sampling of biota are the Aravalli, Mandav (in Kathiawar peninsula), Vindhya, Satpura, Mahadeo, Bhanrer, Kaimur, Maikal, Chhota Nagpur, Golcondah ("Vizag Ghats"), Gawilgarh and Wainganga. The papers by Legris and Meher-Homji (1977) and Meher-Homji (1979) are good starting points, along with the fine compilation of Mani (1974), for understanding what lies unknown in "Dravidia" (= Central Highlands+Peninsular India—Ceylon) which is what is left, above sea level, of the

Greater Indian Plate, at this point of time. The Andaman Islands (if not Nicobars) are a further question mark for true affiliation of their biota and these may also have been part of the Gondwanan split and northward land drift across the now Indian Ocean.

CONSERVATION AND RESTORATION

I do not understand most present "conservation value" judgement norms currently followed but recommend that only by *protecting (and restoring) all remaining pristine and minimally disturbed habitats by legal and military force* can their biota be automatically saved for posterity. But, optimal sizes of these protected *and restored* habitats (PRHs), which may be different for insects from those for larger animal groups, is critical for allowing their wild inhabitants' normal life-cycles and, in addition, maintaining policed corridors between adjacent PRHs for animal range continuity is needed.

When the faunistics of other abundant florally diverse habitats in this subregion become known (e.g., Assam—Burma, Western and Eastern Himalaya, eastern Central Highlands, Eastern Ghats—Carnatic, Andaman—Nicobar Islands : see Map, Fig. 1), the relative richness percentages of Western Ghats flies, butterflies, birds and flowering plants and other taxa may decrease. Which leads to my final observation about the value of biogeography and evohistory and the additional importance of also protecting currently less rich but more ancient "source areas." This present, recent abundance of birds on the Western Ghats is mainly of species adapted to wet forest habitats and ecosystems. Don't we need to preserve other distinct, specially evolved and adapted, biota in less rich, dry-zone and semi-arid habitats ? Are only rice, sugarcane, coffee and cocoa important for mankind and not cotton, millets, chillies and custard apple, for example ? My strong belief is that currently scientifically skewed "valuation" of biodiversity and the resultant incorrect weightage given to these few "Hot Spots" (what about "Cold Spots" and life-giving glaciers, and their high altitude ecosystems, that feed streams and rivers ?) need to be reconsidered and refined. The late M.S. Mani carried out much field work on high altitude entomology on the western Himalaya (see Mani 1974) and wrote some much consulted books on this special and poorly studied science.

For example, papers like those of Williams *et al.* (1996) need to be considered while making conservation decisions on wilderness habitats. As these authors conclude (p. 168) "….. identification of better methods of area selection and their continuing refinement should aid projects dealing with other goals and with other, less well-known groups." They also bring in the value of "complementary areas"—like what the present author terms "source areas" in this sub-continent's context—apart from these so-called hotspots. An article in the *New York Times* newspaper (28th September 1993) reported on the finding of a British team of ecologists which "found that many hot spots, despite the profusion of species, did not contain any rare species…" The celebrated and accomplished E.O. Wilson is quoted as saying that "because of fragmentation different types of conservation reserves in the United States are likely, as the British study found, to be hot spots for different types of organisms. Much more needs to be known about the 'congruence' of species groups and the ecology and population biology of rare species in different areas around the world." Wilson concludes that "the original approach of identifying hot spots and making conservation decisions based on them is basically sound; *we just need to refine it a great deal*" [emphasis mine—K.G.].

Immediate international "armies" (Wilderness Protection Forces) need to be created across national political boundaries (these are of no consequence to any wild plant or animal !), like the Interpol was coordinated to bring international criminals to justice. Destruction of natural resources created by evolution, long before humans evolved, and now irresponsibly over-utilizing them, is a crime greater than anything relating to man's money or his murder, and, unless forcefully checked and stopped will result in human suffering on a large scale, if not extinction.

More than focusing on animals (mostly larger and attractive species) it is absolutely imperative that conservation (what about restoration ? And that too of pre-existing native flora, not just "afforestation" with commercially selected exotic, fruit or timber trees !) executives, in Governments or N.G.O.'s, make *protection and re-planting of primary native vegetation* their chief aim. Meher-Homji (1994), more than a decade ago, documented the alarming situation with remaining percentages of the several "series" under the four major forest types that occur in Peninsular India—Ceylon : Evergreen, Semi-evergreen, Deciduous and Thorn. Our priorities are unfortunately topsy-turvy, short-sighted, commercially influenced and suicidal. Time is short and our unchecked human population growth, and this clearly unsustainable commerce-based and consumer backed "development dream," spells doom for us and maybe most other life on earth !

The current paranoia and concern about "Global Warming" needs to be properly understood and tackled. In my considered opinion, it is the *massive deforestation* that earth has undergone in the last 200 years that is mainly increasing the carbon dioxide content in the atmosphere and influencing accelerated, cumulative, warming as a consequence of logging, burning and clearing. Emissions from "greenhouse gases" can only be secondary "polluters." Afforestation of cleared or denuded forest areas, where agriculture is impractical or economically ill-advised, is the way to bring climatic harmony back on earth and especially if humans control their birth rate within "carrying capacity" and that of living habitations and their sustainable resources. This western, "American," consumerist, industrially focused, lifestyle is what is *absolutely unsustainable* and copying them for individual (or national) *monetory* superiority (psychological), or easy living, will be suicidal and obviously impractial in the long run. Hespenheide (2001: 357) interestingly, and thankfully (!), made the same judgement recently, opining that "Widespread beetle extinction over the next century is especially likely in the face of accelerating environmental destruction of the richest sites in the tropics to accommodate growing human populations and, even more significantly,

to maintain Western European and North American standards of living." The Old World and tribal lifestyle, which was monitored by Nature's graciousness and goodwill, will have to be quickly promoted as an alternative, original, human lifestyle that can and will have to be made sustainable for us and the wildlife (plants also !) that share this only living planet with us ! It is a sustainable *lifestyle* and not "development" that us supposedly intelligent humans must aim for in future, before we keep plundering nature's wealth to its "bones and roots" and untimately leave ourselves thirsty, hungry, and finally "dead as a dodo !"

References

Agarwal, M.L. and M. Sueyoshi 2005. Catalogue of Indian Fruit Flies (Diptera : Tephritidae). *Oriental Insects*, 39: 371-433.

Alexander, C.P. 1961. Classification and synonymy of the Crane-flies described by Enrico Brunetti (Diptera: Families Ptychopteridae, Trichoceridae and Tipulidae). *Records of the Indian Museum*, 59: 19-34.

Alfred, J.R.B., A.K. Das and A.K. Sanyal 1998. *Faunal Diversity in India*. Pp. viii+497. Zoological Survey of India, Calcutta. [Diptera Section by M. Datta, Pp. 285-293]

Amorim, D.S. 1994. A new suprageneric classification of the Scatopsidae (Diptera, Psychodomorpha). *Iheringia (ser. zool.), Porto Alegre*, 77: 107-112.

Aravind, N.A., K.P. Rajashekhar, and N.A. Madhyastha 2005. Species diversity, endemism and distribution of land snails of the Western Ghats, India. *Records of the Western Australian Museum, Supplement* No. 68, pp. 31-38, 3 figs.

Banerjee, D., B. Mitra, S. Roy, and C. Dey 2006. Bee-flies (Diptera, Bombyliidae) of the Western Ghats. *Bionotes*, 8: 44-45.

Barraud, P.J. 1934. *The Fauna of British India.* Volume V. Diptera. Family Culicidae, Tribes Megarhinini and Culicini. Pp. xxvii+463, 8 pls, figs. Taylor and Francis, London. [With APPENDIX: Culicini (Addenda), Dixinae and Chaoborinae].

Becker, T. 1922. Dipterologische studien—Dolichopodidae der Indo-Australischen Region. *Capita Zoologica*, 1(4): 1-247, 222 figs.

Bhimachar, B.S. 1945. Zoogeographical divisions of the Western Ghats, as evidenced by the distribution of hill-stream Fishes. *Current Science*, 14: 12-16.

Bigot, J.M.F. 1891-1892. Catalogue of the Diptera of the Oriental Region. *Journal of the Asiatic Society of Bengal*, Volume LX, Part II. No. 3, Pp. 250-282 (Part I); Volume LXI, Part II, No. 2, Pp. 133-236 (Part II).

Blackwelder, R.E. 1964. Phyletic and Phenetic *versus* Omnispective Classification. *Systematics Association Publication*, No. 6, Pp. 17-28.

Borgmeier, T. 1957. Basic Questions of Systematics. *Systematic Zoology*, 6: 53-69.

Borgmeier, T. 1968. A Catalogue of the Phoridae of the World (Diptera, Phoridae). *Studia Entomologica*, 11: 1-307.

Borgmeier, T. 1971. Supplement to A Catalogue of the Phoridae of the World (Diptera). *Studia Entomologica*, 14: 177-224.

Bravo, F. and D.S. Amorim 1995. First known Neotropical species of *Brunettia* (Diptera: Psychodidae) from southeastern Brazil, with description of a new subgenus and systematic comments on the genus. *Iheringia (ser. zool.), Porto Alegre*, 79: 149-158, 19 figs.

Brown, B.V. 2001. Flies, Gnats, and Mosquitoes. Pp. 815-826. *In:* S.A. Levin [Ed.-in-chief] Encyclopedia of Biodiversity. Volume 2, xxxi+826 pp. Academic Press, San Diego.

Brunetti, E. 1912. *The Fauna of British India*. Diptera. Nematocera, excluding Chironomidae and Culicidae. Volume I. Pp. xviii+581, 12 pls, figs. Taylor and Francis, London.

Brunetti, E. 1920. *The Fauna of British India.* Diptera, Brachycera. Volume I. Pp. ix+401, 4 pls, figs. Taylor and Francis, London.

Brunetti, E. 1923. *The Fauna of British India*. Diptera. Pipunculidae, Syrphidae, Conopidae, Oestridae. Volume III. Pp. xii+424, 6 pls, figs. Taylor and Francis, London.

Champion, H.G. and S.K. Seth 1968. *A Revised Survey of the Forest Types of India*. xxvii+404 pp. Manager of Publications, Delhi.

Chandran, M.D.S. 1997. On the Ecological History of the Western Ghats. *Current Science*, 73: 146-155, 11 figs.

Chaudhuri, P.K., N. Hazra and J.R.B. Alfred 2001. A Checklist of Chironomid Midges (Diptera: Chironomidae) of the Indian subcontinent. *Oriental Insects*, 35: 335-372.

Cherian, P.T. 2002. *The Fauna of India and the adjacent countries. Diptera, Volume IX, Chloropidae (Part 1) Siphonellopsinae and Rhodesiellinae.* xiii+368 pp. Zoological Survey of India, Calcutta.

Christophers, S.R. 1933. *The Fauna of British India*. Volume IV. Diptera. Family Culicidae, Tribe Anophelini. Pp. xi+371, 3 pls, figs. Taylor and Francis, London.

Collar, N.J. 1997. Taxonomy and Conservation: chicken and egg. *Bulletin of the British Ornithologists' Club*, 117: 122-136.

Croizat, L. 1968. The Biogeography of India: a Note on some of its Fundamentals. In: *Proceedings of the Symposium on Recent Advances in Tropical Ecology, Varanasi.* Eds : R.N. Misra, and B. Gopal [Part II], Pp. 544-590, 15 figs. Society of Tropical Ecology, Varanasi.

Crosskey, R.W. 1976. A Taxonomic Conspectus of the Tachinidae (Diptera) of the Oriental Region. *Bulletin of the British Museum (Natural History), Entomology, Supplement* No. 26, Pp. 1-357.

Datta, M. 1980. Collection and Preservation of Blackflies (Diptera: Simuliidae). *Proceedings of the Workshop on Techniques in Parasitology, Zoological Survey of India,* Pp. 75-82, 8 figs.

Datta, M. 1984. A Review of the Simuliidae (Diptera) from the Oriental Region. *Oriental Insects*, 17: 215-267, 15 figs. (1983).

Datta, M. 1985. A Synopsis of the Indian Tabanidae. *Bulletin of the Zoological Survey of India*, 7: 127-138.

Delfinado, M.D. & D.E. Hardy [Eds] (1973, 1975, 1977). *A Catalog of the Diptera of the Oriental Region.* Volume I: x+618 pp. (Suborder Nematocera), Volume II: x+459 pp. (Suborder Brachycera through Division Aschiza, Suborder Cyclorrhapha), Volume III: x+854 pp. (Suborder Cyclorrhapha, excluding Division Aschiza). University Press of Hawaii, Honolulu.

DeVries, P.J. 2001. Butterflies. Pp. 559-573, 5 figs. In: *In:* S.A. Levin [Ed.-in-chief] Encyclopedia of Biodiversity. Volume 1, xxxi+943 pp. Academic Press, San Diego.

Drew, R.A.I. and S. Raghu 2002. The fruit-fly fauna (Diptera : Tephritidae : Dacinae) of the rainforest habitat of the Western Ghats, India. *Raffles Bulletin of Zoology*, 50: 327-352. **[Not seen in original]**

Ferrar, P. 1987. *A Guide to the breeding habits and immature stages of Diptera Cyclorrhapha.* 2 Vols, Pp. 1-907. Entomonograph No. 8. E.J. Brill and Scandinavian Science Press, Copenhagen. **[Not seen in original]**

Fletcher, T.B. 1920. The desirability and practicability of the preparation and publication of a General Catalogue of all described Indian Insects. *Proceedings of the Third Entomological Meeting, Pusa*, Volume III, Pp. 990-999.

Forsyth, J. 1889. The Highlands of Central India. Notes on their forests and wild tribes, natural history, and sports. 388 pp. London. [1919 edn, reprinted in 1996 by Asian Educational Services, New Delhi & Madras]

Forster, E.M. 1924. *A Passage to India*. Pp. 1-317. Penguin Books Ltd, Harmondsworth, Middlesex.

Gadgil, M. 1996a. Documenting Diversity: An experiment. *Current Science*, 70: 36-44.

Gadgil, M. 1996b. Deploying student power to monitor India's lifescape. *Current Science*, 71: 688-697.

Gadgil, M. and V.M. Meher-Homji 1982. Conserving India's Biological Diversity. Pp. i+24, 3 maps. *Proceedings of the Indo—U.S. Binational Workshop on Conservation and Management of Biological Diversity*. 2-11 March 1982, Indian Institute of Science, Bangalore. Department of Environment, Government of India.

Gadgil, M. and V.M. Meher-Homji 1986. Localities of great significance to Conservation of India's biological diversity. *Proceedings of the Indian Academy of Sciences (Animal Sciences/Plant Sciences), Supplement*, Pp. 165-180.

Gamble, J.S. and C.E.C. Fischer 1915-1936. *Flora of the Presidency of Madras.* 3 vols., Pp. lxiv+2017, map. Adlard and Son Ltd, London.

Gaonkar, H. 1996. *Butterflies of the Western Ghats, India, including Sri Lanka*: a biodiversity assessment of a threatened mountain system. Pp. 1-52, 5 figs. Technical Report submitted to the Centre for Ecological Sciences, Indian Institute of Science, Bangalore, India.

Ghorpade, K.D. 1977. First impressions of the Avifauna of Mudigere, Western Ghats. *Newsletter for Birdwatchers*, 17(3): 5-10.

Ghorpade, K.D. 1979. A Decade of Oriental Insects: Trends in Insect Systematics in the Region. *Souvenir, Workshop on Advances in Insect Taxonomy in India and the Orient, Manali*, 9-12 October 1979. Pp. 7-19. Association for the Study of Oriental Insects, Delhi.

Ghorpade, K.D. 1981a. On a new species of *Scenopinus* (Diptera: Scenopinidae) from south India. *Colemania*, 1: 53-54, 3 figs.

Ghorpade, K.D. 1981b. Insect prey of Syrphidae (Diptera) from India and Neighbouring Countries: A Review and Bibliography. *Tropical Pest Management*, 27: 62-82.

Ghorpade, K.D. 1982. BOOK REVIEW. "*Fruit fly (Diptera: Tephritidae) Systematics of the Indian subcontinent*" by V.C. Kapoor, D.E. Hardy, M.L. Agarwal and J.S. Grewal. Pp. vii+113, 99 figs. Export India Publications, Jullundur (1980 ?). *Colemania*, 1: 173.

Ghorpade. K.D. 1986a. Identity of the *Exorista* (Diptera: Tachinidae) species parasitic on Mulberry Silkworm, *Bombyx mori* (Lepidoptera: Bombycidae) in India. *Colemania*, 2: 55-56, fig.

Ghorpade, K. D. 1986b. Section on INSECTS. 109 pp., 125 figs, 83 photos (18 coloured). In: *Encyclopedia of Indian Natural History*. General Editor: R. E. Hawkins. Pp. xiv+620, several figs & photos. Oxford University Press, Delhi, for Bombay Natural History Society, Bombay (Centenary Publication, 1883-1983).

Ghorpadé, K. 1994. Diagnostic Keys to new and known Genera and Species of Indian subcontinent Syrphini (Diptera: Syrphidae). *Colemania* (insect biosystematics), No. 3, Pp.1-15.

Ghorpadé, K. 1997. The Status of Insect Diversity in the Indian sub-continent. Introduction and Overview Part One. *Indian Journal of Biodiversity*, 1: 49-89, map.

Ghorpadé, K. 1998. A provisional, anecdotal appraisal of Diptera taxonomy in the Indian sub-continent. *Colemania* (insect biosystematics), No. 6, Pp.1-24.

Ghorpadé, K. 2000. Letter from an insect-hunting Ornithologist—36. *Pitta* No. 112, Pp. 3-4.

Ghorpadé, K. 2001. Letter from an insect-hunting Ornithologist—44. *Pitta* No. 122-123, Pp. 3-4, map.

Ghorpadé, K. 2002. Letter from an insect-hunting Ornithologist—57. *Pitta* No. 140, Pp. 3-6, map.

Ghorpadé, K. 2007. The Genus *Agnisyrphus* Ghorpadé (Diptera—Syrphidae), peculiar to the Oriental Region, with notes on Phylogeny, Evohistory and Panbiogeography. *Colemania* (insect biosystematics), No. 14, Pp. 1-35, 3 figs, 1 pl., 1 map.

Ghorpadé, K., L. Marinoni and L. Knutson 1999. *Steyskalina picta*, a new genus and species of Tetanocerini (Diptera, Sciomyzidae) from the Oriental Region. *Revista brasiliera de Zoologia*, 16: 835-839, 5 figs.

Gole, P. [Ed.] 1998. The Sayhadri special. *Journal of the Ecological Society*, 11: 1-47.

Hampson, G.F. 1889. The Butterflies of the Nilgiri District, South India. *Journal of the Asiatic Society of Bengal*, 1888, No. 4, pp. 346-368.

Henry, A.N., K. Vivekanathan and N.C. Nair 1979. Rare and threatened flowering plants of south India. *Journal of the Bombay Natural History Society*, 75: 684-697.

Hespenheide, H. 2001. Beetles. Pp. 351-358. *In:* S.A. Levin [Ed.-in-chief] Encyclopedia of Biodiversity. Volume 1, xxxi+943 pp. Academic Press, San Diego.

Hora, S.L. 1931. Indian Net-winged Midges or Blepharoceridae. *Journal of the Bombay Natural History Society*, 35: 342-346, 2 figs.

Howlett, F.M. 1909. Diptera (Flies.) Pp. 545-657, pls LVIII-LXIX (9 col.), figs 348-433. In: H. Maxwell-Lefroy, *Indian Insect Life*. A Manual of the Insects of the Plains (Tropical India). Pp. xii+786 pp., pls I-LXXXIV (many col.), figs 1-536, map. Thacker and Spink, Calcutta [Reprinted by Jagmandar Book Agency, Delhi, 1971].

Jairajpuri, M.S. [Ed.]. 1991. *Animal Resources of India, Protozoa to Mammalia. State of the Art*. Pp. xxvii+694. Zoological Survey of India, Calcutta. [Diptera Sections by Cherian, Datta, Joseph, Parui, Radhakrishnan & Tandon. Pp. 373-417].

Joseph, A.N.T. 1971-1979. The Brunetti types of Tipulidae (Diptera) in the Collection of the Zoological Survey of India. Parts I-XIII. *Journal of Entomology (B)*, 40: 121-131; 42: 59-70 and *Oriental Insects*, 8: 241-280; 9: 229-241; 10: 215-266, 383-391, 557-565; 11: 5-16, 421-448, 467-478; 12: 49-65, 143-156; 13: 29-39.

Joseph, A.N.T. and P. Parui 1984. Studies on the Asilidae (Diptera) collections made by Dr. Ghorpade. *Records of the Zoological Survey of India, Miscellaneous Publications, Occasional Paper* No. 66, iii+40 pp., 16 figs.

Joseph, A.N.T. and P. Parui 1997. Further studies on Asilidae (Diptera) from India in the Ghorpade Collection, Bangalore. *Colemania* (insect biosystematics), No. 5, pp. 1-25, 18 figs.

Joseph, A.N.T. and P. Parui 1998. *The Fauna of India and the adjacent countries. Diptera (Asilidae) (Part-I).* xiv+278 pp. Zoological Survey of India, Calcutta.

Kapoor, V.C. 1993. *Indian Fruit-flies (Insecta: Diptera: Tephritidae).* Pp. vii+228. Oxford and IBH Publishers, New Delhi.

Kapoor, V.C., J.S. Grewal and S.K. Sharma 1987. *Indian Pipunculids (Diptera: Pipunculidae).* A comprehensive Monograph. Pp. 1-201, 31 pls. Atlantic Publishers and Distributors, New Delhi.

Karanth, K.P. 2003. Evolution of disjunct distributions among wet-zone species of the Indian subcontinent: testing various hypotheses using a phylogenetic approach. *Current Science*, 85: 101-108, 8 figs.

Kaur, R. 2003. An update on the distribution of Mosquitoes of the Tribe Aedini in India (Diptera: Culicidae). *Oriental Insects*, 37: 439-455.

Kessel, E.L. and J.R. Clopton 1969. The Platypezidae of the Oriental Zoogeographical Region and islands to the east, with descriptions of four new species (Diptera). *The Wasmann Journal of Biology*, 27: 25-73, 3 figs, 9 maps.

Kevan, P.G. and H.G. Baker 1983. Insects as flower visitors and pollinators. *Annual Review of Entomology*, 28: 407-453.

Knutson, L. and K. Ghorpadé 2004. Insects: Diptera, Sciomyzidae. Pp. 832-845, 2 figs. In: *Freshwater Invertebrates of the Malaysian Region.* C.M. Yule and Y.H. Sen [Eds]. Pp. vii+861, many figs. Academy of Sciences Malaysia, Kuala Lumpur.

Legris, P. and V.M. Meher-Homji 1977. Phytogeographic outlines of the hill ranges of Peninsular India. *Tropical Ecology*, 18: 10-24.

Lewis, D.J. 1987. Phlebotomine Sandflies (Diptera: Psychodidae) from the Oriental Region. *Systematic Entomology*, 12: 163-180.

MacArthur, R.H. and E.O. Wilson 1967. *The Theory of Island Biogeography*. Pp. xi+203, 60 figs, 13 tables. Princeton University Press, Princeton, New Jersey.

Mani, M.S. 1954. Entomological Survey of the Himalayas. 1.—Introduction, Description of Gall Midges (Itinididae = Cecidomyiidae = Diptera) and plant galls from the Western Himalayas. *Agra University Journal of Research* (*Science*), 3: 13-42, 10 pls, 36 figs.

Mani, M.S. [Ed.] 1974. *Ecology and Biogeography in India.* Pp. xix+773. Dr W. Junk, b.v., The Hague.

Mathis, W.N. and K. Ghorpadé 1985. Studies of Parydrinae (Diptera: Ephydridae), I: A Revision of the genus *Brachydeutera* Loew from the Oriental, Australian, and Oceanian regions. *Smithsonian Contributions to Zoology*, No. 406, Pp. iii+25, 27 figs.

Mathis, W.N. and T. Zatwarnicki 1995. World Catalog of Shore Flies (Diptera: Ephydridae). *Memoirs on Entomology, International*, 4: 1-430. **[Not seen in original]**

May, R.M. 1990. Taxonomy as destiny. *Nature, London*, 347: 129-130.

Meher-Homji, V.M. 1979. On the subtropical climate and vegetation of the Indian sub-continent. *Geophytology*, 8: 137-146.

Meher-Homji, V.M. 1983. On the Indo-Malaysian and Indo-African elements in India. *Feddes Repertorium, Berlin*, 94: 407-424, 3 figs.

Meher-Homji, V.M. 1994. Biodiversity and Conservation. *Bulletin of the Botanical Survey of India*, 36: 30-40, 11 figs.

Nagatomi, A. 1970. Rachiceridae (Diptera) from the Oriental and Palaearctic Regions. *Pacific Insects*, 12: 417-466, 65 figs.

Nalini, S. and B. Lomov 1996. The Spot Puffin butterfly *Appias lalage lalage* Doubleday (Pieridae)—a rare record for south India. *Journal of the Bombay Natural History Society*, 93: 596-597.

Nandi, B.C. 2002. *The Fauna of India and the adjacent countries. Diptera Volume X, Sarcophagidae.* xxiv+608 pp., 918 figs, map. Zoological Survey of India, Calcutta.

Nandi, B.C. 2004. Checklist of Calliphoridae (Diptera) of India. *Records of the Zoological Survey of India, Occasional Paper*, No. 231, Pp. 1-47.

Nayar, M.P. 1994. 'Hot Spots' of Plant diversity in India. *Blackbuck*, 10: 42-46.

Nayar, M.P. and A.R.K. Sastry 1987. *Red Data book of Indian Plants.* Vol. 1, Pp. 1-367. Botanical Survey of India, Calcutta. **[Not seen in original]**

Oldroyd, H. 1964. *The Natural History of Flies.* xvi+324 pp., 32 pls, 40 figs. (1st American edition, 1965). W.W. Norton & Co., Inc., New York.

Oosterbroek, P. 1998. The Families of Diptera of the Malay Archipelago. *Fauna Malesiana Handbook* 1, xii+227 pp. Brill, Leiden. **[Not seen in original]**

Oosterbroek, P. 2006. *The European families of the Diptera.* Identification, diagnosis, biology. 205 p., 582 figs, KNNV Publishing, Utrecht.

Pape, T. 1996. A Catalogue of the Sarcophagidae of the World (Insecta: Diptera). *Memoirs on Entomology, International*, 8: 1-558.

Pascal, J.P. 1988. *Wet evergreen forests of the Western Ghats of India: Ecology, structure, floristic composition and succession*. French Institute, Pondicherry. **[Not seen in original]**

Pearson, D.L. and K. Ghorpade 1989. Geographical distribution and Ecological history of Tiger Beetles (Coleoptera: Cicindelidae) of the Indian subcontinent. *Journal of Biogeography*, 16: 333-344, 16 figs.

Prashad, B. 1927. Enrico Brunetti. *Records of the Indian Museum*, 29: 287-290.

Quammen, D. 1996. *The Song of the Dodo.* Island Biogeography in an Age of Extinction. Pp. 1-702, 18 maps [some repeated !]. Touchstone Books, New York.

Rao, S.N. and R.M. Sharma 1977. Insect : Host-plant Index of Gall Midges Cecidomyiidae from the Oriental region. *Natural Sciences Journal, Marathwada University, Aurangabad*, 16: 157-167.

Rasmussen, P. 2005. Biogeographic and conservation implications of revised species limits and distributions of south Asian birds. *Zoologische Mededlingen* (Leiden), 79: 137-146, 3 figs.

Ribeiro, S. 1923. Corrections and amplifications of Indian localities in Dr. T.H. Becker's Monograph of the Dolichopodidae (Diptera). *Records of the Indian Museum*, 25: 335-344.

Ripley, S.D. 1949. Avian relicts and double invasions in peninsular India and Ceylon. *Evolution*, 3: 150-159.

Senior-White, R. 1923. Recent progress in our knowledge of Indian Diptera. *Proceedings of the Fifth Entomological Meeting, Pusa*, Pp. 325-329.

Senior-White, R. 1927. Brunetti as a Dipterologist. *Records of the Indian Museum*, 29: 290-296.

Senior-White, R., D. Aubertin and J. Smart 1940. *The Fauna of British India* including the remainder of the Oriental Region. Diptera. Volume VI. Family Calliphoridae. Pp. xiii+288, 152 figs, map. Taylor and Francis, London.

Sharma, R.M. 1993. A new species of *Xylopriona* Kieffer (Diptera: Cecidomyiidae) from Nilgiri Biosphere Reserve, India. *Hexapoda*, 5: 71-74, 11 figs.

Sharma, R.M. 1999. Descriptions of two new Gall Midges (Diptera: Cecidomyiidae) from Nilgiri Biosphere Reserve, Karnataka. *Records of the Zoological Survey of India*, 97: 167-172.

Soubadra Devy 1998. The occurrence of Spot Puffin in Kalakad—Mundanthorai Tiger Reserve, southern Western Ghats. *Journal of the Bombay Natural History Society*, 95: 522-523.

Spencer, K.A. 1986. New records of Agromyzidae (Diptera) from southern India, with revisionary notes on other Indian species. *Colemania*, 3: 1-12, 12 figs.

Srinivasan, U. and N.S. Prashanth 2006. Preferential routes of dispersal to the Western Ghats in India. An explanation for the avifaunal peculiarities of the Biligirirangan Hills. *Indian Birds*, 2: 114-119, 3 figs.

Subramanian, K.A. and K.G. Sivaramakrishnan 2002. Conservation of Odonate fauna in Western Ghats—A biogeographic perspective. Pp. 11-22, 4 figs. *In:* K.P. Sanjayan, V. Mahalingam & M.C. Muralirangan *of Entomological Research for the new millennium.* G.S. Gill Research Institute, Madras.

Subramanyam, K. and M.P. Nayar 1974. Vegetation and Phytogeography of the Western Ghats. Pp. 178-195, 5 pls, In: M.S. Mani [Ed.] *Ecology and Biogeography in India*. Pp. xix+773. Dr W. Junk, The Hague.

Suwa, M. 1977. Anthomyiidae collected by the Hokkaido University expeditions to Nepal Himalaya, 1968 and 1975 (Diptera). *Insecta Matsumurana (n.s.),* 10: 17-51, 108 figs.

Suwa, M. 1981. Some Anthomyiidae from India (Diptera). *Insecta Matsumurana (n.s.)*, 22: 15-28, 22 figs.
Tenorio, J.M. 1972. A Revision of the Celyphidae (Diptera) of the Oriental Region. *Transactions of the Royal Entomological Society of London*, 123: 359-453, 39 figs.
Thapar, R. 1977. States reorganization: Is small beautiful ? *India Today*. December 16-31, pp. 58-59, map.
Thompson, F.C. and K. Ghorpadé 1992. A new coffee aphid predator, with notes on other Oriental species of *Paragus* (Diptera: Syrphidae). *Colemania*, 5: 1-24, 7 maps, 19 figs.
Van der Wulp, F.M. 1896. *Catalogue of the described Diptera from South Asia.* Pp. viii+220. The Dutch Entomological Society, Martinus Nijhoff, The Hague.
Van Emden, F.I. *The Fauna of India.* Volume VII. Diptera. Cyclorrhapha. Family Muscidae, Part 1. Muscinae, Stomoxydinae and Phaoniinae. Pp. xiv+647, 2 pls, figs. Manager of Publications, Delhi and Zoological Survey of India, Calcutta.
Vane-Wright, R.I. 1993. Milkweed Butterflies (Lepidoptera: Danainae) and conservation priorities in the Andaman and Nicobar Islands, India. *Butterflies*, 4: 21-36, 3 col. pls, 4 figs.
Vats, S.K., R.D. Singh and P.S. Ahuja 1999. On way to extinction ? The scene in Indian grasses. *Current Science*, 76: 122-124.
Vijay Veer 2004. Tabanidae flies (Diptera) from the Indian subregion. *Annals of Forestry*, 12: 301-447.
Williams, P., D. Gibbons, C. Margueles, A. Rebelo, C. Humphries and R. Pressey 1996. A comparison of Richness Hotspots, Rarity Hotspots, and Complementary Areas for conserving diversity of British Birds. *Conservation Biology*, 10: 155-174, 5 figs.
Woodley, N.E. 2001. A World Catalog of the Stratiomyiidae (Diptera). *Myia*, 11: 1-475.

Addendum

Ghorpadé (1998) had given the main reference works on Indian subregion Diptera at that time. Here, other important references than those listed here above, and mainly published in the last decade are cited, in chronological order, for the user's benefit :

Brunetti, E. 1920. Catalogue of Oriental and south Asiatic Nemocera. *Records of the Indian Museum*, 17: i+300.
Datta, M. 1986. Identification of Diptera of Medical and Veterinary importance. Pp. 137-159, 6 pls. In: J.K. Jonathan and P.P. Kulkarni [Eds] Manual: *Collection, Preservation and Identification of Insects and Mites of Economic Importance.* Pp. viii+307.
Alfred, J.R.B., S. Chakraborty and R. Chakraborty 2000. *A Bibliography of the Zoological Survey of India publications in the Twentieth Century* (*1916—1999*). Pp. 1-255.
Alfred, J.R.B., A.K. Das and A.K. Sanyal 2001. *Ecosystems of India*. Pp. 1-416.
Das, A. 2003. A Catalogue of new taxa described by the scientists of the Zoological Survey of India during 1916—1991. *Records of the Zoological Survey of India, Occasional Paper*, No. 208, Pp. 1-530.
Ilango, K. 2005. Wetland Mosquito fauna of Tamil Nadu. *Records of the Zoological Survey of India, Occasional Paper*, No. 241, Pp. 1-36.

Other relevant Zoological Survey of India publications :

Fauna of Nilgiri Biosphere Reserve. 330 pp., 8 col. pls. 2001
Fauna of Sanjay Gandhi National Park [= Borivli, Bombay]. 54 pp., 8 col. pls. 2002.
Fauna of Eravikulam National Park. 87 pp., 12 col. pls. 2002.
Fauna of Orissa. 1,114 pp. 4 Parts in 1987, 1989, 1991, 1993.
Fauna of Lakshadweep. 413 pp. 1991.
Fauna of West Bengal. 6,447 pp. 12 Parts in 1992, 1997, 1999, 2001[Part 7, 792 pp., on Diptera and Lepidoptera, in 1997].
Fauna of Andhra Pradesh. 1,683 pp. 4 Parts in 1993, 2004-2005.
Fauna of Meghalaya. 4,349 pp. 10 Parts in 1995, 1999, 2000 [Part 6, 537 pp., on Diptera and Lepidoptera, in 2000].
Fauna of Delhi. 903 pp. 1997.
Fauna of Tripura. 1,553 pp. 4 Parts in 2000, 2002.
Fauna of Gujarat. 891 pp. 2 Parts in 2000, 2004.
Fauna of Sikkim. 1,685 pp. 4 Parts in 2003.
Fauna of Manipur. 982 pp. 3 Parts in 2004-2005.
Fauna of Bihar (including Jharkhand). 213 pp. 2004.
Fauna of Nagaland. 624 pp. 2006.
Fauna of Arunachal Pradesh. 908 pp. 2 Parts in 2006.

P O S T S C R I P T

This chapter is dedicated to the memory of the late K. Poornachandra Thejaswi, who expired recently. I spent a few days off and on during my field trips to the singularly biodverse Mudigere area (in Chikmagalur District, Karnataka) with this wonderful human being, who was living in his coffee estate there, and could imbibe some "*gyaan*" (knowledge) about these wonderful Ghats as well as admire the halftone photographs of birds and insects that Thejaswi had given or displayed to me (*cf* Ghorpade, 1977).

L E G E N D **Fig. 1.** Biogeographic divisions of the Indian subregion.