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AQUATIC INSECTS OF NORTHERN WESTERN GHATS

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INTRODUCTION

The streams and rivers of the Western Ghats is a prominent landscape feature of the peninsular India. The Western Ghats is the catchment for 3 large, 13 medium and 17 minor rivers of the peninsular India (Rao, 1975). These 33 rivers and associated wetlands harbour high diversity of freshwater organisms. These streams, rivers and associated wetlands of the region are one of freshwater biodiversity hotspots of the world (World Conservation Monitoring Centre, 2000).

Small and large flowing water bodies are generally denoted as streams and rivers respectively. The network of streams and rivers of drainage is an ecological continuum and interact strongly with surrounding landscape. The entire drainage network and its immediate landscape are termed as riverine ecosystem. Here a riverine ecosystem approach is adopted, considering streams, rivers and its riparian landscape to study the aquatic insects of northern Western Ghats.

Biodiversity of freshwater systems are highly proportional to the habitat exten. Only 0.01% percent of globe's surface is covered with water. However, the freshwater systems support about 1,26,000 species of animals and 2,614 species of plants, which is 9.5 and 1 percent of all known animal and plant species respectively (Balian *et al.,* 2008). There is no comprehensive document on the freshwater biodiversity of the northern Western Ghats. However, for many groups some information is available. (Mohu *et al.,* 2010)

THE RIVERINE ECOSYSTEM

Rivers and their landscapes are complex dynamic ecosystems, primarily determined by interactions of five main components: physical habitat, flow regime, the energy or food base of the system, biological interactions and water quality. The components interact to maintain ecological integrity of the system. Interactions within a river basin have three spatial dimensions: vertically including ground water, longitudinally as the river flow from head waters to sea and latitudinally as rivers move across flood plains (WWF, 2007). The flow regime changes temporally and is largely determined by the seasonal rainfall patterns. This seasonal dynamics of flow regime has important influence on the ecology of the system.

Streams and rivers are vital to the ecological integrity of the landscape. The dynamics of the system and their functions in the landscape change with water flow levels. At normal flow levels, the streams and rivers provide adequate habitat for aquatic organisms, maintain water table levels in flood plain, soil moisture for terrestrial plants, provide drinking water and enable fish movements between feeding spawning grounds. Occasional high pulse flows shape physical character of river channel and habitats, prevent encroachment of riparian vegetation into river bed, restore normal water quality by flushing away waste and pollutants and maintain salinity in the estuaries. Large floods provide migration and spawning cues for fishes, provide nursery area for juvenile fish,

recharge flood plain water table, purge invasive alien plant and animal species from the system, disperse seeds and fruits of riparian plants and redistribute nutrients in the flood plain (WWF, 2007).

Stream orders and river zones are two terms used to classify stream and river habitats **(Box-1)**. Streams and rivers are longitudinally connected with other streams, rivers, wetlands, estuaries and eventually to marine ecosystem. This connectivity is important in the transport of biota, energy and material. Laterally, streams and rivers are connected with terrestrial ecosystems through riparian zone. The riparian zone provides important habitats, organic and nutrient inputs, and ecological processes (temperature and light regulation). A diverse group of terrestrial and aquatic species use rivers and streams and their riparian areas for foraging, breeding, migration and dispersal **(Box-2)**.

Box-1: Habitats in River Systems

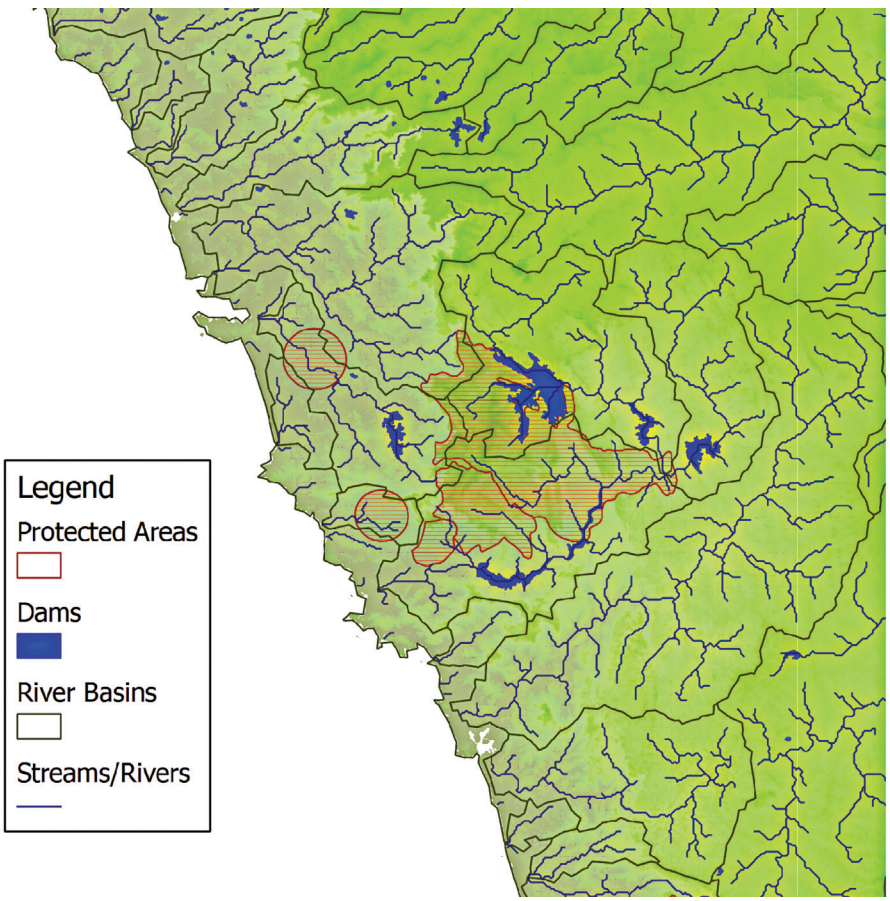
1. **Stream Orders:** Within a drainage net work, stream tributary relationship is classified as stream orders. First order streams are uppermost channels in a drainage network that has no upstream tributaries. When two first order streams meet they join to form second order and a third order stream is formed by confluence of two second order streams and so on.
2. **River Zones:** Zones of the river ecosystems are divided into three i.e., *headwater zone*, *mid-reach* or *transfer zone* and a lower *main stem zone*. The zones are classified based on the most dominant process in each zone. In head water zone due to steep gradient and narrow stream valleys, erosion is greater than deposition. In the mid-reach stream channel is wider with low gradient. In this zone river transitions from erosion to depositional. Further down, the gradient is low, channel is wider and deeper. Water velocity is low and all the rivers load settle out here.
3. **Reach:** Stretch of stream or river with distinct geologic condition, channel gradient and watershed vegetation is called reach**.** Diversity of habitat within a reach contributes significantly to the overall diversity of the river system. Biological communities of each type of reach are distinct.
4. **Cascades:** Cascade is a stretch of stream where the water flows through boulders and cobbles with high turbulence. It is usually found in headwater zone with moderate to high gradient streams. Water velocity and dissolved oxygen is high. Animal species living in cascades have specific adaptations like suckers or flat body shape to live in turbulent waters.
5. Riffles: Riffles are created when stream flows through straight and shallow stretches of channel with coarse errosion resistant bottom substrate. Constant agitation of water surface increases dissolved oxygen level in this habitat.
6. **Pools:** Pools are formed in stretches of streams and rivers, where physical obstacle causes the flow to erode the bottom substrate sideways or downward. Commonly they are found in river bends or below a waterfall (plunge pool). Water is deeper and cooler in pools. Woody and organic debris collect in pools.
7. **Waterfalls:** When the stream perpendicularly descends through the channel a waterfall is created. Erosive power of this habitat is high and usually a pool is created at the base of a waterfall. Spray zones of waterfalls are habitats for many plant and animal species specifically adapted to that habitat.
8. **Bars:** Stretches of streams where bands or ridges of sediment get deposited are called bars. They are usually formed downstream of bends or after a flood episode.
9. **Stream Ponding:** When a stream or river channel crosses a fault line, it causes a deflection and upstream stagnation of water. Stream ponding is widespread in streams flowing through Kodagu, Dakshina Kannada, Udupi, Shimoga and Uttara Kannada districts. They are important habitat and summer refugia for fishes.

Box-2: Riparian Zones

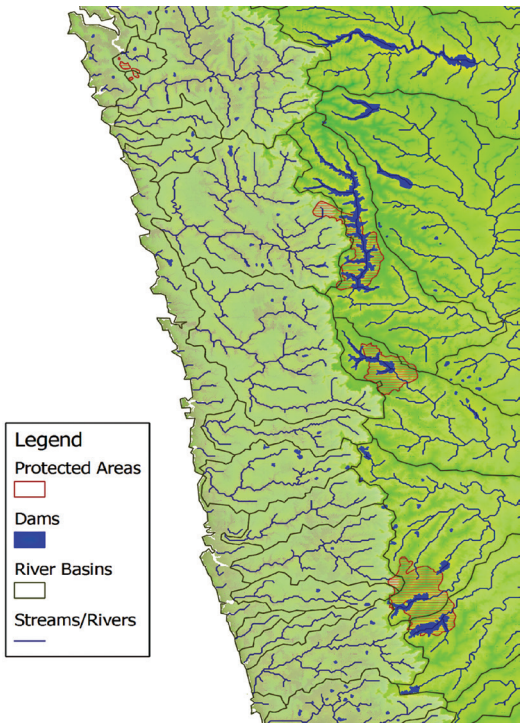
The landscapes adjacent to rivers and streams are called riparian zone. It is also the landscape where the flood water spreads when the river or stream channel over flows. Flood plains and riparian zones are same for rivers with distinct flood plain. The riparian zones in different part of the river system have distinct functions. In headwater zone the riparian vegetation provides complete shading of streams there by regulating the temperature and light. It also provides leaf litter and woody debris to the streams. Streams and rivers of mid reach and flood plain have distinctive and animal communities. Due to their high productivity and water availability, mid reach and flood plain riparian zones are intensely used for agriculture and other developmental activities.

Riparian zones with natural vegetation cover provide bank stability; act as a barrier for soil and nutrient erosion. They are important habitats for many species of invertebrates, amphibians, reptiles, birds and mammals in their critical life history stages. Riparian corridors are important routes through which many animals disperse and migrate across landscapes. In fragmented landscapes, riparian corridors provide connectivity between large patches of natural vegetation for the movement of animals.

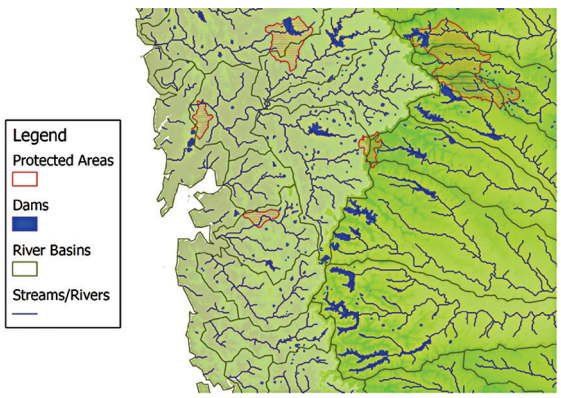
The streams and rivers draining western and eastern slopes of the Western Ghats is now globally recognized freshwater ecoregion based on the distribution of freshwater fishes. Based on freshwater fish species richness and endemism the river systems fall under three ecoregions *viz.,* Southern Deccan Plateau (Godavari-Krishna river systems), south eastern Ghats (Cauvery and other east flowing rivers) and Western Ghats (all the west flowing rivers) (Abell *et al.,* 2008).



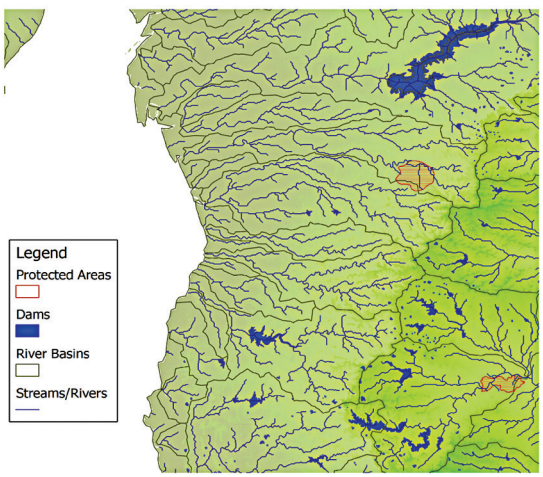
Map-1. Maps of streams, rivers and dams of the Northern Western Ghats (Goa and Sindudurg District)



Map-2. Maps of streams, rivers and dams of the Northern Western Ghats (Ratnagiri and Raigad District)



Map-3. Pune and Mumbai Region



Map-4. Dhule and Dangs Region

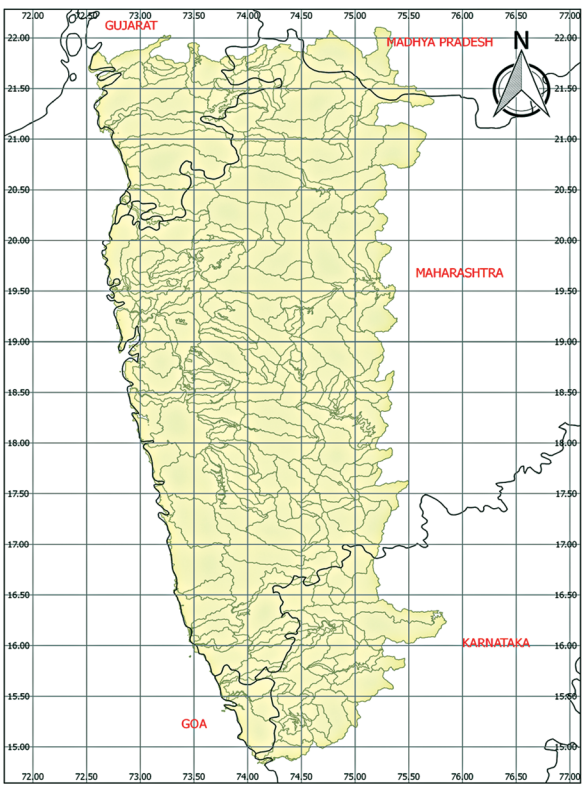
GEOGRAPHIC FEATURES

The western escarpment of the peninsular India- the Western Ghats divides the water shed into east and west flowing rivers. The major east flowing rivers of the peninsula, Godavari, Krishna and Cauvery have major catchments in the eastern slopes of the Western Ghats and drain into Bay of Bengal. The west flowing rivers are relatively smaller and drain into the Arabian Sea. The streams and rivers on either side of the catchment traverse wide range of altitudinal, rainfall, temperature and vegetation gradients. This geographic feature of streams and rivers has direct influence on the energy dynamics of the system and creates diverse habitats within a basin.

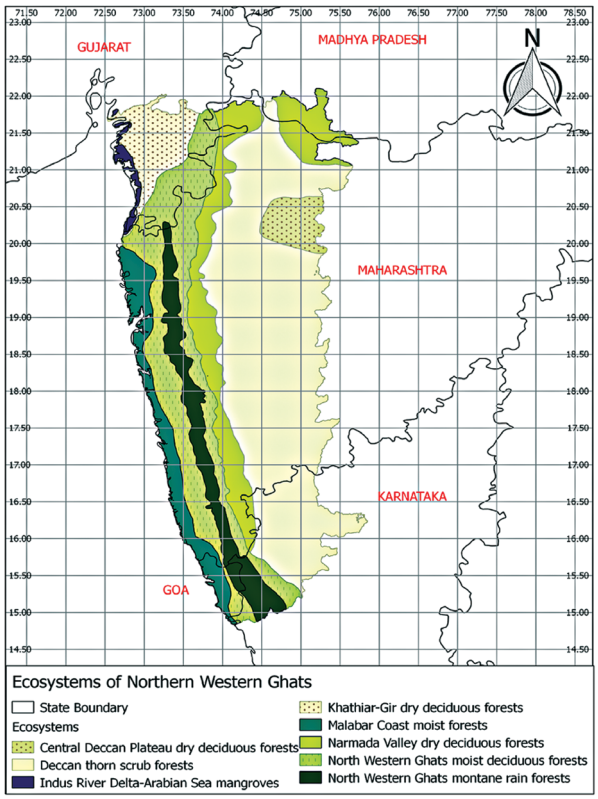
The northern Western Ghats forms the catchment of rivers such as Tapi, Godavari, Krishna, Purna, Savitri, Vasishti, Vytharani etc. Due to long dry spell of over 8 months, most of the rivers have water only during monsoon. Map of the study area with river basins and ecosystems are provided in Map-05 & 06.

AQUATIC INSECTS

Insects are the most diverse group of organisms in freshwater. Estimates on the global number of



Map-5. Study region



Map-6. Ecosystems of Northern Western Ghats

aquatic insect species derived from the fauna of North America, Australia and Europe is about 45,000. About 5,000 species are estimated to inhabit inland wetlands of India. Aquatic insects of inland wetlands comprise some well-known groups like mayflies (Ephemeroptera), dragonflies (Odonata) and caddiesflies (Trichoptera). Aquatic insects such as dragonflies and damselflies (Odonata) are very colourful and prominent insects of the wetlands. Different functional groups of aquatic insects such as shredders, scrapers, filter feeders and predators are important links in nutrient recycling. Aquatic insects primarily process wood and leaf litter reaching the wetland from the surrounding landscape. Nutrients processed by aquatic insects are further degraded into absorbable form by fungal and bacterial action. Plants in the riparian zone absorb this nutrient soup transported through the wetlands. In addition to this significant ecosystem function, aquatic insects are also a primary source of food for fishes.

The origin of aquatic insects has been controversial and doubts still exist as to whether or not insects are primarily or secondarily adapted to aquatic environments. The widely accepted view is that the ancestor of myriapod-insect group (millipedes, centipedes, and insects) lived in leaf litter areas along margins of pond like environment. Primitive insects of this moist environment were ancestors of aquatic insects. Their fossil record extends to Devonian in the Paleozoic era. Among extend aquatic insects, dragonflies and damselflies (Odonata) and mayflies (Ephemeroptera) are the most primitive and are the only insects with aquatic juveniles. The understanding of aquatic insect evolution and phylogeny has been hampered by poor fossil record of freshwater animals. Living aquatic insects represent 12 insect orders. Of this, larvae of species of mayflies (Ephemeroptera), dragonflies and damselflies (Odonata), stoneflies (Plecoptera), alderflies (Megaloptera), lacewings (Neuroptera), flies (Diptera), caddiesflies (Trichoptera), moths (Lepidoptera) and wasps (Hymenoptera) are aquatic with terrestrial adults. Larval or nymphal and adult stages of aquatic beetles (Coleoptera) and bugs (Hemiptera) are fully aquatic.

Aquatic insects have tackled the problem of living in aquatic environment by evolving various morphological and physiological modifications. These include air-tubes to obtain atmospheric oxygen, cutaneous and gill respiration, the extraction of air from plants, hemoglobin pigments, air bubbles and plastrons. Air-tubes are present in aquatic bugs (Hemiptera) and files (Diptera) restricting their activity to water surface. Cutaneous and gill respiration is widespread in the immature stages of most of the aquatic insects. This helps them to live among submerged substrates. Adult beetles and bugs often respire by the use of an air bubble. Some species use plastron (a system of microhairs or papillae) that hold an air film. Plastron respiration helps these insects to stay longer under water. Chironomid (Diptera) larvae living in eutrophic lakes survive in low oxygen levels through the use of hemoglobin pigments.

One of the major physical forces faced by aquatic insects of running waters is water current. In running waters aquatic insect morphology are closely related to hydraulic stress and the necessity to remain in close contact with the substrate. A diverse range of body modifications are present in aquatic insects. Modifications such as flattening of body, streamlining, reduction of projecting

structures, suckers, friction pads, hooks, silk and sticky secretions are widely present in different groups of insects. Morphological adaptations are closely followed by behaviour adaptations. Aquatic insects avoid water current by burrowing into the substrate or occupying a space in the substrate with minimum hydraulic stress.

Aquatic insects have evolved diverse lifehistory strategies to suit their environment. Many temporary pool breeding species have egg stage which can remain in total dry condition (eg: *Aedes)*. In many species of caddiesflies, gelatinous egg mass matrixes protect the eggs and larvae from desiccation and freezing for months together. Some species have staggered hatching which prevents overcrowding of newly hatched larvae.

Very few aquatic insects are adapted to a completely submerged life cycle. Most of the aquatic insects spend at least one part of their life cycle in terrestrial habitat, a major problem being completely submerged is respiration. Many species have developed morphological and physiological adaptations to survive in particular oxygen concentration. The distinction is being very evident in running and standing water where the former is very well oxygenated than the latter. This is one important factor that determines the distribution of groups like mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddiesflies (Trichoptera). These groups achieve their maximum diversity in running water. Among holometabolous aquatic insects, aquatic pupa is found in caddiesflies (Trichoptera), flies (Diptera) and aquatic moths (Lepidoptera). Aquatic beetles, alderflies (Megaloptera) and lacewings (Neuroptera) have terrestrial pupa.

During the course of life, aquatic insects encounter diverse physical environmental conditions, the most pronounced being temperature. The temperature varies daily and seasonally. This variation in temperature affects emergence pattern of aquatic insects. In tropics because of relatively constant temperature, many pool breeding species show continuous emergence throughout the year. However, in the Western Ghats, most of the stream breeding species emerge during pre and post monsoon months. Some species in tropics follow an emergence pattern coinciding with phases of moon.

The presence of diapausing egg and pupa is important life history evolutions that help insects to survive unfavourable conditions. Aquatic insects complete single or multiple generations during a year. Some tropical species have life cycle greater than a year. Life cycle completion time for a species varies with altitude and latitude.

Essentially all aquatic insects are omnivorous, at least in their early instars. Species which use similar morpho-behavioural mechanisms for food acquisition have evolved similar mouth parts. This has facilitated classification of aquatic insects to functional feeding groups, which is equivalent of guild. The "functional group" approach reflects both convergent and parallel evolution leading to functionally similar organisms. Mouth parts, legs and other morphological structures or constructed devices (silk nets) together with associated feeding behaviour may change with larval development. Widely recognized functional feeding groups are shredders, collectors, scrappers, predators and piercers. The shredders feed on woody debris and leaf litter, and collectors filter feed or gather suspended organic matter from water column. Scrappers graze algae and other plants growing on substrate. Predators feed on other aquatic invertebrates and small vertebrates. Piercers obtain liquid food from plants or other animals.

Aquatic insects are adapted to either running waters (streams and rivers) or standing waters (ponds and lakes). These habitats can also be viewed as erosional (streams and rivers) or depositional (ponds and lakes). Both stream/ river currents and lake shoreline waves create erosional habitats while lake basins, river flood plain pools and stream/river backwaters provide depositional conditions. Species adapted to erosional habitats frequently colonize lake shorelines. Similarly many species of depositional habitats are common in flood plain pools and backwaters.

The habitats for the aquatic insects can be visualized within the framework of various spatial-temporal scales. At a spatial scale, it ranges in size from particles of few millimeters to the entire drainage basin, which extends to squares of kilometers. Temporally, the changes in the habitats can be visualized from days to thousands of years. The permanence of the physical structures of the habitats varies with the spatial scale. This ranges from few days for individual grain and microhabitat to thousands of years for the drainage

network. Insect communities of the wetlands respond to this spatial-temporal variation as well.

Within a given habitat, aquatic insects maintain their location by clinging, swimming, skating or burrowing into the habitat. Distribution of aquatic insects within a habitat is determined by intricate interplay between substrate, flow, turbulence and food availability. The habit (mode of locomotion, attachment or concealment) of a given species determines the frequency of movement within the habitat.

Substrate, an important physical component of habitat is very complex. The water current and the nature of the available parental material determine the physical nature of the substrate. The organic detritus adds complexity to the substrata and can strongly influence the organism's response to the substrate. It has been established across continents and biomes that the faunal composition changes with the substrate. Sand is a relatively poor habitat with low abundance and diversity. Relatively, the diversity is high in silty-sand and biomass may be high and diversity low in muddy substrata. The presence of sand and silt reduces and changes fauna. At least in stony substrata it is known that the space available for colonization determines species abundance. In general, diversity and abundance increase with substrate stability and the presence of organic detritus.

OBJECTIVES

To document the diversity of aquatic insects of riverine ecosystems of the northern Western Ghats.

Methodology:

Field surveys:

Rivers and streams of southern Gujarat and Western Maharashtra were surveyed. Details of the survey localities are provided in Table-1 & Table-2. Different methods are employed to sample aquatic insects from the target habitats. The methods employed for collecting aquatic insects from different habitats are outlined below. In all the methods, collected samples are stored in 70% ethanol and labelled separately in the field.

Lotic habitats (Streams and Rivers):

In streams where the water flows through boulders and cobbles with high turbulence using nets is extremely difficult owing to its physical nature. An "all out search" method is used to collect the aquatic insects. The effort in sampling is standardized by restricting the collection of aquatic insects from 10sqm area for one hour. Within the sampling area, aquatic insects are searched in all the possible substrata such as bedrocks, boulders, cobbles, leaf litter and dead wood. A sable hairbrush or forceps is used to collect all samples.

In stretches of streams and rivers where the water flows with little turbulence over gravel and sand, physical nature permits to use nets. Aquatic insects were sampled by taking three, 1-minute kick-net samples (mesh opening: 180um; area $1m^2$). The kick-net is held against water current and an area of $1m^2$ in front of the net is disturbed for one minute. Contents of the net is pooled and preserved in 70% ethanol.

Pools are stretches of streams and rivers where the water flow is minimum with least turbulence. Aquatic insects on water surface are collected using a nylon pond net (mesh opening: 500um; diameter: 30cm; depth: 15cm). All out search method mentioned earlier is also employed to collect aquatic insects from the substratum in the shallow pools.

Table-1. Details of Survey localities

Sl. No.	State	Districts	Duration
1	Maharashtra	Pune, Nasik, Dhule, Nandurbar	October-2008
2	Maharashtra	Sangli & Kholapur	January-2009
3	Maharashtra	Thane, Mumbai, Raigad	September-2009
4	Maharashtra	Kholapur	January-2010
5	Gujarat	Dangs	September-2010
6	Gujarat	Navsari	September-2010

Lentic habitats (Ponds and lakes):

In ponds and lakes aquatic insects can be sampled using a pond net mentioned earlier. A bigger pond net (mesh opening: 500um; diameter: 60cm; depth: 50cm) with adjustable handle is quite useful in large lakes and ponds. Many aquatic beetles and bugs use aquatic vegetation as a shelter. Aquatic vegetation can be taken out to the shore with the pond net and vigorously searched for aquatic insects using a forceps. Make a special effort to sample shores of the water body to collect semi aquatic insects.

Collection of Adult Odonata:

Adult Odonata were collected using an insect sweep net. Collected adults were kept alive in separate paper envelops and starved for one or two days. The starved odonates were killed by dropping in absolute alcohol and drying under 15W blub for overnight. Dried samples were kept in paper envelops with locality lables.

National Zoological Collection studies:

Unidentified collections of Odonata, aquatic Hemipterta and aquatic Coleoptera, collected from Northern Western Ghats deposited at Western Regional Centre, Pune were studied, identified, georeferenced and the data were computerized.

Literature studies:

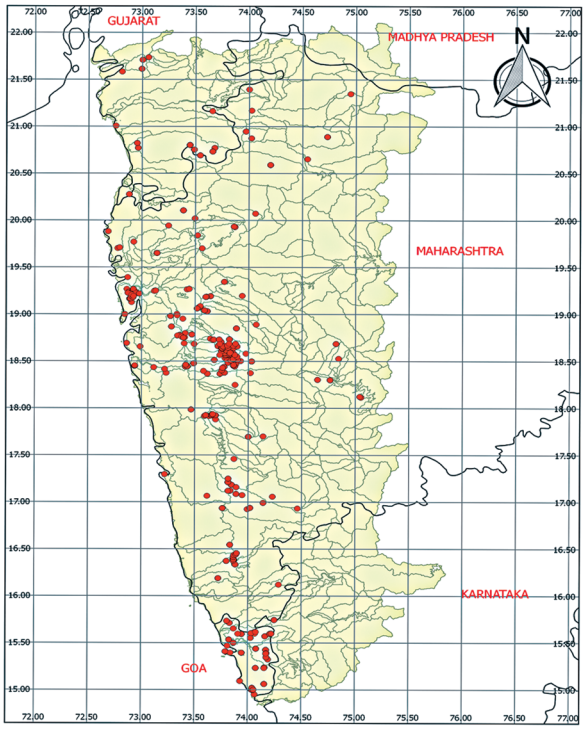
Published literature on aquatic insects of northern Western Ghats was consulted to document their diversity. The details of the literature consulted are provided in the list of references.

RESULTS

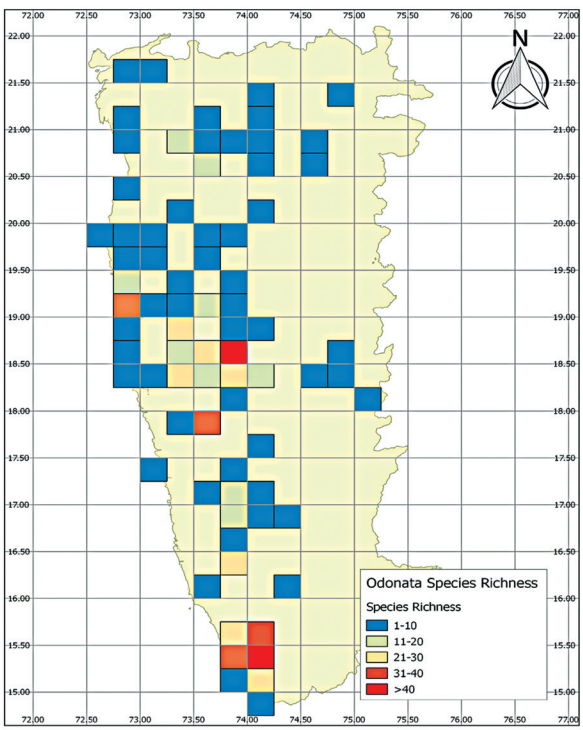
Odonata

A total of 1055 examples of Odonata belonging to 11 families, 51 genera and 83 species were studied from northern Western Ghats. Details of specimen examined are provided below. Among Anisoptera families, Libellulidae was most dominant and Coenagrionidae dominated Zygopteran families. The genera such as, *Trithemis*, *Orthetrum*, *Diplacodes* and *Pantala* dominated northern Western Ghats. Most abundant species were *Trithemis festiva* (Rambur, 1842), *Orthetrum sabina* (Drury, 1770), *Brachythemis contaminata* (Fabricius,1793), *Pantala flavescens* (Fabricius, 1798), *Trithemis aurora* (Burmeister, 1839), *Diplacodes trivialis* (Rambur, 1842). These species are habitat generalists widespread throughout south and south east Asia. They prefer to breed in stagnant water bodies such as pools, ponds and lakes.

Odonata diversity mapping was carried out using 1602 records of 102 species from WRC, Pune collection, current study and published literature. High diversity of Odonata was recorded in Pune and Goa region (Maps 03 & 04).



Map-7. Distribution of Odonata Records



Map-8. Species Richness of Odonata

Rank abundance of Family, Genus & Species

Family	No. Examples
Euphaeidae	5
Macromiidae	5
Lestidae	12
Chlorocyphidae	16
Gomphidae	21
Calopterygidae	27
Platycnemididae	32
Aeshnidae	33
Protoneuridae	36
Coenagrionidae	142
Libellulidae	726
Total	1,055

Genus	No. Examples
Caconeura Kirby, 1890	1
Cyclogomphus Selys, 1854	1
Elattoneura Cowley, 1935	1
Mortonagrion Fraser, 1920	1
Neurobasis Selys, 1853	1
Prodasineura Cowley, 1934	1
Tetrathemis Brauer, 1868	1
Urothemis Brauer, 1868	1
Zyxomma Rambur, 1842	1
Epophthalmia Burmeister, 1839	2
Hylaeothemis Ris, 1909	2
Acisoma Rambur, 1842	3
Anaciaeschna Selys, 1878	3
Cercion Navas,1907	3
Cratilla Kirby, 1900	3
Gynacantha Rambur, 1842	3
Lathrecista Kirby, 1889	3
Macrogomphus Selys, 1857	3
Macromia Rambur, 1842	3
Microgomphus Selys, 1858	3
Sympetrum Newman, 1833	3
Tholymis Hagen, 1867	3
Aciagrion Selys, 1891	4
Brachydiplax Brauer, 1868	4

Genus	No. Examples
Euphaea Selys, 1840	5
Libellago Selys, 1840	5
Paragomphus Cowley, 1934	6
Ictinogomphus Cowley, 1934	8
Palpopleura Rambur, 1842	8
Rhyothemis Hagen 1867	8
Rhinocypha Rambur, 1842	11
Tramea Hagen, 1861	11
Lestes Leach, 1815	12
Potamarcha Karsch, 1890	15
Bradinopyga Kirby, 1893	17
Ceriagrion Selys, 1876	19
Vestalis Selys, 1853	26
Anax Leach, 1815	27
Crocothemis Brauer, 1868	28
Pseudagrion Selys, 1876	30
Copera Kirby, 1890	32
Disparoneura Selys, 1860	33
Neurothemis Brauer, 1867	35
Ischnura Charpentier, 1840	41
Agriocnemis Selys, 1877	44
Brachythemis Brauer, 1868	74
Pantala Hagen, 1861	76
Diplacodes Kirby, 1889	103
Orthetrum Newman, 1833	155
Trithemis Brauer, 1868	172
Total	1,055

Species	No. of Examples
Aciagrion hisopa (Selys, 1876)	1
Aciagrion occidentale Laidlaw, 1919	1
Caconeura ramburi (Fraser,1922)	1
Ceriagrion olivaceum Laidlaw, 1914	1
Cyclogomphus wilkinsi Fraser,1926	1
Elattoneura tetrica (Laidlaw,1917)	1
Gynacantha dravida Lieftinck,1960	1
Lestes umbrinus Selys,1891	1
Macromia indica Fraser,1924	1

Species	No. of Examples
Mortonagrion varralli Fraser,1920	1
Neurobasis chinensis (Linnaeus, 1758)	1
Prodasineura verticalis (Selys,1860)	1
Pseudagrion indicum Fraser, 1924	1
Ischneura nursei (Morton,1907)	1
Sympetrum hypomelas (Selys, 1884)	1
Tetrathemis platyptera Selys, 1878	1
Tramea virginia (Rambur, 1842)	1
Urothemis signata (Rambur, 1842)	1
Zyxomma petiolatum Rambur, 1842	1
Aciagrion pallidum Selys, 1891	2
Copera ciliata (Selys, 1863)	2
Epophthalmia vittata Burmeister, 1839	2
Gynacantha bayadera Selys,1891	2
Hylaeothemis indica Fraser,1946	2
Macromia cingulata Rambur,1842	2
Orthetrum anceps (Schneider, 1845)	2
Sympetrum fonscolombii (Selys, 1840)	2
Tramea limbata (Desjardins,1832)	2
Acisoma panorpoides Rambur, 1842	3
Anaciaeschna jaspidea (Burmeister, 1839)	3
Cercion dyeri (Fraser, 1920)	3
Copera vittata Selys, 1863	3
Cratilla lineata (Brauer, 1878)	3
Lathrecista asiatica (Fabricius, 1798)	3
Macrogomphus annulatus (Selys, 1854)	3
Microgomphus torquatus (Selys, 1854)	3
Tholymis tillarga (Fabricius, 1798)	3
Agriocnemis femina (Brauer, 1868)	4
Brachydiplax sobrina (Rambur, 1842)	4
Pseudagrion rubriceps Selys, 1876	4

Species	No. of Examples
Euphaea fraseri (Laidlaw, 1920)	5
Lestes elatus Hagen in Selys, 1862	5
Libellago lineata (Burmeister, 1839)	5
Orthetrum chrysis (Selys, 1891)	5
Pseudagrion microcephalum (Rambur, 1842)	5
Vestalis apicalis Selys, 1873	5
Lestes viridulus Rambur, 1842	6
Orthetrum luzonicum (Brauer, 1868)	6
Paragomphus lineatus (Selys, 1850)	6
Ictinogomphus rapax (Rambur, 1842)	8
Palpopleura sexmaculata (Fabricius, 1787)	8
Pseudagrion hypermelas Selys,1876	8
Rhyothemis variegata (Linnaeus, 1763)	8
Tramea basilaris (Palisot de Beauvois, 1805)	8
Trithemis kirbyi Selys, 1891	10
Anax guttatus (Burmeister, 1839)	11
Neurothemis fulvia (Drury, 1773)	11
Neurothemis tullia (Drury, 1773)	11
Rhinocypha bisignata Hagen in Selys, 1853	11
Agriocnemis splendidissima Laidlaw, 1919	12
Pseudagrion decorum (Rambur, 1842)	12
Neurothemis intermedia (Rambur, 1842)	13
Trithemis pallidinervis (Kirby, 1889)	13
Orthetrum glaucum (Brauer, 1865)	14
Potamarcha congener (Rambur, 1842)	15
Anax immaculifrons Rambur, 1842	16
Ischnura senegalensis (Rambur, 1842)	16
Bradinopyga geminata (Rambur, 1842)	17

Species	No. of Examples
Ceriagrion coromandelianum (Fabricius, 1798)	18
Orthetrum taeniolatum (Schneider, 1845)	21
Vestalis gracilis (Rambur, 1842)	21
Ischnura aurora (Brauer, 1865)	24
Copera marginipes (Rambur, 1842)	27
Agriocnemis pygmaea (Rambur, 1842)	28
Crocothemis servilia (Drury, 1770)	28
Disparoneura quadrimaculata (Rambur, 1842)	33
Orthetrum pruinosum (Burmeister, 1839)	42
Trithemis festiva (Rambur, 1842)	64
Orthetrum sabina (Drury, 1770)	65
Species	**No. of Examples**
Brachythemis contaminata (Fabricius, 1793)	74
Pantala flavescens (Fabricius, 1798)	76
Trithemis aurora (Burmeister, 1839)	85
Diplacodes trivialis (Rambur,1842)	103
Total	**1,055**

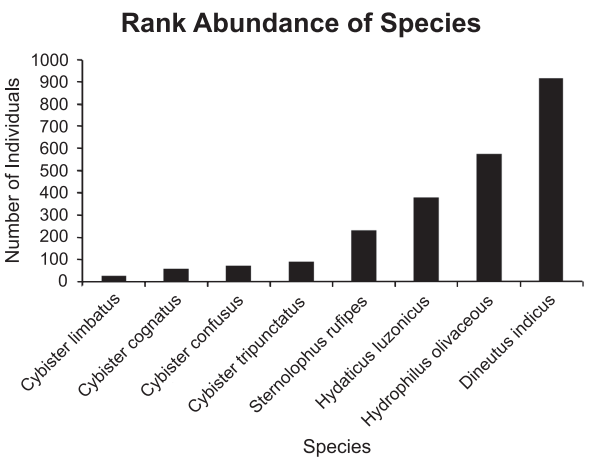
Coleoptera:

A total of 2,333 examples of aquatic Coleoptera belonging to 3 families, 5 genera and 8 species were studied from northern Western Ghats. Details of specimen examined are provided below. Among families, Hydrophilidae was most dominant followed by Gyrinidae and Dytiscidae. The genera such as *Dineutus* and *Hydrophilus* were most dominant. Most abundant species were *Dineutus indicus* Aubé, 1838 and *Hydrophilus olivaceous* Fabricius,1781. All the species reported are widespread generalist species.

Rank Abundance of Family Genus & Species

Family	Frequency	No. Examples
Dytiscidae	16	615
Gyrinidae	5	918
Hydrophilidae	20	800

Genera	Frequency	No. Examples
Cybister	14	239
Dineutus	5	918
Hydaticus	7	376
Hydrophilus	20	573
Sternolophus	6	227
Species	**Frequency**	**No. Examples**
Cybister cognatus Sharp, 1882	8	56
Cybister confuses Sharp, 1882	9	68
Cybister limbatus (Fabricius, 1775)	7	24
Cybister tripunctatus (Olivier, 1795)	12	91
Dineutus indicus Aubé, 1838	5	918
Hydaticus luzonicus Dejean, 1833	7	376
Hydrophilus olivaceous Fabricius, 1781	20	573
Sternolophus rufipes Solier, 1834	6	227
Total		2333



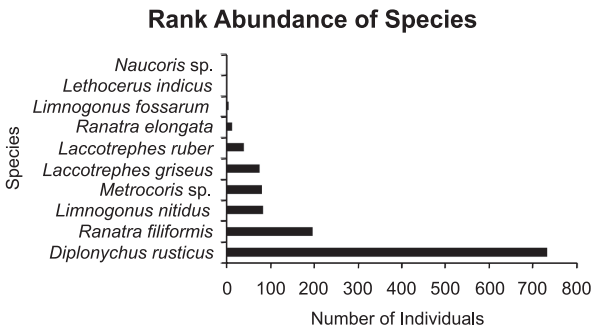
Hemiptera:

A total of 1237 examples of aquatic Hemiptera belonging to 4 families, 7 genera and 10 species were studied from northern Western Ghats. Details of specimen examined are provided below. Among

families, Belostomatidae was most dominant followed by Nepidae and Gerridae. The genera such as *Diplonychus* and *Laccotrephes* were most dominant. Most abundant species were *Diplonychus rusticus* and *Ranatara filiformis.* These species are found in diverse freshwater habitats such as rivers, pools, ponds and paddy fields.

Rank Abundance of Family Genus & Species

Family	Frequency	No. Examples
Belostomatidae	11	733
Gerridae	2	173
Family	**Frequency**	**No. Examples**
Naucoridae	1	1
Nepidae	24	330
	Frequency	**No. Examples**
Genus		
Diplonychus	10	732
Laccotrephes	15	117
Lethocerus	1	1
Limnogonus (Limnogonus)	1	91
Metrocoris	1	82
Naucoris	1	1
Ranatra	17	213
	Frequency	**No. Examples**
Sepecies		
Diplonychus rusticus	10	732
Laccotrephes griseus	13	76
Laccotrephes ruber	12	41
Lethocerus indicus	1	1
Limnogonus (Limnogonus) nitidus	1	86
Limnogonus (Limnogonus) fossarum	1	5
Metrocoris sp.	1	82
Naucoris sp.	1	1
Ranatra elongata	5	14
Ranatra filiformis	16	199
Total		**1237**



SUMMARY AND CONCLUSION

The streams, rivers, reservoirs and ponds of northern Western Ghats covering states of Gujarat and Maharashtra were surveyed to document Odonata, Hemiptera and Coloeoptera. In addition to field studies, specimens deposited in the Western Ghats Regional Centre, ZSI, Pune were also examined. Current study documents 102 species of Odonata (83 from current study and rest from literature) from northern Western Ghats. Ten species of aquatic Hemiptera and eight species of coleoptera were also recorded. All the recorded species have wide geographic distribution and are habitat generalists. These species are adapted to non perennial water bodies and short life cycle. Due to long dry spell which is about 8 months, most of the streams dry up after monsoon. Hence breeding habitats are available only for about 4 months. Due to availability of breeding habitats for a brief period, species which complete lifecycle in short duration dominate the community. However, where ever perennial streams are available, such as in Phansad, the species such as *Euphaea fraseri, Hylaeothemis indica, Caconeura ramburi and Rhynocypha bisignata* are present. This indicate that availability of larval breeding habitats play an important role in species distribution.

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Table-2. State and district wise details of localities.

Sl. No.	STATE	DISTRICT	LOCALITY	LONGITUDE	LATITUDE
1	Goa	Bardez	Porvorim	73.825	15.534
2	Goa	Bicholim	Amona	73.943	15.394
3	Goa	Bicholim	Mayem	73.944	15.593
4	Goa	Canacona	Cotigao	74.043	15.019
5	Goa	Mormugao	Vasco	73.792	15.408
6	Goa	North Goa	Molem	74.175	15.390
7	Goa	North Goa	Rajniwas cabo Goa	73.929	15.092
8	Goa	North Goa	Donapaula, Karanzalem	73.810	15.468
9	Goa	North Goa	Maxem	74.065	14.949
10	Goa	North Goa	Loliem Maxem	74.065	14.949
11	Goa	North Goa	Paigin, Goa	74.041	14.997
12	Goa	North Goa	Bondla	74.079	15.436
13	Goa	North Goa	Cotigaon	74.043	15.019
14	Goa	North Goa	Kalay village near Molem sanctuary	74.172	15.384
15	Goa	North Goa	Arvellum, Goa	74.027	15.551
16	Goa	North Goa	Kodal,Sattari	74.064	15.612
17	Goa	North Goa	Hiware, Sattari	74.063	15.612
18	Goa	North Goa	Nagve village	73.722	16.187
19	Goa	North Goa	Stream 10 km on the way to Phonda	73.799	16.371
20	Goa	North Goa	Lolagam-Maxem	73.909	15.596
21	Goa	North Goa	Kotegaon	74.066	15.597
22	Goa	North Goa	Nagve	73.868	15.651
23	Goa	North Goa	Hiware, Sattari	73.830	15.711
24	Goa	North Goa	Hiware, Sattari	73.830	15.711
25	Goa	Ponda	Paytale and Sada	73.795	15.406
26	Goa	Ponda	Bondla	74.079	15.436
27	Goa	Quepem	Mangal	74.075	15.232
28	Goa	Sanguem	Tudav	74.158	15.237
29	Goa	Sanguem	Doodh Sagar	74.171	15.424
30	Goa	Sanguem	Savri waterfall	74.249	15.743
31	Goa	Sattari	Brahmakarmali	74.163	15.569
32	Goa	Sattari	Cadval	74.207	15.594
33	Goa	Sattari	Derodem	74.220	15.597
34	Goa	Sattari	Cumthal	74.032	15.601
35	Goa	South Goa	Canacona	74.051	14.996
36	Goa	South Goa	Cotigaon	74.043	15.019
37	Goa	South Goa	Bhagwan Mahavir Sanctury	74.175	15.390

Table 2. contd.

Sl. No.	STATE	DISTRICT	LOCALITY	LONGITUDE	LATITUDE
38	Goa	South Goa	Bhagwan Mahavir Sanctuary	74.175	15.390
39	Goa	South Goa	Chicalim	73.839	15.395
40	Goa	South Goa	Patridevi (Patradevi, Perneum)	73.805	15.733
41	Goa	South Goa	Tourist hostel, Vasco	73.791	15.408
42	Goa	South Goa	Gokarde, Canacoa	74.055	15.000
43	Goa	South Goa	Khargel. Paigion (Paiguin)	74.055	15.000
44	Goa	South Goa	Fanasmal. Sanguem	74.155	15.230
45	Goa	South Goa	Vilian Kudi , Range Bhati South Goa	74.190	15.323
46	Goa	South Goa	Arvellum, Goa	74.027	15.551
47	Goa	South Goa	Chorlium	73.660	20.733
48	Goa	South Goa	Kalay village	74.156	15.061
49	Goa	South Goa	Doodh Sagar	74.171	15.424
50	Goa	Tiswadi	St. Cruz & Ribandar	73.868	15.499
51	Goa		Molem	74.175	15.390
52	Goa		Zuari river & around	73.812	17.210
53	Goa		Polayum	73.681	18.511
54	Goa		Keri Nalla	74.174	15.345
55	Goa		Kalay village near Molem sanctuary	74.172	15.384
56	Goa		Stream on the way to Arjuna Dam	74.075	15.615
57	Goa		Stream 1km after Chandor village	73.799	16.371
58	Gujarat	Balsar	Bilmora, Balsar, Gujrat	72.963	20.771
59	Gujarat	Bharuch	Lalit sagar tank, Honsot, Ankleswar	72.811	21.583
60	Gujarat	Bharuch	Ankleswar	72.995	21.613
61	Gujarat	Bharuch	Near Trav nallah ca 1 km Norht of Ankleshwar	72.995	21.613
62	Gujarat	Bharuch	Hansol, Bharuch	73.003	21.708
63	Gujarat	Bharuch	Bank of Narmada river, Bharuch	73.003	21.708
64	Gujarat	Bharuch	Dodh ki khori, ea 6 km east of Bharuch	73.058	21.736
65	Gujarat	Bilimora	Bilmora, Balsar, Gujrat	72.963	20.771
66	Gujarat	Surat	From garden at Bhimpore ca 21 km South West of Surat.	72.754	21.006

Table 2. contd.

Sl. No.	STATE	DISTRICT	LOCALITY	LONGITUDE	LATITUDE
67	Gujarat	The Dangs	Chinchali	73.660	20.733
68	Gujarat	The Dangs	Gir river, near Borepad in Taluka-Ahwa	73.679	20.771
69	Gujarat	The Dangs	Ambika river, Navtnad Rest house. Navasari	73.544	20.692
70	Gujarat	The Dangs	Mahal	73.660	20.733
71	Gujarat	The Dangs	Camp site near Ambika river	73.488	20.753
72	Gujarat	The Dangs	Bharad Pond and around	73.447	20.802
73	Gujarat	Valsad	Bara talab (tank) at Gandur ca 6 km North of Bilimora	72.954	20.822
74	Maharashtra	Bombay	Bombay print vallay	73.632	17.914
75	Maharashtra	Bombay	Sasupada nature trail	72.917	19.221
76	Maharashtra	Bombay	Kanheri Caves	72.917	19.241
77	Maharashtra	Bombay	Hattigate	72.861	19.267
78	Maharashtra	Dhule	Konkangaon. Taluka-Sakri, 13 km South west to Pimpalner	74.022	20.874
79	Maharashtra	Dhule	Shelbari river 7 km South East to taluka-Sakri-Shivelipada	74.732	20.890
80	Maharashtra	Dhule	Shelbari dam, 27 km South East to Sakri	74.732	20.890
81	Maharashtra	Dhule	Panbara. Taluka-Navapur, 30 km South East to Navapur	73.971	20.947
82	Maharashtra	Dhule	Panbara. Taluka-Navarpur, 30 km south east to Navapur	73.971	20.947
83	Maharashtra	Dhule	Jabaala. Taluka-Navapur 14 km west to Navapur	73.657	21.163
84	Maharashtra	Dhule	Malangaon 30 km North West to Pimpalner	74.024	21.169
85	Maharashtra	Dhule	Borpada. Taluka-Navapur, 34 km North East to Navapur	74.001	21.394
86	Maharashtra	Dhule	Sule road 8 km North to Shirpur on Bombay Agra road	74.949	21.348
87	Maharashtra	Kolhapur	Savarai Sada tank and around, Compt.-46	73.894	16.454

Table 2. contd.

Sl. No.	STATE	DISTRICT	LOCALITY	LONGITUDE	LATITUDE
88	Maharashtra	Kolhapur	Khadakwadi, Kolhapur district	74.288	16.119
89	Maharashtra	Kolhapur	On the way to Surangi gate to Rameshwara temple. Compt. No-20	73.881	16.334
90	Maharashtra	Kolhapur	Vasant sagar and around	73.871	16.381
91	Maharashtra	Kolhapur	On the way to Dajipur to Hasane.	73.861	16.389
92	Maharashtra	Kolhapur	Sambarkund and around	73.887	16.440
93	Maharashtra	Kolhapur	Gaganbawda, Kolhapur district	73.832	16.543
94	Maharashtra	Kolhapur	Radhanagari WLS	73.867	16.377
95	Maharashtra	Kolhapur	Wagache pani and around	73.869	16.434
96	Maharashtra	Kolhapur	Sawari Sada cave and around	73.894	16.454
97	Maharashtra	Kolhapur	Pawaneshwar temple and around.	73.881	16.334
98	Maharashtra	Kolhapur	Ugwaidevi Temple and around.	73.864	16.373
99	Maharashtra	Kolhapur	Bhagwati river and around	73.865	16.387
100	Maharashtra	Kolhapur	Naniwale (Hasane) and around	73.864	16.414
101	Maharashtra	Kolhapur	Malewadi dam site	73.865	16.387
102	Maharashtra	Kolhapur	Naniwale(Hasane) and around	73.864	16.414
103	Maharashtra	Mumbai	Mumbai	73.355	18.777
104	Maharashtra	Mumbai	Parel Tank	72.843	18.999
105	Maharashtra	Mumbai City	Mumbai	73.355	18.777
106	Maharashtra	Mumbai City	Parel Tank	72.843	18.999
107	Maharashtra	Mumbai City	Vihar and Pawai lakes	72.905	19.126
108	Maharashtra	Mumbai City, Mumbai suburban	Yeoor	72.948	19.226
109	Maharashtra	Mumbai City, Mumbai suburbans	Near Kanheri Cave	72.917	19.186
110	Maharashtra	Mumbai City, Mumbai suburbans	BetweenKanheri Phata to Borivali Park	72.900	19.205
111	Maharashtra	Mumbai City, Mumbai suburbans	Kanheri Caves	72.907	19.207
112	Maharashtra	Mumbai City, Mumbai suburbans	Between Kanheri carves, Borivali Park	72.901	19.209

Table 2. contd.

Sl. No.	STATE	DISTRICT	LOCALITY	LONGITUDE	LATITUDE
113	Maharashtra	Mumbai City, Mumbai suburbans	Jambhulnal Peak	72.918	19.214
114	Maharashtra	Mumbai City, Mumbai suburbans	Around rest house	72.946	19.224
115	Maharashtra	Mumbai City, Mumbai suburbans	Yeoor	72.948	19.226
116	Maharashtra	Mumbai City, Mumbai suburbans	Lion safari and around	72.879	19.236
117	Maharashtra	Mumbai City, Mumbai suburbans	Silondha	72.941	19.239
118	Maharashtra	Mumbai City, Mumbai suburbans	Tulsi Lake & around	72.922	19.267
119	Maharashtra	Mumbai City, Mumbai suburbans	Nala behind film city	72.887	19.163
120	Maharashtra	Mumbai City, Mumbai suburbans	Nursery garden and around	72.921	19.186
121	Maharashtra	Mumbai City, Mumbai suburbans	Navapada and environs.	72.917	19.186
122	Maharashtra	Mumbai City, Mumbai suburbans	Tulsi nala, Sanjay Gandhi National part, Borivali	72.908	19.195
123	Maharashtra	Mumbai City, Mumbai suburbans	Krishnagiri and around	72.888	19.221
124	Maharashtra	Mumbai City, Mumbai suburbans	Near Upavan Yeoor S.G.N.P	72.955	19.221
125	Maharashtra	Mumbai City, Mumbai suburbans	Hathigate, Goregaon	72.871	19.226
126	Maharashtra	Mumbai City, Mumbai suburbans	Tebipada cross, small stream	72.922	19.267
127	Maharashtra	Mumbai City, Mumbai suburbans	B.M.C. water works and around	72.924	19.770
128	Maharashtra	Mumbai City, Mumbai suburbans	Chenna(E), SGNP, Borivali	72.884	19.227
129	Maharashtra	Mumbai City, Mumbai suburbans	Film city Hattigate	72.891	19.163
130	Maharashtra	Mumbai City, Mumbai suburbans	Sasupada Nature trail Yeoor range	72.917	19.177
131	Maharashtra	Mumbai City, Mumbai suburbans	Light collection on Rest house S.G.N.P. Borivali	72.885	19.224
132	Maharashtra	Mumbai City, Mumbai suburbans	Gandhi Smarak and around	72.871	19.226

Table 2. contd.

Sl. No.	STATE	DISTRICT	LOCALITY	LONGITUDE	LATITUDE
133	Maharashtra	Mumbai City, Mumbai suburbans	Tulsi lake Behind Nursary	72.922	19.267
134	Maharashtra	Mumbai City, Mumbai suburbans	Tulsi Lake Nursary Rd.	72.922	19.267
135	Maharashtra	Mumbai City, Mumbai suburbans	Vasai and around	72.868	19.392
136	Maharashtra	Mumbai City, Mumbai suburbans	Narsuray to Hattigate, Goregaon film city	72.896	19.165
137	Maharashtra	Mumbai City, Mumbai suburbans	On the way Tulsi lake to nursary	72.917	19.177
138	Maharashtra	Mumbai City, Mumbai suburbans	On the way Sasupada Nature trail	72.908	19.197
139	Maharashtra	Mumbai City, Mumbai suburbans	Dhapodem Beat Range Kurdi S.G.N.P	72.901	19.197
140	Maharashtra	Mumbai City, Mumbai suburbans	Garegaon Hattigate	72.871	19.226
141	Maharashtra	Mumbai City, Mumbai suburbans	Tulsilake	72.924	19.192
142	Maharashtra	Nashik	Stream Near Trimbak	73.871	19.928
143	Maharashtra	Nashik	Moshi, Deotal, Nasik	73.862	19.933
144	Maharashtra	Nashik	Mulshi, Deola, Nasik Dist.	73.862	19.933
145	Maharashtra	Nashik	Bhokhadhar, Tal: Niphad	74.201	20.590
146	Maharashtra	Nashik	Aruni River, Satana	74.201	20.590
147	Maharashtra	Nashik	Anami River, Satana	74.201	20.590
148	Maharashtra	Nashik	Devalali, Nasik	74.547	20.653
149	Maharashtra	Nashik	Border of Dhulia & Nasik	74.062	20.072
150	Maharashtra	Nasik	Harsul	73.387	20.105
151	Maharashtra	Nasik	Igatpuri	73.564	19.701
152	Maharashtra	Nasik	Satgauv	73.496	20.019
153	Maharashtra	Pune	Khadakwasala	73.773	18.439
154	Maharashtra	Pune	Below Lakadi Bridge	73.843	18.514
155	Maharashtra	Pune	Pune	73.857	18.521
156	Maharashtra	Pune	Wakade Bagh, Shivaji Nagar	73.839	18.532
157	Maharashtra	Pune	Compund of H.Q.Pune	73.760	18.648
158	Maharashtra	Pune	Law College Compound, Pune	73.810	18.482
159	Maharashtra	Pune	Law College compound	73.829	18.517
160	Maharashtra	Pune	Sambhaji Park	73.847	18.521

Table 2. contd.

Sl. No.	STATE	DISTRICT	LOCALITY	LONGITUDE	LATITUDE
161	Maharashtra	Pune	Nalla near Dilip Roy's Banglow Pune	73.875	18.532
162	Maharashtra	Pune	N.C.L., Compound, Pune	73.811	18.542
163	Maharashtra	Pune	Pune University Campus	73.827	18.552
164	Maharashtra	Pune	University of Poona	73.827	18.552
165	Maharashtra	Pune	Empress Garden, Poona	73.898	18.512
166	Maharashtra	Pune	Shivajinager	73.855	18.532
167	Maharashtra	Pune	Ferguson College Garden, Poona	73.841	18.535
168	Maharashtra	Pune	Sinhagad fort	73.735	18.366
169	Maharashtra	Pune	Bank of Mutha River	73.838	18.508
170	Maharashtra	Pune	Santanesh lodge compound, Lonawala	73.402	18.753
171	Maharashtra	Pune	Xevier's village	73.402	18.753
172	Maharashtra	Pune	Lonawala	73.408	18.797
173	Maharashtra	Pune	Khandala ghat, Zaviar's vill. Khandala	73.614	19.031
174	Maharashtra	Pune	University Campus	73.827	18.552
175	Maharashtra	Pune	Noshrapur Village	73.876	18.247
176	Maharashtra	Pune	Kharagvasala	73.758	18.428
177	Maharashtra	Pune	Pirangut	73.681	18.511
178	Maharashtra	Pune	Moshi	73.847	18.660
179	Maharashtra	Pune	Vadgaon Village	73.643	18.738
180	Maharashtra	Pune	Pawarwadi, Saswad,	74.019	18.373
181	Maharashtra	Pune	Phanswadi dam, Kamte village	73.279	18.868
182	Maharashtra	Pune	Katrajgaon ca 15 km South of Pune	73.860	18.450
183	Maharashtra	Pune	Kondhawa village	73.882	18.469
184	Maharashtra	Pune	Nalla near Pirangut ca 15 miles from Pune	73.681	18.511
185	Maharashtra	Pune	Nalla near Pashan village and Pashan tank	73.780	18.532
186	Maharashtra	Pune	Pashan village	73.796	18.540
187	Maharashtra	Pune	University compound pond, Aundh road	73.827	18.552
188	Maharashtra	Pune	Wagoli village	73.976	18.579
189	Maharashtra	Pune	Rajbag, Loni, Pune	74.071	18.889
190	Maharashtra	Pune	Sindhi colony	73.813	18.549

Table 2. contd.

Sl. No.	STATE	DISTRICT	LOCALITY	LONGITUDE	LATITUDE
191	Maharashtra	Pune	Pune University	73.827	18.552
192	Maharashtra	Pune	Poona University compound	73.827	18.552
193	Maharashtra	Pune	Bank of Mula river near T.B. Hospital, Aundh	73.810	18.568
194	Maharashtra	Pune	Hadapsar fish farm	73.927	18.501
195	Maharashtra	Pune	Behind Law college road	73.829	18.513
196	Maharashtra	Pune	Karla	73.470	18.783
197	Maharashtra	Pune	Lone	74.030	18.497
198	Maharashtra	Pune	Pawana Dam near kamshet	73.491	18.682
199	Maharashtra	Pune	Nalla near Municipal tank, Talegaon	73.667	18.726
200	Maharashtra	Pune	Khed	73.886	18.848
201	Maharashtra	Pune	Stream, 2 km from Kivale village	73.714	18.659
202	Maharashtra	Pune	Saha Village	75.053	18.115
203	Maharashtra	Pune	Khanota Village	75.042	18.122
204	Maharashtra	Pune	Old Bhigwan Village	74.646	18.303
205	Maharashtra	Pune	Hill stream near Talegaon lake	73.676	18.728
206	Maharashtra	pune	Vasran Village, Khandala	73.367	18.772
207	Maharashtra	Pune	Kosale village, Ca 40 N/E of Khandala	73.385	18.951
208	Maharashtra	Pune	Rajapur village, on the way Bhimashankar Road	73.614	19.031
209	Maharashtra	Pune	Bhorgiri & around 7 kms SE. of Bhimashankar Tal: Khed	73.588	19.039
210	Maharashtra	Pune	Beyond Vanaspati point , Bhimashankar, Tal. Ambegaon	73.644	19.191
211	Maharashtra	Pune	Bhimashankar ridge Khandas Vill	73.531	19.069
212	Maharashtra	Pune	E.S.I.S. Hospital campus	73.801	18.580
213	Maharashtra	Pune	Near Akurdi railway station , a temporary pond	73.764	18.649
214	Maharashtra	Pune	Z.S.I. W.R.S., Shivajinagar, Ferguson College Road	74.843	18.527
215	Maharashtra	Pune	Z.S.I. W.R.C. Akurdi	73.760	18.648
216	Maharashtra	Pune	Kothrud (at residence)	73.810	18.482
217	Maharashtra	Pune	Paud road	73.801	18.508

Table 2. contd.

Sl. No.	STATE	DISTRICT	LOCALITY	LONGITUDE	LATITUDE
218	Maharashtra	Pune	Near Pavana river, New Sangvi	73.828	18.589
219	Maharashtra	Pune	New Sangvi	73.828	18.589
220	Maharashtra	Pune	On roadside near Akurdi railway station	73.764	18.649
221	Maharashtra	Pune	Akuardi railway station	73.764	18.649
222	Maharashtra	Pune	On the way Khandala to Khopoli (Bombay-Pune road)	73.336	18.772
223	Maharashtra	Pune	Nigdole	73.549	19.075
224	Maharashtra	Pune	Bhalsi	73.544	19.079
225	Maharashtra	Pune	Ahupe	73.600	19.183
226	Maharashtra	Pune	Bakalon	73.606	19.185
227	Maharashtra	Pune	Kondhwan	73.540	19.074
228	Maharashtra	Pune	On the way of Sambarshingh	73.548	19.086
229	Maharashtra	Pune	Pimple Gurav-Kasarwadi near Pawana	73.828	18.588
230	Maharashtra	Pune	Rahatni near Pawana	73.796	18.608
231	Maharashtra	Pune	Thergaon Boat Club	73.778	18.624
232	Maharashtra	Pune	Valvekarwadi	73.761	18.636
233	Maharashtra	Pune	Valhekarwadi near Pawana River	73.754	18.638
234	Maharashtra	Pune	Rawet Upsa Station	73.748	18.641
235	Maharashtra	Pune	Durga Tekdi	73.759	18.670
236	Maharashtra	Pune	Pimple Nilakh (Mula river)	73.789	18.566
237	Maharashtra	Pune	Pawana River opp. Bus Stop, Old Sangvi	73.820	18.570
238	Maharashtra	Pune	Pawana-Mula Sangam, Old Sangvi	73.831	18.573
239	Maharashtra	Pune	Bopkhel village	73.858	18.583
240	Maharashtra	Pune	Vishalnagar (Wakad) on Mula river	73.778	18.587
241	Maharashtra	Pune	Pimple Gurav near Pawana River	73.828	18.588
242	Maharashtra	Pune	Kasarwadi (Pawana river) near Railway Station	73.820	18.605
243	Maharashtra	Pune	Wakad	73.747	18.606
244	Maharashtra	Pune	Kasarwadi (Pawana river) near Railway Station	73.796	18.611

Table 2. contd.

Sl. No.	STATE	DISTRICT	LOCALITY	LONGITUDE	LATITUDE
245	Maharashtra	Pune	Pimpri-Rahatni Bridge	73.796	18.611
246	Maharashtra	Pune	PCMC Fruit Nursery, Chikhali	73.755	18.630
247	Maharashtra	Pune	Punawale (Pawana river)	73.754	18.637
248	Maharashtra	Pune	Bhosri Dumping station	73.862	18.639
249	Maharashtra	Pune	Tata Lake (Chinchwad)	73.809	18.643
250	Maharashtra	Pune	Ganesh Talav, Nigdi	73.763	18.655
251	Maharashtra	Pune	Charholi Budruk	73.894	18.655
252	Maharashtra	Pune	Moshi lake	73.858	18.663
253	Maharashtra	Pune	Chikhali sewage Plant &	73.803	18.665
254	Maharashtra	Pune	Dudulgaon	73.879	18.684
255	Maharashtra	Pune	Newale wasti, near Chikhali	74.818	18.685
256	Maharashtra	Pune	Tahmini	73.399	18.689
257	Maharashtra	Pune	Talawade vill. Near Indrayani river	73.743	18.705
258	Maharashtra	Pune	Talawade Plant Nursery (PCMC)	73.726	18.729
259	Maharashtra	Pune	Nighorje vill near Indrayani	73.822	18.732
260	Maharashtra	Pune	Ojhar backwater	73.940	19.195
261	Maharashtra	Pune	Bhigwan	74.764	18.300
262	Maharashtra	Pune	Panshet	73.616	18.366
263	Maharashtra	Pune	Sinhagad valley	73.776	18.377
264	Maharashtra	Pune	Varasgaon	73.580	18.395
265	Maharashtra	Pune	Paddy field 3 (Jhalanwadi)	73.751	18.401
266	Maharashtra	Pune	Khadakwasla	73.758	18.428
267	Maharashtra	Pune	Stream 3	73.412	18.442
268	Maharashtra	Pune	Katraj tekdi	73.871	18.443
269	Maharashtra	Pune	Paddy field 1	73.429	18.444
270	Maharashtra	Pune	Stream 2	73.429	18.444
271	Maharashtra	Pune	Stream 4	73.414	18.461
272	Maharashtra	Pune	Stream 1	73.488	18.476
273	Maharashtra	Pune	Mutha River	73.837	18.506
274	Maharashtra	Pune	Empress Garden	73.892	18.512
275	Maharashtra	Pune	CME	73.836	18.586
276	Maharashtra	Pune	Katraj lake	73.861	18.454
277	Maharashtra	Pune	Pune	73.861	18.457
278	Maharashtra	Pune	Empress Gardens	73.898	18.512

Table 2. contd.

Sl. No.	STATE	DISTRICT	LOCALITY	LONGITUDE	LATITUDE
279	Maharashtra	Pune	Pune	73.898	18.512
280	Maharashtra	Pune	Byrobah Nullah	73.898	18.512
281	Maharashtra	Pune	Poona, Satara	73.857	18.521
282	Maharashtra	Pune	Horticulture Gardens	73.894	18.547
283	Maharashtra	Pune	Mula River, Pune	73.732	18.565
284	Maharashtra	Pune	Mullah canal	73.873	18.565
285	Maharashtra	Pune	Moolah river	73.873	18.565
286	Maharashtra	Pune	Pune	73.873	18.565
287	Maharashtra	Pune	Moolah canals	73.873	18.565
288	Maharashtra	Pune	Indraprastha College, New Sangvi	73.825	18.583
289	Maharashtra	Pune	Dehu road	73.732	18.682
290	Maharashtra	Pune	Indrayani River	73.819	18.686
291	Maharashtra	Raigad	Rest House compound Alibag, Kolaba	72.987	18.655
292	Maharashtra	Raigad	Varsoli Bander, 4 km North of Alibag, Kolaba	72.860	18.692
293	Maharashtra	Raigad	Khandala Garden	73.374	18.760
294	Maharashtra	Raigad	Matheran	73.270	18.980
295	Maharashtra	Raigad	Kharbat Stone off 13 km from Roha	73.230	18.374
296	Maharashtra	Raigad	Roha rest house and around.	73.115	18.433
297	Maharashtra	Raigad	Savargaon on Nerul-Karjat road	73.330	19.002
298	Maharashtra	Raigad	Dhawari River near Borgaon vill. Karjat	73.332	18.987
299	Maharashtra	Raigad	Savrat Talav	72.935	18.449
300	Maharashtra	Raigad	Phansadgan	72.937	18.450
301	Maharashtra	Raigad	Chikalgaon stream	72.937	18.453
302	Maharashtra	Raigad	Ganapati Ghat near stream 1, Khandas village	73.519	19.060
303	Maharashtra	Ratnagiri	Sadavli vill. Devrukh, Ratnagiri	73.616	17.065
304	Maharashtra	Ratnagiri	Jaigad	73.219	17.295
305	Maharashtra	Ratnagiri	Suitawade ca 15 km South East of Raigad	73.216	18.416
306	Maharashtra	Ratnagiri	Amba Reserve Forest	73.760	16.934

Table 2. contd.

Sl. No.	STATE	DISTRICT	LOCALITY	LONGITUDE	LATITUDE
307	Maharashtra	Sangli	Dudhari Sangali	74.462	16.931
308	Maharashtra	Sangli	Bivur vill. Shirala, Sangli	74.141	16.990
309	Maharashtra	Sangli	Nivalegaon.Compt. No-31	73.834	17.121
310	Maharashtra	Sangli	Dhigara Amba and around. Compt no-26	73.843	17.184
311	Maharashtra	Sangli	Zolambi-Lapangarh.Compt no-20	73.812	17.210
312	Maharashtra	Sangli	Zolambi. Compt.-21	73.812	17.210
313	Maharashtra	Sangli	Zolambi	73.812	17.210
314	Maharashtra	Sangli	Lapangarh, on the way to Zolambi	73.845	17.183
315	Maharashtra	Sangli	Lapangarh on the way to Zolambi	73.845	17.183
316	Maharashtra	Sangli	Chandoli	73.868	17.458
317	Maharashtra	Sangli	Mokacha Odna and around.	73.812	17.118
318	Maharashtra	Sangli	Kasav pani	73.814	17.248
319	Maharashtra	Satara	Kalyan river	73.118	19.246
320	Maharashtra	Satara	Khandala	73.391	18.750
321	Maharashtra	Satara	Chinchani	72.685	19.881
322	Maharashtra	Satara	Koyna river near Por village	73.591	17.917
323	Maharashtra	Satara	Ambe Nalli near Pratapgad	73.602	17.924
324	Maharashtra	Satara	Ambenali near Mahableshwar	73.602	17.924
325	Maharashtra	Satara	Mahabaleshwar	73.656	17.922
326	Maharashtra	Satara	Ambenali nalla/small stream ca 2 km East of Rest House, Ambenali	73.602	17.924
327	Maharashtra	Satara	Lingmala Falls	73.694	17.923
328	Maharashtra	Satara	Old Mahabaleshwar	73.667	17.935
329	Maharashtra	Satara	Kalachiwadi. Varnawati	73.993	16.923
330	Maharashtra	Satara	On the road near Devar village, Varnawati	74.019	16.936
331	Maharashtra	Satara	Pethland. Varnawati	74.228	17.056
332	Maharashtra	Satara	Kulachiwadi	73.945	17.073
333	Maharashtra	Satara	Near Tambawe village	73.888	17.085

Table 2. contd.

Sl. No.	STATE	DISTRICT	LOCALITY	LONGITUDE	LATITUDE
334	Maharashtra	Satara	Karade hills. Varnawati	73.888	17.157
335	Maharashtra	Satara	Gureghar nursary, Mahabaleshwar	73.602	17.924
336	Maharashtra	Satara	Mahabaleshwar near Venna Lake	73.663	17.933
337	Maharashtra	Satara	Mahabaleshwar Near Venna Lake	73.662	17.933
338	Maharashtra	Satara	Near Dhom dam, Mahabaleashewar	73.662	17.933
339	Maharashtra	Satara	Satara	74.001	17.694
340	Maharashtra	Satara	Yenna Valley	73.694	17.879
341	Maharashtra	Satara	Mahabaleshwar	73.660	17.920
342	Maharashtra	Satara	Connaught peak	73.674	17.922
343	Maharashtra	Satara	Pool at Lingmala	73.693	17.923
344	Maharashtra	Satara	Gymkhana garden	73.666	17.930
345	Maharashtra	Satara	Mahabaleshwar	73.667	17.935
346	Maharashtra	Thane	Palghar, Thana West Coast Survey	72.774	19.702
347	Maharashtra	Thane	From grassfield at Golvira ca 2 km East of Palghar Rest house	72.792	19.709
348	Maharashtra	Thane	Thane	72.978	19.219
349	Maharashtra	Thane	Kalyan	73.130	19.250
350	Maharashtra	Thane	Khutat, Murbad	73.425	19.264
351	Maharashtra	Thane	Murbadi river, Bangarpada, Murbad	73.444	19.268
352	Maharashtra	Thane	Deherja river, Ten village, Vada	73.142	19.650
353	Maharashtra	Thane	Jaisagar dam, Jawhar	73.249	19.943
354	Maharashtra	Thane	Bhilad lake near Silvasa	72.881	20.277
355	Maharashtra	Thane	Malashej Ghat	73.773	19.344
356	Maharashtra	Thane	Vanderi Mane Ghat	73.521	19.840
357	Maharashtra	Thane	Mardhe river, Western ghat Survey	74.139	17.698
358	Maharashtra	Thane	Polddipur	73.465	17.984

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Plate 1 : Stuey of Localities

Dajipur Lake, Radhanagari WLS, Kholapur, Maharashtra

Pond with aquatic weeds, Nadurbar district

Gira waterfalls, Dangs, Gujarat

Punra River, Ahwa Dangs, Gujarat

Purna River, Mahal, Gujarat

Collecting aquatic insects at Chandoli NP

Sorting aquatic insects at Chandoli NP

Plate 2 : Odonata

Neurobasis chinensis

Vestalis gracilis

Rhinocypha bisignata

Caconeura ramburi

Euphaea fraseri

Paragomphus lineatus

Microgomphus torquatus

Trithemis kirbyi

Plate 3 : Aquatic Hemiptera

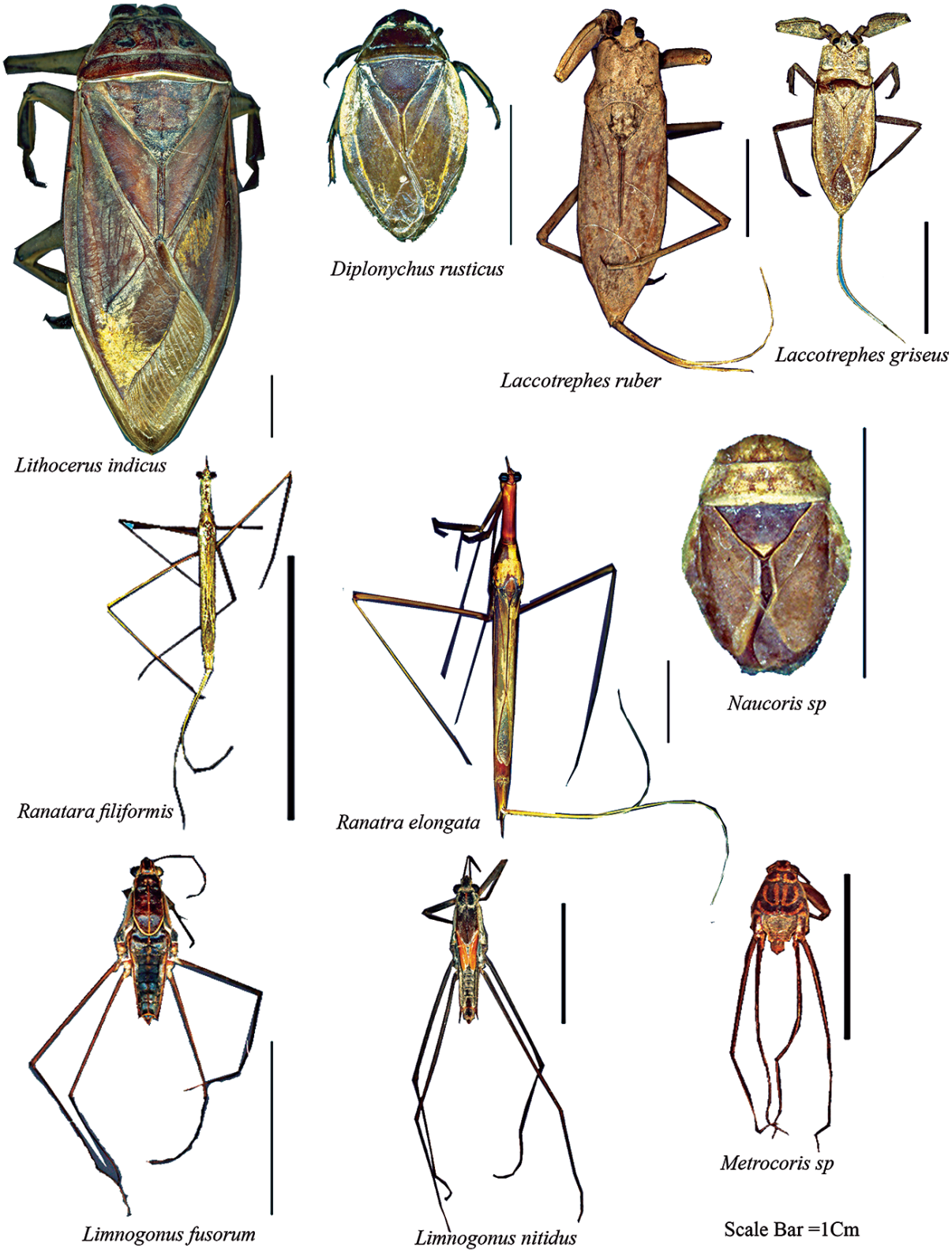


Plate 4 : Coleoptera

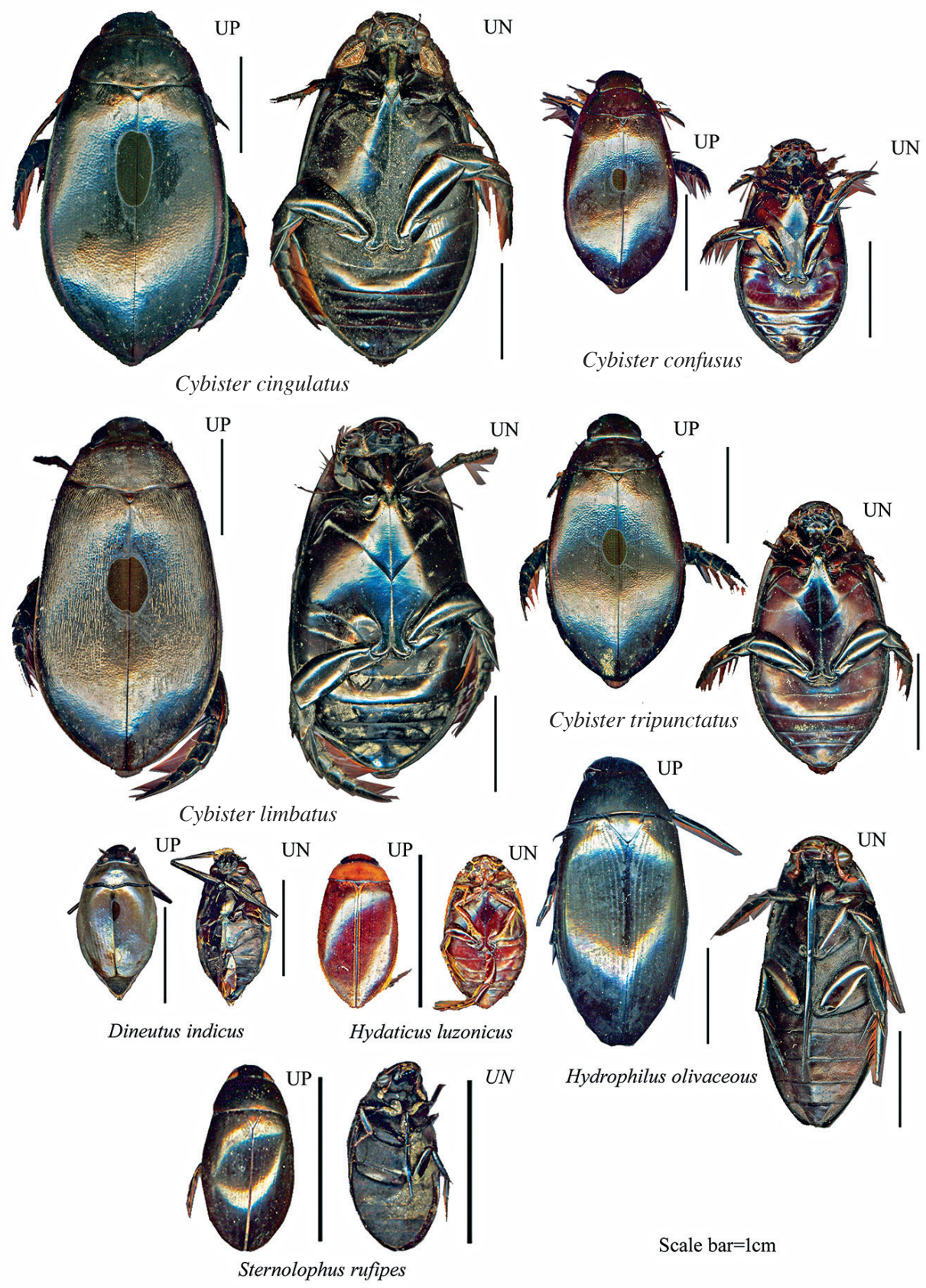
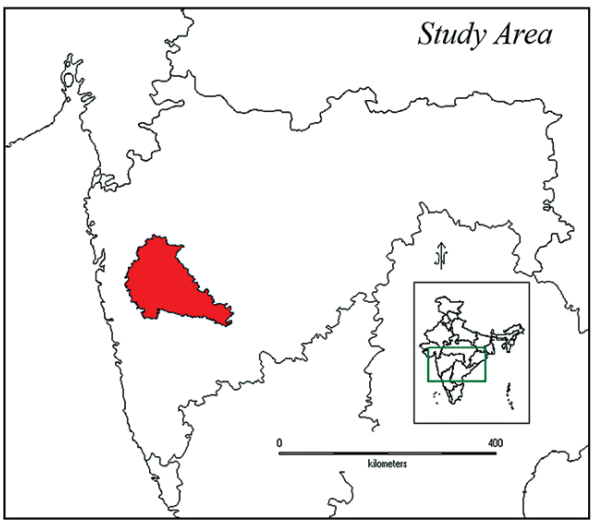
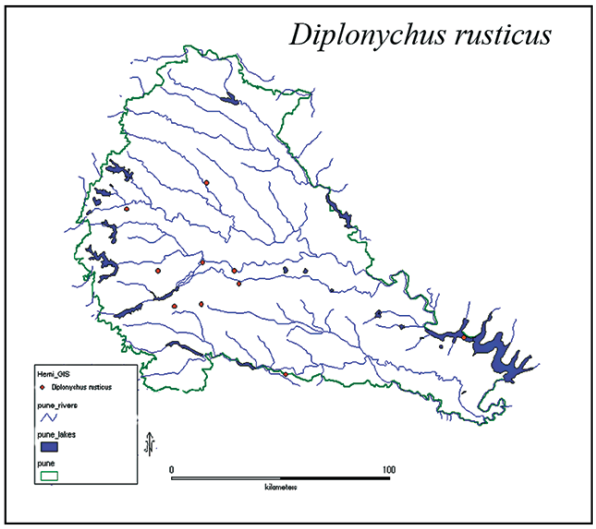
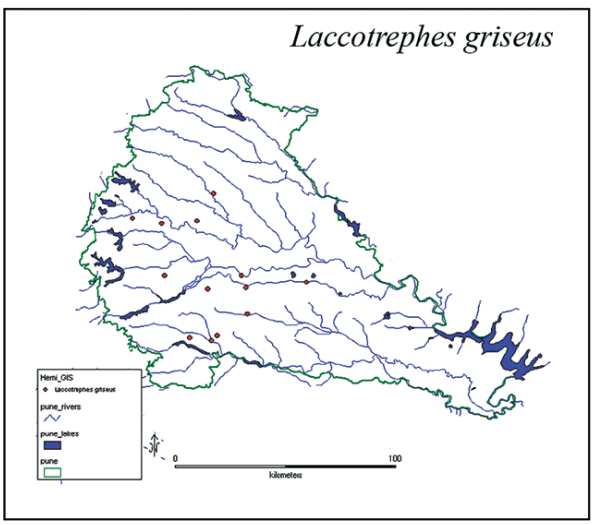
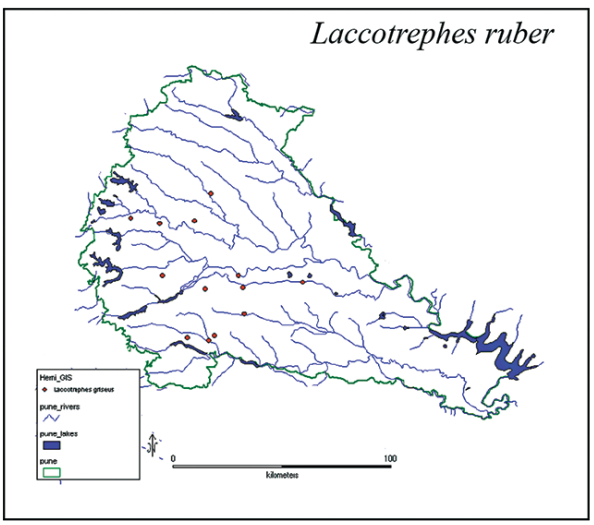


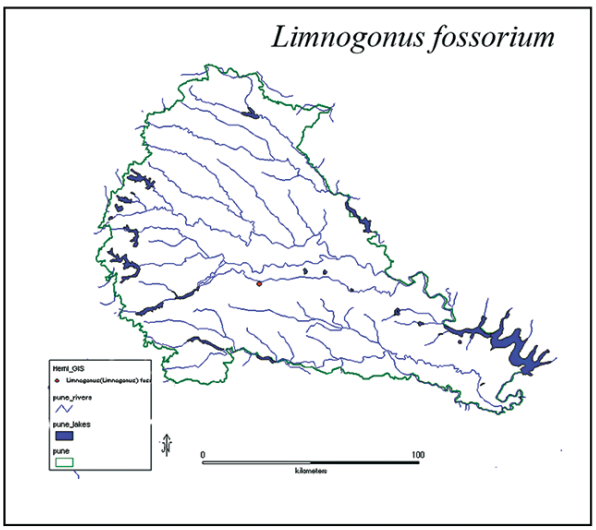
Plate 5 : Hemiptera Species Distribution Maps











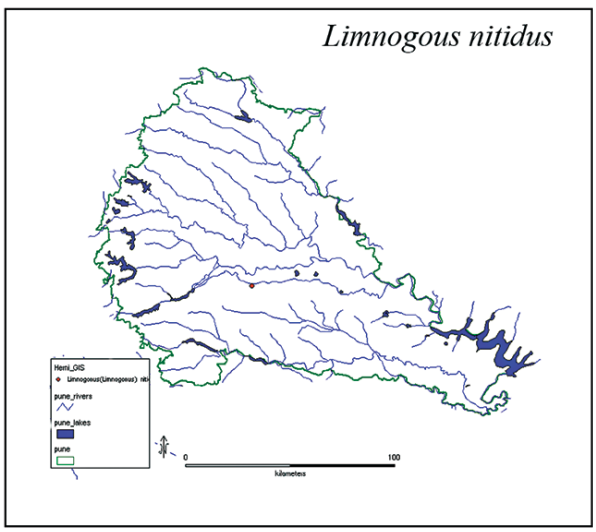
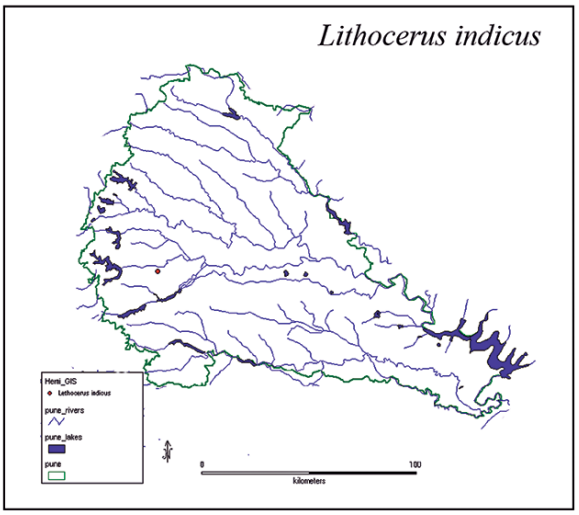
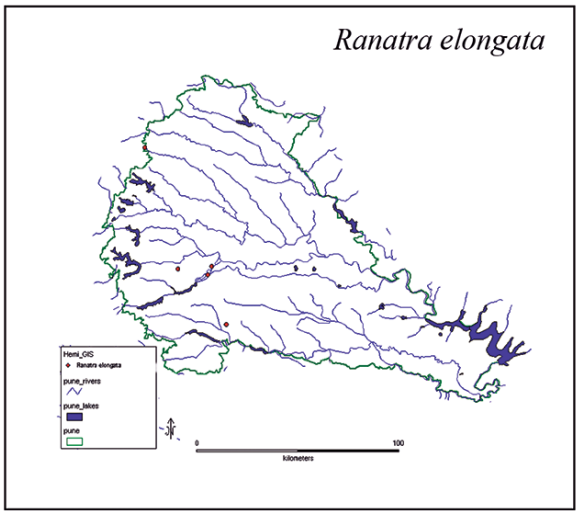
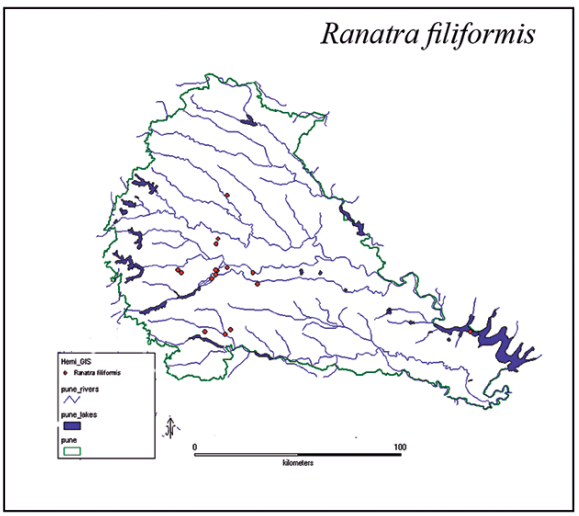
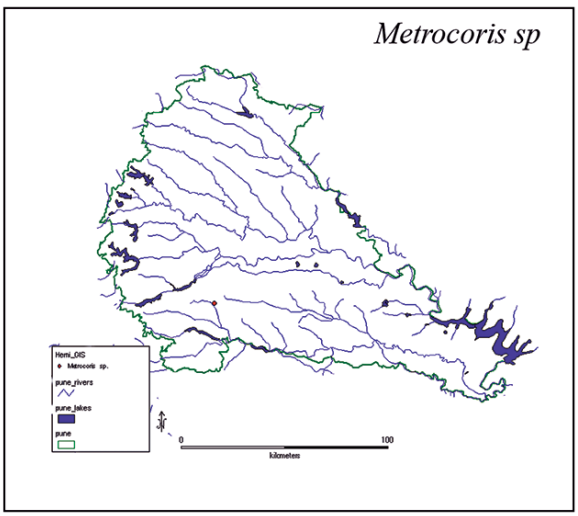


Plate 6 : Hemiptera Species Distribution Maps









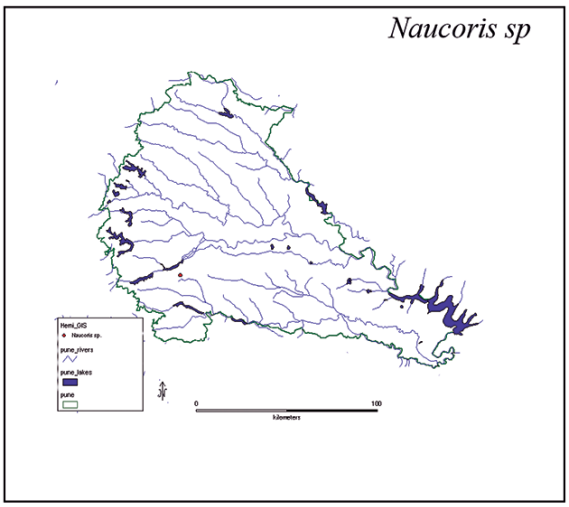
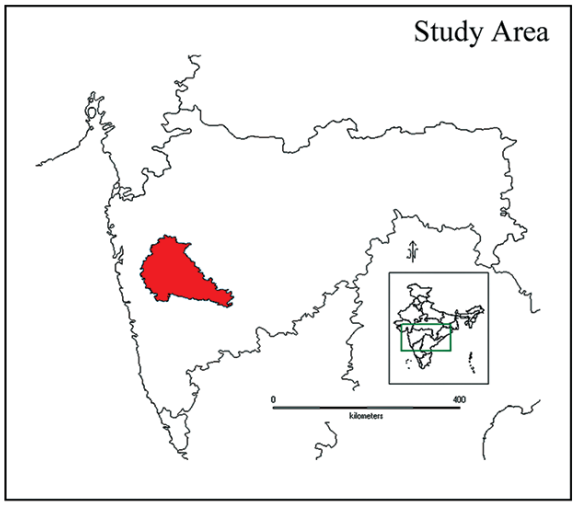
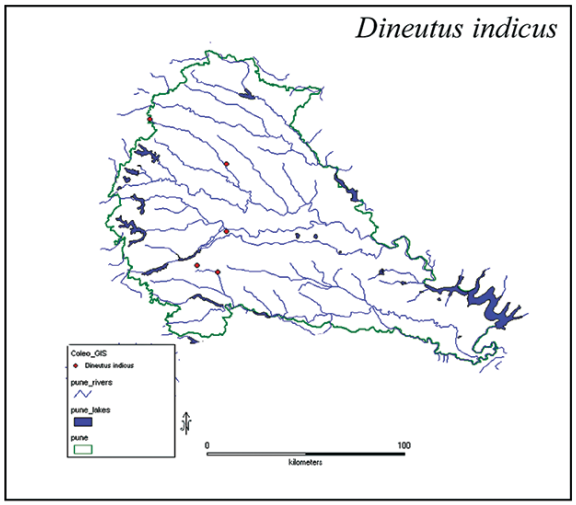
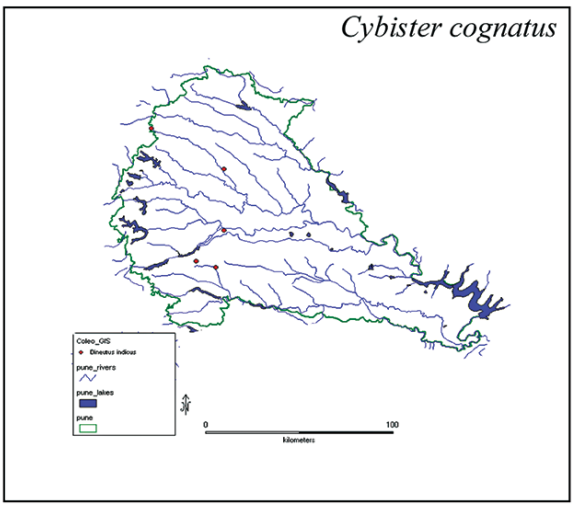
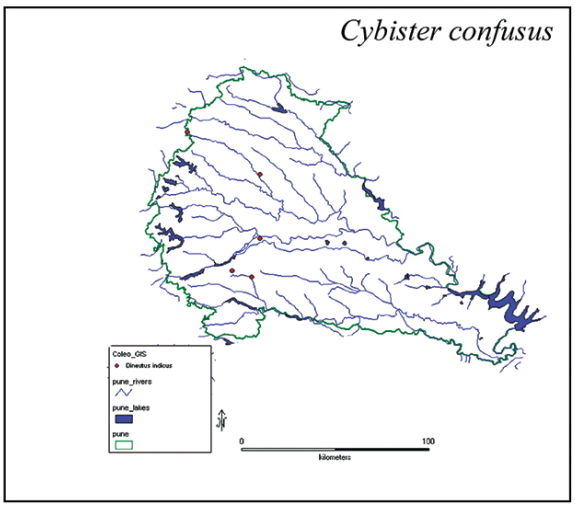


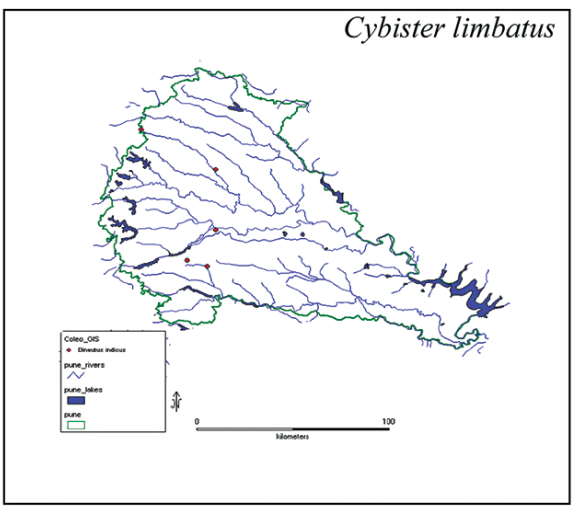
Plate 7 : Coleoptera Distribution Maps











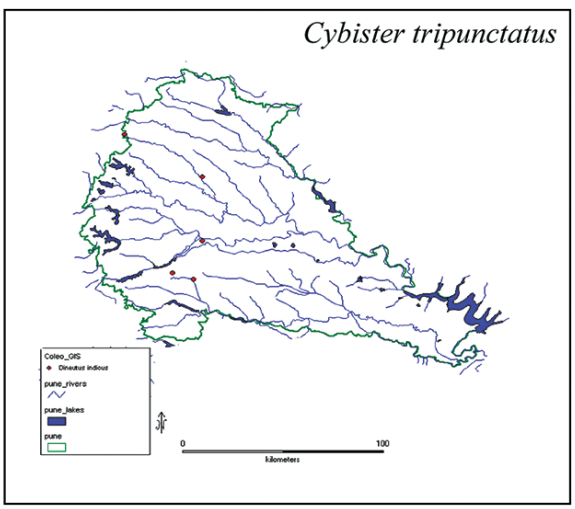
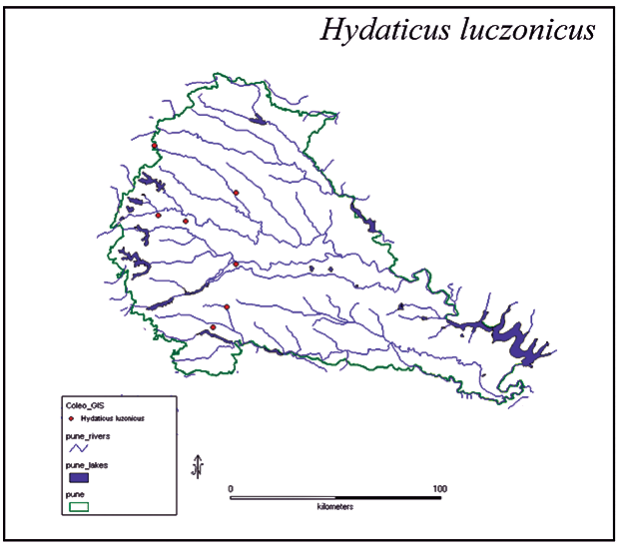
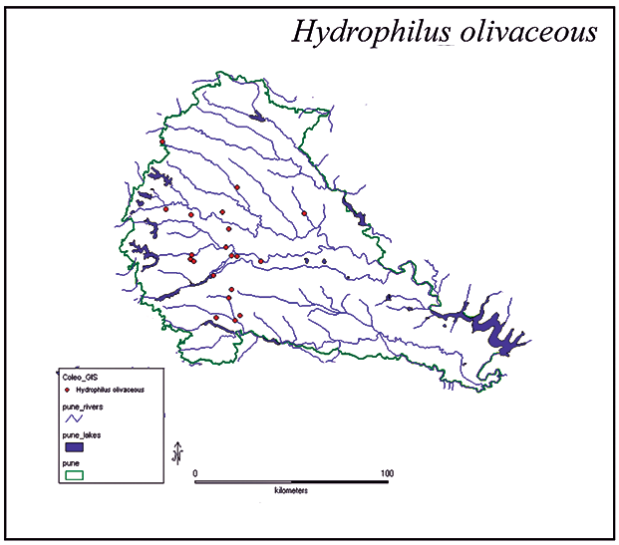


Plate 8 : Coleoptera Distribution Maps

Hydaticus luczonicus



Hydrophilus olivaceous



Sternolophus rufipes