INSECT FAUNA OF STATES AND UNION TERRITORIES IN INDIA

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ABSTRACT

The paper presents an account of the current insect biodiversity in India. For the first time, the insect species diversity of states and union territories is described, and the gaps are highlighted by region and group. An introduction is provided to threatened species of insects, and a strategy for conservation of insects is also discussed.

INTRODUCTION

Insects are the most exuberant manifestations of earth's life. It defies imagination to understand how their simple unifying body plan has been modified to produce an enormous variety of species and how it has been able to exploit almost every conceivable type of environment from the equator to the arctic region and from sea level to the snowfields of the highest mountains, on land, in air and in water—almost everywhere. The class Insecta or the higher taxa-subphylum Hexapoda (which additionally includes Collembola, Protura and Diplura) is the world's most species-rich group of organisms, with over 1 million described species. They are most diverse in tropical forests, where the un-described fauna has been estimated to comprise 5 to 50 million species. Hexapods are a well-established monophyletic group, characterized by the presence of three major body divisions—head, thorax, abdomen—and a single pair of locomotory appendages on each thoracic segment. Some primitive insects have retained appendages on the abdominal segments, but these are much smaller and less functional than those on the thorax. The more derived groups of insects usually have a pair of wings on each of the mesothoracic and metathoracic segments, which have been lost or modified in some groups, especially the Diptera.

The fossil record of insects goes back to the earliest record of terrestrial life, with Collembola and lower insects recorded from the lower Devonian, almost 400 million years ago, and possibly, there are even earlier traces from the Silurian. Insects have been prominent members of the fossil record ever since, with most prominent major groups having been preserved from late Paleozoic or early Mesozoic formations (200-250 million years ago).

There is ample proof that insects were systematically investigated many centuries before Aristotle. Hymns of Atharva Veda on the control of insects attacking crops reflect the variety of pests. Manudharma Sastra (1000 BC) identifies bees and biting insects such as mosquitoes and ants, while the treatise of Charaka (1200 BC) on bees and Shushmita's (100-200 AD) work on stings and his classification of ants (piplika) and flies (mahashikala) are of interest. Amarasimha coined the term shashpada for the Hexapoda nearly 1000 years ago (Ananthakrishnan, 2000).

Modern entomological systematic work was initiated with the establishment of the East India Company, through the abiding interest of amateur entomologists in the armed, civil, forest and medical services. The first entomologist who made an extensive study of Indian insects was J. C. Fabricius (1745-1808), and the publication of Carl Linnaeus' (1758) Systema Naturae (10th edition) provided the earliest record of Indian insects, with descriptions of 28 species. Westwood's (1847) 'Cabinet of Oriental Insects' provides a selection of some of the rarer and more beautiful species of insects native to India (Ananthakrishnan, 2000). Since much of the pioneering work was carried out by British amateur entomologists, who explored various parts of the Indian subcontinent , particularly the hilly areas of the eastern and western Himalaya, the Western Ghats and popular places, much of their material was taken to their country for identification. These efforts led to the publication of several volumes on the Fauna of British India. With the establishment of the ZSI at Kolkata in 1916, regular surveys were carried out in all parts of India including unexplored and inaccessible areas. The Forest Research Institute (FRI), Dehradun, presently under the Indian Council of Forest

Research and Education (ICFRE), and the Indian Agricultural Research Institute (IARI), under the Indian Council of Agricultural Research (ICAR), have contributed to our knowledge of economically important insects of forests and agriculture, respectively.

The kingdom Animalia is represented by 15,52,319 species that have been described so far globally in 40 phyla in a new evolutionary classification. The phylum Arthropoda alone includes 12,42,040 species, constituting about 80% of the total number of species. The most successful group, Insecta, accounts for about 66% (10, 20,007 species in 39 orders) of all animals. The most successful insect order, Coleoptera, represents about 38% (3, 87,100 species) of the insect species of the world (Zhang, 2011). Compilations on the insect fauna of India have been produced from time to time. Maxwell and Howlett (1909) published the book Indian Insect Life, wherein 25,700 species of insect were reported from the Indian region, including adjacent countries. Beeson (1941) and Menon (1965) estimated the number of species from India to be 40,000 and 50,000, respectively. In recent times, Varshney (1997) reported 51,450 species under 589 families. Subsequently, Varshney (1998) reported the occurrence of 59,353 species of insect belonging to 619 families in India.

TAXONOMIC ACCOUNT

KINGDOM ANIMALIA

PHYLUM ARTHROPODA

SUBPHYLUM HEXAPODA

The traditional morphology-based or appearance-based insect classifications have given way to modern classification systems based on evolutionary history and genetic data. All the insects were formerly included in the order Insecta, which is currently classified as Hexapoda, but recently scientists have excluded the orders Collembola, Protura and Diplura from the class Insecta, and these have been upgraded to the class level.

COLLEMBOLA

Commonly known as springtails, these are small, wingless, soft-bodied hexapods measuring usually between 0.2 and 5.0 mm in length and possessing a spring-like jumping organ, the furcula, underneath the fourth abdominal segment. The mouthparts are entognathous. The antennae are usually four-segmented. Compound eyes may be present or absent. There are 8130 described species of Collembola worldwide (Janssens, 2012). The Indian Collembola fauna is represented by 299 species in 103 genera under 19 families (Mandal, 2009), of which 45 species are endemic.

PROTURA

Proturans, with entognathous, piercing mouthparts, are small, wingless, un-pigmented hexapods measuring less than 2.5 mm in length. Antennae and eyes are absent. The anterior legs sensory, and all tarsi are one-segmented, with a single claw. The front legs serve as antennae. A unique feature is the telson tail, which is common in crustaceans but is absent in other insects. The telson tail is used for locomotion and for defense. There are 804 described species of Protura worldwide. From India, presently 20 species have been reported in 10 genera under 3 families (Prabhu, 1986), of which 17 species are endemic.

DIPLURA

Diplurans are elongate, wingless hexapods usually found in moist soil, forest leaf litter and humus and measure 3-28 mm in length. The japygids are easily identified by the pincers at the end of the abdomen (modified cerci), while in the campodeids the cerci are not pincer-like and many segments have long hair. The mouthparts are entognathous, and the antennae are many-segmented. The flagellar segments are provided with muscles. Compound eyes and ocelli are absent. The tarsi have 1 or 2 segments. The abdomen is provided with appendages formed from lateral styli, and cerci are present. The world fauna of Diplura comprises 976 species, and the Indian fauna is represented by 18 species in 9 genera under 4 families (Mandal, 2010b), of which 12 species are endemic.

CLASS INSECTA (TRUE INSECTS)

SUBCLASS APTERYGOTA

Archaeognatha and Zygentoma (Thysanura): The order Thysanura includes some of the most primitive, wingless insects. They are covered with silvery scales. The scales give rise to the common name “silverfish”. The order is cosmopolitan. These insects are larger than the other members of the subclass Apterygota and are easily distinguishable from the other closely related groups by their long, many-segmented antennae, 2 anal cerci and single median telson at the terminal part of the abdomen. The mouthparts are ectognathous, adapted for biting. Over 1200 species of Thysanura have been reported worldwide (Mendes, 1990). In India, the suborder Archaeognatha is represented by 10 species belonging to 6 genera and 2 families, and the suborder Zygentoma includes 28 species belonging to 15 genera and 3 families (Mandal, 2010c). Among the known taxa, 23 species are endemic to India.

SUBCLASS PTERYGOTA

EXOPTERYGOTA

EPHEMEROPTERA

Commonly known as mayflies, this ancient group of aquatic insects evolved 290 million years ago. Mayflies are found in unpolluted wetlands, especially streams and lakes. The adults have a life span of a few hours to a few weeks, depending upon the species. These insects are important benthic macro-invertebrates and play a major role in the degradation of organic matter. They are also reliably used as bio-indicators of water and habitat quality. More than 3000 species of mayfly belonging to 400 genera and 42 families are presently known globally. Of these, 124 species under 46 genera and 12 families have been reported from India, including 72 species endemic to India (ZSI, 2012).

ODONATA

These insects are commonly known as dragonflies (Anisoptera) and damselfies (Zygoptera). They are amphibiotic insects that spend the major part of their life in freshwater ecosystems. The adults are flying insects and have short life spans. The larvae are carnivorous and voracious feeders, while the adults are predaceous insects. This order includes approximately 6000 species in 37 families, under three suborders, namely Zygoptera, Anisozygoptera and Anisoptera. The first consolidated work on Indian Odonata is by Fraser (1933, 1934, 1936), published in three volumes in the Fauna of British India series. Recently, Prasad and Varshney (1995) published a check-list of 499 species and subspecies of Odonata from the Indian region. Presently, 463 species belonging to 139 genera under 19 families are listed from India (ZSI, 2012), of which 115 species are endemic.

PLECOPTERA

These are commonly known as stoneflies and are generally found in high-altitude hill streams of cold temperate regions. The nymphs are found under stones in these streams, and the adults are weak fliers, found near the streams on tree trunks, stones or bushes. Globally, 3788 species of stonefly belonging to 286 genera and 16 families are known; 116 species under 25 genera and 8 families have been reported from India (ZSI, 2012), of which 66 species are endemic.

ORTHOPTERA

This order includes grasshoppers, crickets and katydids, characterized by the presence of enlarged hind legs, which are used to jump great distances. Many katydids are masters of camouflage, with green, leaf-like wings bearing markings that resemble leaf veins, fungal infections and even insect-feeding damage. Some grasshoppers and katydids are strong fliers, whereas crickets are usually much more likely to stay on the ground. Most male Orthoptera produce sound to attract mates, and the calls of katydids and crickets are an integral part of the evening chorus in tropical regions of the world. They are mostly herbivorous, while some are predators. Altogether, 24,276 species of Orthoptera are known globally. A total of 1033 species belonging to 398 genera under 21 families are known from India (Shishodia *et al.,* 2010), of which 563 species are endemic.

PHASMIDA

The walking-sticks are species with long, stick-like bodies covered in warts, bumps and spines. The flattened species, camouflaged like leaves, are appropriately referred to as leaf insects, and all these are herbivorous. Out of 3029 species of leaf insects and stick insects belonging to 391 genera and 7 families known globally, 144 species under 41 genera and four families have been reported from India (ZSI, 2012), 99 of these species being endemic to the country.

DERMAPTERA

Earwigs are a distinctive group of insects that have a pair of forceps-like appendages at the posterior apex of the abdomen. Wings are absent in some species, and when wings are present, they are modified, such that the forewings are shortened and hardened and the hind wings are extensively folded, exposing most of the abdomen. These species are omnivorus, predatory or herbivorous and are nocturnal. They are found in leaf litter, under rocks, in rotten logs or in any hidden crevice. Presently, 1978 species of earwigs are known globally, of which 298 species belonging to 75 genera and 7 families have been reported from India (ZSI, 2012). Among the known taxa, 117 species are endemic to India.

EMBIOPTERA

These insects are referred to as web-spinners. They form a small group of soft–bodied, relatively small, gregarious insects and are found in most tropical and warm temperate climates. The web-spinners are an unusual group of small insects that live in silk galleries of their own production. They are narrow-bodied and wingless (except for some males) and have the first tarsal segment swollen and filled with silk glands. The galleries they spin are found under bark, beneath stones or in the open in more humid regions; from these galleries they feed on vegetable debris, rotten wood, moss or lichens. There are 464 extant embiid species worldwide (Zhang, 2011). In India, the order is represented by 31 species belonging to 5 genera under two families, namely Embiidae and Oligotomidae (ZSI, 2012), of which 14 are endemic to the country.

BLATTODEA

Commonly known as cockroaches, these are flattened terrestrial insects. Usually cryptic and nocturnal scavengers, they were earlier included in the order Dictyoptera. They vary in shape and size from small, delicate species a few millimeters in length to large, bulky forms 6 cm long. They are usually cryptically colored. Presently, 7,314 species of cockroach are known globally, of which 186 species belonging to 58 genera and 12 families have been reported from India (ZSI, 2012). Of these, 60 species are endemic.

MANTODEA

The praying mantids are voracious predators. They have modified, spiny, raptorial forelegs that grasp and crush their prey (usually other insects; very rarely, even small vertebrates). Most mantids are green or brown in colour and resemble leaves or petals of flowers. The camouflage assists them in resisting attacks by predators and in avoiding detection by their prey. Presently, about 2400 species of mantids are known globally, of which 174 species belonging to 72 genera and 11 families have been reported from India (ZSI, 2012). Among the known taxa, 77 species are endemic to India.

ISOPTERA

Commonly known as termites and white ants, these are the only eusocial group of insects other than the Hymenoptera. They feed on cellulose from wood, leaves and plant debris, which is digested in their guts by symbiotic microbial flagellate protozoans or spirochaete bacteria. They have strong social organization, division of labour amongst castes, superb architectural ability, concealed and symbiotic mode of life. These insects are notable for their pest status and the fact that they release methane, a potent greenhouse gas, into our environment. Presently, 2864 species of termites under 195 genera distributed over 9 families are known globally, of which 271 species belonging to 52 genera and 7 families have been reported from India (ZSI, 2012). Of these, 172 species are endemic to the country.

PSOCOPTERA

They are commonly known as bark and book lice. These small insects are less than 1 cm in length, have large, globular heads and rounded bodies, and may or may not bear 2 pairs of wings. They live on plants, on bark, in leaf litter and sometimes in human habitation, and their food is plant, fungus and dead-insect debris. Out of 5720 species of bark and book lice reported from around the world, only 105 species belonging to 16 families have been reported from India. Of these, 15 are endemic.

PHTHIRAPTERA

Commonly known as lice, these are specialized ectoparasites of mammals and birds. Some species, such as the chewing lice, feed on skin, hair or feathers, whereas others, such as the sucking lice, suck blood from their hosts. All these are small, wingless, flattened insects found only on their hosts. So far, 5102 species of lice have been reported globally. A total of 400 species have been reported from India, including 16 endemic species.

HEMIPTERA

This order includes the Heteroptera, or true bugs, and the Homoptera, made up of the cicadas, leaf-hoppers, tree-hoppers, plant-hoppers, aphids, whiteflies, scales and others. All have distinctively modified mouthparts that are in the form of piercing-sucking beaks that they use to obtain food. The predatory species pierce their prey, usually other insects, injecting digestive enzymes to kill and begin the process of digestion. Predation is restricted to some heteropterans—a few also feed on vertebrate blood. The majority of the heteropterans and all the homopterans are plant feeders. Most species are terrestrial, and some are aquatic. Altogether, 103,590 species of Hemiptera belonging to 152 families and 4 suborders are known globally. Of these, 6479 species under 92 families have been reported from India (ZSI, 2012). Among the known taxa, 2421 species are endemic to India.

THYSANOPTERA

The thrips are unusual insects. They are small and slender-bodied, with or without slender, fringed wings. The last tarsal segment of the legs has an inflatable bladder, which is used to improve the grip of an insect on the substrate. The mouthparts are asymmetrical and of the piercing-sucking form and are used to feed on debris, fungi or plants. Altogether, 6019 species of thrips are known globally, of which 686 species under 258 genera and 7 families have been reported from India. A total of 520 species are endemic to the country.

ENDOPTERYGOTA

MEGALOPTERA

These are commonly known as alder flies and dobsonflies. The larvae of megalopterans are predatory and aquatic, usually living in clear, running water. The adults are medium- to large-sized insects, some of them having enormously enlarged

mandibles. So far, 354 species of alder flies and dobsonflies have been reported from around the world. Of these, 25 species under 7 genera and 1 family have been reported from India.

RAPHIDIOPTERA

These are also called snakeflies. The larvae of snakeflies are terrestrial, living on the ground in rotting wood or leaf litter and feeding on smaller insects. So far, 254 species of snakefly have been reported from around the world, and of these 5 species under 2 genera and 1 family have been reported from India.

NEUROPTERA

This group includes lacewings, ant-lions and others. The adults have a greatly elongated prothorax, which gives them a snake-like appearance. Neuropterans are diverse, with a number of forms being elaborate or bizarre. The lacewings are more normal-looking, and the antlions and owlflies are damselfly-like. All are relatively soft-bodied, with large wings that bear elaborately reticulate wing venation. Some adults are known to be predatory, as are most of the immature insects. Immature ant-lions dig conical pits. Their prey falls into these and are grabbed by the waiting larvae. Lacewing larvae prey on aphids and other soft-bodied insects found on foliage. So far, 5868 species of lacewing and ant-lion have been described globally, and of these, 312 species under 112 genera under 12 families have been reported from India.

COLEOPTERA

The beetles represent the greatest proportion of described insect species. More than 1 out of every 4 living organisms is a beetle, and out of the approximately 8,00,000 described species of Insecta, the number of beetle species is 3,59,000 (Arnett *et al.*, 2002; Beutel and Leschen, 2005). This figure has been updated to 3,87,100 species (Zhang, 2011). The Coleoptera are the most successful order of insects in terms of number of species. They are the largest group of organisms in the world. The mesothoracic (first) pair of wings of beetles are greatly strengthened and hardened, such that they are of little or no use in flight but are superb shields when held over the vulnerable abdomen. These hardened forewings, called elytra, are usually held flush over the back of the beetle. The elytra make it slippery and difficult to grasp a beetle, and it is hard and difficult to crush. In many groups, the overall body form is solid, flattened and compact, allowing beetles to hide easily, penetrate cryptic habitats and even burrow extensively in soil. There is no doubt that these modifications have allowed beetles to become the prominent form of insect life on the planet.

Based on estimates including all 169 families of the Coleoptera, more than 3,87,100 species have been described globally and are considered valid. A majority of the species fall under 6 hyper-diverse families (namely the Curculionidae, Staphylinidae, Chrysomelidae, Carabidae, Scarabaeidae and Cerambycidae), each with at least 20,000 species. Differential topography, wide climatic features and varied ecological conditions have contributed to a diversified beetle fauna in India. A part of the fauna has already been worked out and accounts for about 4.86% of all known species of the world, i.e., about 17,455 species belonging to 114 families under 2 suborders, the Adephaga and Polyphaga (ZSI, 2012). Of these, 3100 species are endemic to India.

STREPSIPTERA

These little-known insects are referred to as twisted-winged parasites. These are extremely unusual parasitoids, their hosts being other insects. The adults are highly sexually dimorphic, with the males being free-living, winged insects, whereas the females in all but one family are endoparasitoids—wingless, legless and with only vestigial eyes and appendages on the head. The body of the female extrudes from the body wall of the host, emitting pheromones to attract males that copulate with special openings (external genitalia being absent). So far, 609 species pertaining to 41 genera and 9 families are known globally, of which only 21 species in 8 genera and 4 families are known from India (ZSI, 2012). Of these, 15 species are endemic.

MECOPTERA

These insects are commonly known as scorpion-flies and hanging-flies. The males carry the terminal abdominal segments upturned in the manner of scorpions. Most are terrestrial. The larvae are scavengers, and the adults are scavengers or predators, preying on small insects. The adults and larvae of the unusual brachypterous family Boreidae feed on mosses, whereas the adults of one genus of the Panorpodidae are herbivorous. One family, Nannochoristidae, has aquatic immature forms that feed on larval chironomid midges. Some species have elaborate courtship behaviours involving the presentation of nuptial gifts of dead insects to the female. There are 757 species known from all over the world, representing 9 families. Of these, 23 species belong to two genera, Bittacus and Neopanorpa, are reported from India (Rust and Byers, 1976). Twenty of these species are endemic to India (ZSI, 2012).

SIPHONAPTERA

Fleas are highly modified, laterally flattened, wingless blood feeders. Their hosts are birds and mammals. Usually they are found in the nests of or other areas frequented by their hosts. The larvae are usually free living, feeding on organic detritus and

blood in the droppings of the adults, although some are obligate ectoparasites. The adults are extremely laterally flattened and thus able to travel smoothly between the hairs or feathers of their hosts. Often they have backward-jumping legs that allow them to leap to and from their hosts. So far 2075 species of flea belonging to 151 genera in 18 families have been reported globally. In India, this is the least worked out group, and so far there are only 46 species belonging to 24 genera in 8 families (ZSI, 2012). Of these 15 species are endemic to India.

DIPTERA

These are the true flies and are found nearly everywhere. Their distinctive feature is the reduction of the metathoracic wings to a pair of knob-like halteres that act as gyroscopes in flight. This modification has increased their maneuverability and allowed the Diptera to become unparalleled masters of aerial locomotion. Although some adult flies require extensive protein meals to produce mature eggs and to fly, most of the feeding is done by larvae, which can be predators, scavengers, herbivores, parasitoids and even true parasites. Free-living Diptera larvae are found in soil and rotting vegetation, feeding on plants, sometimes exposed on vegetation. Aquatic forms are found in the silt or sand underlying a body of water (sometimes interstitially), on the surface of rocks, logs or vegetation, or in water columns. Parasitoids attack mostly other arthropods, but some endo-parasites attack mammals. The extant Diptera of the world include 1,59,294 species belonging to 159 families. In India, presently 6337 species of true fly belonging to 1180 genera and 87 families are known, including 110 endemic genera and 2183 endemic species endemic.

LEPIDOPTERA

This order includes butterflies and moths. They are among the best-known insects, especially the colorful, diurnal group called butterflies. Most of the diversity of the group, however, is in the nocturnal, often drably colored, moths, which constitute about 80% of the species of Lepidoptera. The larvae are usually called caterpillars and are best known as voracious feeders on plants. Larval feeding takes place on the surface of the plant or within it (as in leaf miners and stem borers), and almost every plant part—leaf, stem, root, flower and seed—can be affected. Some species are also predatory, and some feed on animal material, such as wool, but almost all species are phytophagous. Adults of most families have mouthparts that are modified to form long, coiled tubes that are used for taking up liquids, usually nectar from flowers. About 15,000 species of moth and butterfly belonging to 84 families are known from India (ZSI, 2012), including 1641 species and subspecies of butterfly (Varshney, 2006). Among the known taxa, about 1500 species are endemic to India, mainly butterflies.

TRICHOPTERA

Caddis-flies are close relatives of the Lepidoptera. Caddis-flies have aquatic larvae that are found in nearly every type of freshwater environment. Most construct cases or shelters from plant material, twigs, stones or sand grains tied together with silk. Some also construct nets to capture debris for food, whereas others are predatory, attacking other aquatic insects. The adults are slender, moth-like insects, often with long, thin antennae. A total of 14,899 caddis-fly species, 610 genera and 46 families are known globally. Of these, 1046 species of caddis-fly belonging to 94 genera and 27 families have been reported from India (ZSI, 2012).

HYMENOPTERA

This order includes bees, wasps, ants, sawflies, *etc*. In general, they possess two pairs of membranous wings, with forewings larger than the hind wings. The forewings and hind wings are held together by small hooks (hamuli), but some species may be wingless. The mouthparts are mandibulate (chewing type). Female hymenopterans usually have a hardened ovipositor that may be modified for sawing, piercing or stinging. The order Hymenoptera is divided into 2 suborders, the Symphyta (sawflies) and the Apocrita. The most primitive families are phytophagous, but a great diversity of parasitoids, predators and plant feeders has evolved from these groups. The parasitoids include some of the smallest known insects, which attack the eggs of their much larger hosts. Other parasitoids attack a variety of immature insects, especially those belonging to other holometabolous groups, and develop as endo- or ecto-parasitoids. Some are obligatory hyper-parasitoids—parasitoids of parasitoids; others oviposit in plant tissue and induce the formation of plant galls, in which the larvae feed. The predatory Hymenoptera attack a wide range of hosts, especially other arthropods, which they often subdue but do not kill with a venomous sting. The larvae of these species have a supply of fresh food to consume when they hatch from an egg laid on the paralyzed prey. Most species hide their prey in some sort of burrow or nest to prevent its being taken by other insects or scavenging animals. Some of these provisioning wasps have moved on to pollen and nectar for food, as with the bees. Sociality has evolved a number of times in the Hymenoptera, with the largest and most complex colonies formed by ants and bees.

A total of 1,16,861 species of Hymenoptera (Sharkey, 2007) have been described from around the world. According to recent expert estimates, more than 12,605 species of Hymenoptera in the 12 superfamilies Proctotrupoidea (6 species), Diaprioidea (139), Platygastroidea (150), Ceraphronoidea (9), Cynipoidea (10), Chalcidoidea (2697), Chrysidoidea (1000), Apoidea (1833), Vespoidea (900), Ichneumonoidea (5500), Stephanoidea (11) and Tenthredinidae (350) are known to have been reported from India (ZSI, 2012).

The current diversity of insects in India as compared with that of the world is presented in Table-1. Of the 39 insect orders known globally, 27 are represented in India. The insect orders Geroptera, Protodonata, Palaeodictyoptera, Mishchopterida, Diaphanopterodea, Paoliida, Caloneurodea, Titanoptera, Grylloblattodea, Mantophasmatodea, Zoraptera, Miomoptera and Glosselytrodea have not yet been reported from India.

Presently, 63,760 species of insect (Hexapoda) in 658 families representing 27 orders and three class are reported from India. Eight orders, *viz.* the *Lepidoptera, Coleoptera, Orthoptera, Diptera, Hemiptera, Odonata, Hymenoptera* and *Thysanoptera*, constitute the bulk (94%) of the insect fauna, while the remaining 21 orders are represented by small numbers (6%) of species. The order Coleoptera has the greatest diversity in terms of families—114 families—followed by *Hemiptera* (92 families), *Diptera* (87 families), *Lepidoptera* (84 families) and *Hymenoptera* (65 families).

Table 1. Major divisions of extant Hexapoda in India

S. No..	Class/order	Common name	Number of species described (world) * (Zhang, 2011)	Species in India** (ZSI, 2012)	Genera	Families
	Subphylum Hexapoda		10,29,741*	63,760		658
	Class Collembola	Springtails	8130	299**	103	19
	Class Protura	Proturans	804*	20**	10	3
	Class Diplura	Diplurans	976*	18**	09	04
	Class Insecta	True insects	10,20,007*	63,423		631
1	Order Archaeognatha	Jumping bristletails	513*	10**	6	2
2	Order Zygentoma	Silverfish	561*	28**	15	3
3	Order Ephemeroptera	Mayflies	3240*	124**	46	12
4	Order Odonata	Dragonflies and damselflies	5899*	463**	139	19
5	Order Plecoptera	Stoneflies	3788*	116**	25	8
6	Order Orthoptera	Grasshoppers, crickets, katydids, etc.	24,276*	1033	398	21
7	Order Phasmida	Walking-sticks	3029*	144**	41	8
8	Order Dermaptera	Earwigs	1978*	298	75	7
9	Order Embioptera	Web-spinners	464*	31**	5	2
10	Order Blattodea	Cockroaches	7314*	186**	58	12
11	Order Mantodea	Mantids	2400*	174**	72	11
12	Order Isoptera	Termites	2864	271**	52	7
13	Order Psocoptera	Bark and book lice	5720*	105	-	16
14	Order Phthiraptera	Lice	5102*	400	-	8
15	Order Hemiptera	True bugs	1,03,590*	6479**	-	92
16	Order Thysanoptera	Thrips	6019*	686**	258	7
17	Order Megaloptera	Alder flies, dobsonflies	354*	25	7	1
18	Order Raphidioptera	Snakeflies	254*	5	2	1

19	Order Neuroptera	Lacewings, ant-lions and others	5868*	312	112	12
20	Order Coleoptera	Beetles	3,87,100*	17,455**	-	114
21	Order Strepsiptera	Twisted-winged parasites	609*	21**	8	4
22	Order Mecoptera	Scorpion-flies	757*	23**	2	2
23	Order Siphonaptera	Fleas	2075*	46	24	8
24	Order Diptera	Flies	1,59,294*	6337	1180	87
25	Order Lepidoptera	Butterflies and moths	1,57,424*	15,000**	-	84
26	Order Trichoptera	Caddis-flies	14,999*	1046**	94	27
27	Order Hymenoptera	Sawflies, ants, bees and wasps	1,16,861*	12,605	65	57

INSECT FAUNA OF STATES AND UNION TERRITORIES OF INDIA

India's insect fauna is distributed over a wide range of ecosystems, climatic regions and altitudes. Publication of the State Fauna Series was started by the Zoological Survey of India in 1987 to make available information on the faunal wealth of all the states and union territories. Twenty states (Odisha, Lakshadweep, West Bengal, Meghalaya, Andhra Pradesh, Tripura, Delhi, Gujarat, Sikkim, Manipur, Bihar, Nagaland, Arunachal Pradesh, Mizoram, Madhya Pradesh, Goa, Tamil Nadu, Uttarakhand, Maharashtra and Andaman and Nicobar Islands) have been covered to date (Editor-Director, 1987-2012). Many groups of insects have been included in the series. The author of the present work has also compiled accounts of the insect biodiversity of the Andaman and Nicobar Islands (Chandra, 1999a), Madhya Pradesh and Chhattisgarh (Chandra, 2004a), Ladakh-Jammu and Kashmir (Chandra and Sidhu, 2009) and Sikkim (Chandra, 2011b). The 50 volumes of the Fauna of British India and 25 volumes of the Fauna of India pertaining to 9 insect orders, namely Odonata (Fraser, 1933, 1934, 1936), Orthoptera (Kirby, 1914; Chopard, 1969), Isoptera (Roonwal and Chhotani, 1989; Chhotani, 1997), Dermaptera (Burr, 1910; Srivastava, 1988, 2003), Hemiptera (Distant, 1902-1918; Ghosh, 1980, 1982, 1984a, 1984b; Ghosh and Quednau, 1990; Ghosh and Agarwala, 1993; Ananthasubramanian, 1996; Ghosh and Ghosh, 2006), Coleoptera (Andrews, 1929, 1935; Arrow, 1910, 1917, 1925, 1931, 1949; Cameron, 1930, 1931, 1932, 1934, 1939a, 1939b; Fowler, 1912; Gahan, 1906; Jacoby, 1908; Vazirani, 1984; Pajni, 1990; Maiti and Saha, 2004, 2009), Diptera (Brunetti, 1912, 1920, 1923; Christophers, 1933; Baraud, 1934; Senior-White *et al*., 1940; Emden, 1965; Joseph and Parui, 1998; Cherian, 2002; Nandi, 2002), Lepidoptera (Hampson, 1892, 1894, 1895, 1896; Bell and Scott, 1937) and Hymenoptera (Bingham, 1897, 1903; Morley, 1913; Mani, 1989a, 1989b; Gupta and Jonathan, 2003) were also referred to in the preparation of the present work. Monographs, special publications, the Conservation Area Series, the Ecosystem Series, Records of the Zoological Survey of India (journal), Occasional Papers and other scattered research papers/articles on insects, including authentic online information, were also consulted to evaluate the insect diversity in all the states and union territories better. Contributions to insect systematic are listed group-wise in Table 2.

Table 2. Selected contributions to insect systematics in India, (by group)

S. No.	Class/order	References
	Subphylum Hexapoda	
	Class Collembola	Mitra (1993); Hazra and Mandal (2007a and b); Mandal (2009); Mandal and Hazra (2009); Janssens (2012)
	Class Protura	Prabhu (1986); Mandal (2010a)
	Class Diplura	Mandal (2010b)
	Class Insecta	
1	Order Archaeognatha	Mandal (2010c)

2	Order Zygentoma	Mendes (1990); Hazra and Mondal (2007a); Mandal (2010c)
3	Order Ephemeroptera	Hubbard and Peters (1978); Sivaramakrishnan et al. (2009)
4	Order Odonata	Fraser (1918-1919); Prasad and Varshney (1995); Mitra (1994, 1999, 2002a, 2002b, 2006); Mitra and Babu (2010); Uniyal et al. (2000); Emiliyamma et al. (2006, 2007); Mitra and Mitra (2009).
5	Order Plecoptera	Das (2008).
6	Order Orthoptera	Kirby (1914); Uvarov (1927); Chopard (1969); Bhowmik (1985a, 1985b); Vasanth (1993); Shishodia (1991); Shisodia et al. (2010)
7	Order Phasmida	Mandal and Yadav (2010)
8	Order Dermaptera	Burr (1910); Srivastava (1988)
9	Order: Embioptera	Kapur and Kripalani (1957)
10	Order Blattodea	Mandal,S.K. (2008)
11	Order Mantodea	Mukherjee et al. (1995); Vyjayandi (2007); Sureshan (2009)
12	Order Isoptera	Maiti (1983); Bose (1984, 1999); Roonwal and Chhotani (1989); Maiti and Chakraborty (1994); Chhotani (1997); Rathore and Bhattacharya (2004)
13	Order Psocoptera	New (1977)
14	Order Phthiraptera	Lakshminarayana (1979, 1982a, 1982b, 1986); Adhikary and Ghosh (1994)
15	Order Hemiptera	Distant (1902-1918); Mathur (1975); Varshney (1976, 1992, 2002); Basu (1981 (1982)); Datta et al. (1985); Ghosh and Dhar (1985); Kandasamy (1985); Datta (1988); Mukhopadhyay (1988); Viraktamath and Wesley (1988); Thirumalai (1989, 1994, 2007); Rao (1990); Chakraborty et al. (1994); Hegde (1994); Ananthasubramanian (1996); Viraktamath (1998); Ambrose (2003); Jesudasan (2003)
16	Order Thysanoptera	Ananthakrishnan and Sen (1980); Sen, Pramanik and Sengupta (1986); Sen (1994)
19	Order Neuroptera	Ghosh (1984, 2000).
20	Order Coleoptera	Gahan (1906); Jacoby (1908); Arrow (1910, 1917, 1925, 1931, 1949); Fowler (1912); Marshall (1916); Maulik (1919, 1926, 1936); Andrews (1929, 1935); Cameron (1930, 1931, 1932, 1937); Balthasar (1963a and b, 1964); Vazirani (1977, 1984); Pal (1985, 2004); Maiti and Saha (1986); Ramamurthy and Ghai (1988); Sengupta (1988); Uniyal and Vats (1988); Uniyal et al. (1989); Supare et al. (1990); Saha et al. (1992); Sengupta and Pal (1996); Poorani and Ramamurthy (1997); Chandra (1999b); Uniyal and Mathur (2000); Chakraborty and Chakraborty (2001); Poorani (2002); Maiti and Saha (2004); Uniyal and Bhargav (2007b); Bhargav et al. (2009).
21	Order Strepsiptera	Kathirithamby (1989)
22	Order Mecoptera	Prasad (1998); Penny and Byers (1979); Chandra (2004b)
23	Order Siphonaptera	Iyenger (1973); Adhikari and Ghosh (1994)
24	Order Diptera	Brunetti (1912, 1920, 1923); Christophers (1933); Datta (1983); Barraud (1934); Emden (1965); Senior-White et al. (1940); Delfinado and Hardy (1973, 1975, 1977); Singh and Ipe (1973); Joseph and Parui (1983, 1984, 1990, 1998); Alfred and Dasgupta (1992); Cherian (2002); Nandi (2002, 2004); Parui et al. (2004); Banerjee and Mitra (2006); Mitra et al. (2008, 2010)
25	Order Lepidoptera	Marshall and De Niceville (1882); De Niceville (1886, 1890); Cotes and Swinhoe (1887-1889); Hampson (1892, 1894, 1895, 1896, 1908, 1912, 1917, 1919, 1930); Evans (1932); Bell and Scott (1937); Talbot (1939, 1947); Wynter-Blyth (1957); Arora (1976 and 1983); Arora and Gupta (1979); Holloway (1984); Gupta and Shukla (1987, 1988); Gupta (1994); Smetacek (1994); Uniyal and Mathur (1998); Varshney (2006); Uniyal (2007); Uniyal and Bhargav (2007a); Kumar (2008); Arora et al. (2010); Bhardwaj and Uniyal (2012); Sanyal et al. (2013)

26	Order Trichoptera	Heigler (1992)
27	Order Hymenoptera	Bingham (1897, 1903); Morley (1913); Hammer (1960); Hayat (1974); Boucek and Subba Rao (1978); Mani (1989a, 1989b); Mani and Sharma (1982); Mukherjee (1994); Tiwari (1999); Sureshan (2003, 2007, 2009); Gupta (2004); Sureshan and Narendran (2004); Narendran and Sudheer (2005); Narendran (2007); Rajamohana (2007); Priyadarsanan (2000); Tak (2008)
28	Miscellaneous	Maxwell-Lefroy (1909); Stebbing (1914); Beeson (1941); Menon (1965); Champion and Seth (1968); Anon (1980, 1991, 2013); Ghosh (1996, 1992-2001); Varshney (1997, 1998); Ananthakrishnan (2000); Mathew and Binoy (2003); Chandra and Rajan (2004); Chandra (2007a, 2007b, 2009a, 2009b, 2011a); Chakravarthy et al. (2008); Alder Peter and Foottit (2009); Chandra and Sidhu (2009); Chandra et al. (2010); Ramakrishna et al. (2010); Sanyal and Alfred (2011); Zhang (2011)

Map 1. Insect fauna of states and union territories in India.

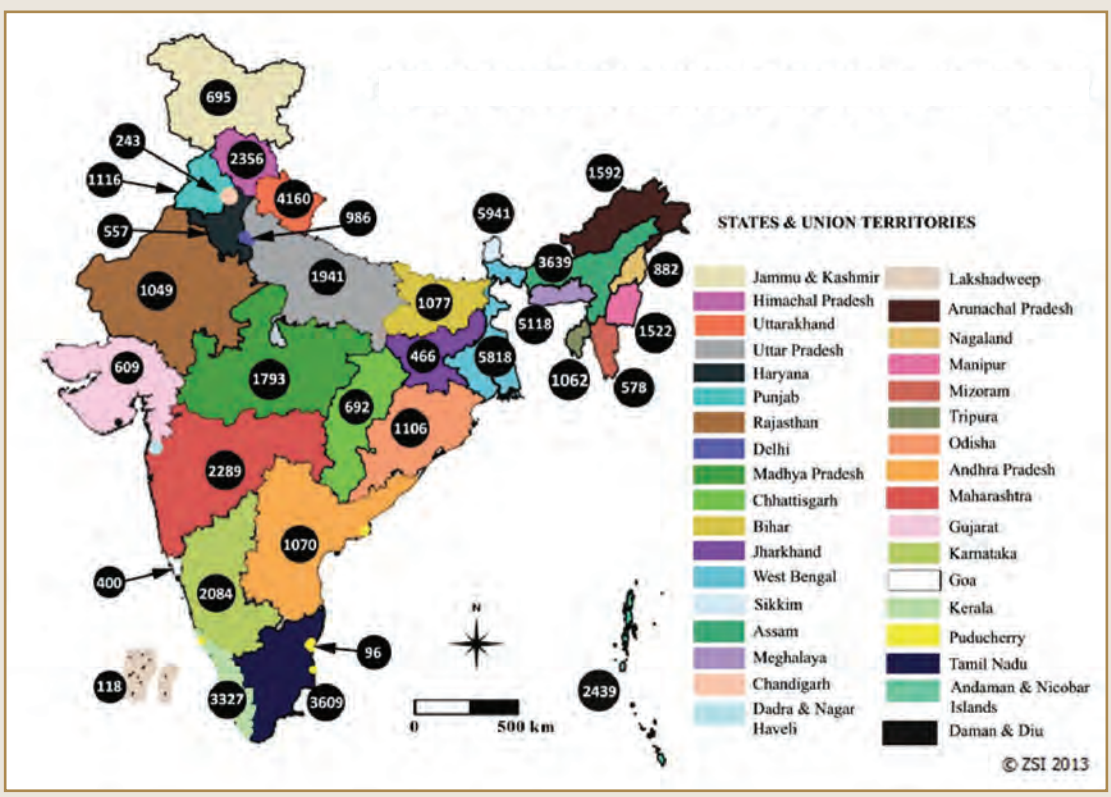

Table 3. Insect fauna of states and union territories, by group

Taxon	Andman and Nicobar Islands	Andhra Pradesh	Arunachal Pradesh	Assam	Bihar	Chandigarh	Chhattisgarh	Delhi	Goa	Gujarat	Haryana	Himachal Pradesh	Jammu & Kashmir	Jharkhand	Karnataka	Kerala	Lakshadweep	Madhya Pradesh	Maharashtra	Manipur	Meghalaya	Mizoram	Nagaland	Odisha	Puducherry	Punjab	Rajasthan	Sikkim	Tamil Nadu	Tripura	Uttarakhand	Uttar Pradesh	West Bengal
Collembola	18	22	27	20								21	15	10		60		27	24	27	11	21	18	21			6	39	24	11	31	35	25
Protura																20																	1
Diplura													1			5			8										4				1
Archaeognatha	2	1										10	4			2													5		1	1	
Zygentoma	1	6						3				5	2						8	3							2	3	5	2	4	4	9
Ephemeroptera	1	1		4	3							25	8	1	5	5		12	19	6	5			5				2	24	5	1	3	17
Odonata	72	68	92	65	63	8	52	47	39	58	17	86	23	109	137	137		90	101	68	151	64	48	58		36	48	45	135	35	122	69	185
Dermaptera	14	3	80	18	5		6	4				30	14		32	19	3	16	13	28	49	15	3	14	4	3	3	50	75	14	36	12	79
Plecoptera				30								20	2		3	6		1	1	8	16					1		6	12			8	21
Embioptera	2	1		3							1				7	4		2			2							6	7		2		8
Orthoptera	85	84	149	221	123	36	81	94	37	22	30	165	77	14	155	129	10	121	146	120	161	94	46	146	19	52	87	123	341	108	144	100	278
Phasmida	4		4	21	3								1		3	6		1	1		11		8					16	20				28
Mantodea	7	13	20	29	14		3		9			20	4	10	23	14	1	31	56	10	25			27			9	17	35	2		55	35
Blattaria	12	14	20	5				9				1			2	2	4	10	12	8	26			12	4		4	17	47	10			23
Isoptera	40	12	44	26	9		6	14	5	60	8	12	16	18	47	56		35	17	22	31	15	11	31		9	61	16	46	27	47	28	55
Psocoptera				22									2			36			14	7	6			1						5			39
Phthiraptera	4	15		16	5		1	6		4	3	20	22		2	6		7	11	18	4		1	1		41	39	35	3		8	28	35
Thysanoptera	29	77	9	24	11	8		116	9	7	17	31	21		145	141		81	63	26	49	1	3	8		45	20	17	321	35	31	88	124
Coleoptera	580	137	73	810	156	17	250	102	4	126	280	205	99	52	144	302	9	355	420	325	911	50	45	198	21	296	239	994	750	283	1074	210	1570
Neuroptera	13	4	9	34	37		24		2			15	10		36	5		33	74	7	45	10		23	1	12	5	36	23	4		13	79
Mecoptera				3			1			1		2			1	3	1	1	2						1			4	7		1		3
Siphonaptera	2			3						1	2	5	8		9	4		2	7	2						2		6	11		1	8	13
Strepsiptera			2		1										2														1				14
Diptera	303	71	272	589	146	72	25	79	7	106		417	135		164	342	3	257	386	92	321	71	69	39		109	135	634	464	119	541	93	681
Lepidoptera	804	153	494	980	250	80	193	111	251	150	124	570	107	209	318	529	84	475	253	269	1775	145	493	141		340	216	2528	319	135	1523	190	1020
Trichoptera	20	4	160	129	36			1				5	22		53	40		24	43	131	158	16		7		24		179	65			154	79
Hymenoptera	176	201	117	227	180	3	20	248	32	62	61	319	83	43	669	997	3	77	339	52	754	7	7	199	31	102	116	619	612	61	181	806	430
Total	2439	1070	1592	3639	1077	243	692	986	400	609	557	2356	695	466	2084	3327	118	1793	2289	1522	5118	578	882	1106	96	1116	1049	5941	3609	1062	4160	1941	5818

DISCUSSION

The insect distribution is mainly influenced by the ecological, climatic and edaphic factors, such as the vegetation, rainfall and temperature. The insect fauna in the Himalayan Zone, including the mountains in Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, north-west Bengal, Meghalaya and Arunachal Pradesh, is influenced by the Palaearctic elements. However, the insect fauna of the desert areas of Rajasthan, Gujarat and Ladakh (cold desert) varies due to variation in extreme temperature in these states. The tropical humid forests of the Western Ghats and the eastern Himalaya are different from the island ecosystems of the Andaman and Nicobar Islands, but the greatest numbers of endemic species occur in these ecosystems.

The present account is a compilation of the information available in about 5000 references. Despite non-uniformity across states and taxa in the available information, certain trends are visible. These trends permit us to infer both gaps in our knowledge and survey the insect fauna of the various states and union territories. It is evident that the insect diversity of Sikkim (5941) is the greatest, followed by those of West Bengal (5818), Meghalaya (5118) and Uttarakhand (4160). All these states are quite well explored, but many more species are expected, possibly up to 15,000 species. The number of species ranges from 2000 to 4000 in the states of Kerala (3327), Tamil Nadu (3609), Karnataka (2084), Maharashtra (2289), Himachal Pradesh (2356), Assam (3639) and the Andaman and Nicobar Islands (2439), and the biodiversity hotspots in India fall in them. These areas are still under-explored, and the diversity therein is expected reach up to 10,000 species. Andhra Pradesh (1070 species), Arunachal Pradesh (1592), Bihar (1077), Madhya Pradesh (1793), Manipur (1522), Odisha (1106), Punjab (1116), Rajasthan (1049), Tripura (1062) and Uttar Pradesh (1941) have 1000 to 2000 species. These states are also under-explored, and their insect diversity is expected to include more than 6000 species. The states of Chhattisgarh, Delhi, Gujarat, Jammu and Kashmir, Haryana, Jharkhand, Mizoram and Nagaland are the least explored, and fewer than 1000 species have been reported from each of them, and the number of species may be up to 4000 species. Fewer than 500 species have been reported from the union territories, namely Chandigarh, Lakshadweep and Puducherry, and the state of Goa. They are almost unexplored, and more than 2000 species may be found if intensive surveys are undertaken (Tables–4 & 5). Very few species (fewer than 100) have been reported so far from Dadra and Nagar Haveli, Daman and Diu. These union territories are not included in the present account.

The numbers of species known to occur in the states and union territories are shown in Map-1. The areas and numbers of species are compared in Table-4 and Figure-1. It is evident from the data in Table-4 that the level of faunal exploration in the various states and union territories varies from 5% to 60%. There is a need to prioritize the areas and the groups to be surveyed so that a better understanding of the the biodiversity is obtained. Moreover, the resources utilized for studying common groups such as butterflies may be reduced, since lesser known groups are neglected. There are some groups, such as Protura, Diplura, Plecoptera, Embioptera, Psocoptera, Phthiraptera, Strepsiptera, Mecoptera and Siphonaptera, that have not been dealt with at all in the last few decades.

The tropical evergreen forests of the eastern Himalaya and the hills of north-east India including the states of Sikkim, Meghalaya, Arunachal Pradesh, Manipur, Nagaland, Tripura and Mizoram and north-west Bengal harbour the greatest number of insect species, followed by the states in which the Western Ghats fall, such as Kerala, Tamil Nadu, Karnataka and Maharashtra. The third biodiversity-rich areas in terms of insects are the western Himalayan region and the Andaman and Nicobar Islands.

There are still many inaccessible areas in the country that have not been adequately explored for assessment of the insect wealth. In some cases, information relating to a particular group of insects is available from only one or a few states. The present study may yield information on not only gap areas at the macro level for all the states and union territories but also gaps relating to taxa at the micro level. This information will help obtain a holistic view of insect biodiversity so that biodiversity may be monitored at various levels across regions and periods.

Table 4. Comparison of area, forest cover and insect fauna in states and union territories

S. No.	States and Union Territories	Total Area (Sq. Km.)	Percentage of the total area of country	Total Forest Cover (Sq. Km)	Percentage of forest cover	Total No. of insect species known	Percentage of Insect diversity	Insect fauna explored (%)
1	Andaman & Nicobar Islands	8249	0.2509	6964	84.42	2439	3.83	50

2	Andhra Pradesh	275069	8.3677	44419	16.15	1070	1.68	20
3	Arunachal Pradesh	83743	2.5475	68019	81.22	1592	2.50	20
4	Assam	78438	2.3861	27826	35.48	3639	5.71	40
5	Bihar	94163	2.8645	5558	5.90	1077	1.69	20
6	Chandigarh	114	0.0035	15	13.16	243	0.38	40
7	Chhattisgarh	135191	4.1126	55998	41.42	692	1.09	20
8	Delhi	1483	0.0451	170	11.46	986	1.55	40
9	Goa	3702	0.1126	2156	58.24	400	0.63	20
10	Gujarat	196022	5.9631	14946	7.62	609	0.96	10
11	Haryana	44212	1.3449	1517	3.43	557	0.87	20
12	Himachal Pradesh	55673	1.6936	14353	25.78	2356	3.70	40
13	Jammu & Kashmir	222236	6.7605	21267	9.57	695	1.09	20
14	Jharkhand	79714	2.4249	22716	28.50	466	0.73	10
15	Karnataka	191791	5.8344	36449	19.00	2084	3.27	40
16	Kerala	38863	1.1822	15577	40.08	3327	5.22	50
17	Lakshadweep	32	0.0010	23	71.88	118	0.19	10
18	Madhya Pradesh	308245	9.3769	76429	24.79	1793	2.81	30
19	Maharashtra	307713	9.3608	46865	15.23	2289	3.59	30
20	Manipur	22327	0.6792	17219	77.12	1522	2.39	50
21	Meghalaya	22429	0.6823	16839	75.08	5118	8.03	60
22	Mizoram	21081	0.6413	18430	87.42	578	0.91	10
23	Nagaland	16579	0.5043	13609	82.09	882	1.38	20
24	Odissa	155707	4.7367	48366	31.06	1106	1.73	30
25	Puducherry	480	0.0146	40	8.33	96	0.15	30
26	Punjab	50362	1.5320	1580	3.14	1116	1.75	30
27	Rajasthan	342239	10.4111	15826	4.62	1049	1.65	30
28	Sikkim	7096	0.2159	3262	45.97	5941	9.32	60
29	Tamil Nadu	130058	3.9564	22643	17.41	3609	5.66	40
30	Tripura	10486	0.3190	8093	77.18	1062	1.67	30
31	Uttarakhand	53483	1.6270	24465	45.74	4160	6.52	50
32	Uttar Pradesh	240928	7.3291	14118	5.86	1941	3.04	20
33	West Bengal	88752	2.6999	12343	13.91	5818	9.12	60
		3,28,7263		6,78,333		63,760		

Table 5. Estimates of insect diversity of states and union territories

S. no.	States and union territories	Number of insect species known	Status of exploration	Status	Estimate of number of species
1	Sikkim, West Bengal, Meghalaya, Uttarakhand	4000 to 6000	Quite well explored	Very rich diversity	>15,000
2	Assam, Kerala, Tamil Nadu, Andaman and Nicobar Islands, Himachal Pradesh, Karnataka, Maharashtra	2000 to 4000	Under-explored	Rich diversity	>10,000

3	Andhra Pradesh, Arunachal Pradesh, Bihar, Madhya Pradesh, Manipur, Odisha, Punjab, Rajasthan, Tripura, Uttar Pradesh	1000 to 2000	Under-explored	Moderate diversity	>6000
4	Chhattisgarh, Delhi, Gujarat, Jammu and Kashmir, Haryana, Jharkhand, Mizoram, Nagaland	500 to 1000	Least explored	Poor diversity	>4000
5	Chandigarh, Dadra and Nagar Haveli, Daman and Diu, Goa, Lakshadweep, Puducherry	0 to 500	Unexplored	Very poor diversity	>2000

ENDEMISM IN INSECT FAUNA OF INDIA

Insect diversity in India is characterized by a high level of endemism. The diversity of insects is greater in the north-eastern states, the Western Ghats and the Andaman and Nicobar Islands, and these areas also have a high level of endemism. A high percentage of endemism is noted in the primitive insect groups, viz., Protura (85%), Diplura (66%) and Thysanura (60%), followed by Collembola (15 %). Among the exopterygotes, Thysanoptera has the highest percentage of endemism (75%), followed by Phasmida (68%), Ephemeroptera (58%), Plecoptera (57%), Orthoptera (54%), Embioptera (45%) and Isoptera (44%), and there is less than 40% endemism in the remaining orders. Among the endopterygotes, the endemism in species level is the highest in Mecoptera (86%), followed by Neuroptera (76%), Strepsiptera (71%), Hymenoptera(71%), Trichoptera (60%), Diptera (35%) and Coleoptera (17 %), while the order Lepidoptera shows only 10% endemism since the moth fauna is widely distributed in the Indo-Pacific region (Table 6).

Table 6. Numbers of endemic genera and species of insect in India

	Class/order	Number of species known in India	Endemic genera	Endemic species	Percentage of species endemic to India
A	Class Collembola	299	22	45	15.05
B	Class Protura	20	4	17	85.00
C	Class Diplura	18	3	12	66.66
D	Class Insecta				
1	Order Thysanura	38	12	23	60.52
2	Order Ephemeroptera	124	-	72	58.06
3	Order Odonata	463	6	115	24.83
4	Order Plecoptera	116	-	66	56.89
5	Order Orthoptera	1033	77	563	54.50
6	Order Phasmida	144	-	99*	68.75
7	Order Dermaptera	298	3	117	39.26
8	Order Embioptera	31	-	14	45.16
9	Order Blattodea	186	14	60	32.25
10	Order Mantodea	174	24	77*	32.25
11	Order Isoptera	271	-	172*	44.25
12	Order Psocoptera	105	-	15	14.28
13	Order Phthiraptera	400	-	16	04.00
14	Order Hemiptera	6479	579	2421	37.36

15	Order Thysanoptera	686	92	520	75.80
16	Order Neuroptera	342	13	262	76.60
17	Order Coleoptera	17,455	923	3100	17.75
18	Order Strepsiptera	21	-	15	71.42
19	Order Mecoptera	23	-	20*	86.95
20	Order Siphonaptera	46	-	15	32.60
21	Order Diptera	6337	107	2183*	35.06
22	Order Lepidoptera	15,000	100	1500	10.00
23	Order Trichoptera	1046	5	650	62.14
24	Order Hymenoptera	12,605	516	9000	71.40
	Total	63,760		21,166	33.40

All data other than those indicated with asterisks are from Varshney (1998).

THREATS AND CONSERVATION

Threats: Changes in habitats all across the country, particularly in fragile ecosystems such as freshwater ecosystems and forests areas, has also impacted the insect diversity of India. Pollution of streams, particularly through drainage and siltation, has resulted in profound changes in aquatic insect communities. The conservation of natural habitats for agricultural purposes, particularly for cultivation of cash crops, has resulted in a great loss of native insect populations. The introduction of exotic insects for the control of pests or weeds directly or indirectly affects the population of native insects. However, the major factor responsible for the loss of insect populations during the last few decades is the widespread use of organic pesticides.

CONSERVATION

There are certain creative approaches needed for the conservation of insect diversity. First and foremost is the maintenance and conservation of natural reserves which are about 5% under the protected area network. There are many specialist species that migrate to specific habitats found in reserves of a particular size. With a reduction in the extent of a habitat in a transformed landscape, population declines or species extinctions may follow. There is a need to maintain as much natural diversity as possible at various spatial levels in a heterogeneous landscape. This will afford opportunities for maximal growth of indigenous species of plant to support endemic species and suppress invasive species. Landscapes must be maintained undisturbed or at a minimal level of disturbance to protect larger assemblages of species and to permit their migration. Small natural patches also have important conservation value for certain insect species and may act as stepping stone habitats for some species. The corridors, which are continuous strips of habitats between large, similar landscapes, are to be established to improve the chances of survival of isolated populations. Various studies have illustrated how insects move along the corridors of natural landscapes. The insect fauna migrates from one region to another, and the population is maintained.

THREATENED SPECIES

The degradation of sensitive and fragile ecosystems, especially forest and freshwater areas, has caused concern among environmentalist and conservation biologists. A total of 99 national parks, 513 wildlife sanctuaries, 41 conservation reserves and 4 community reserves have been notified (Anon, 2008). The Indian Wildlife (Protection) Act, 1972 lists a total of 493 species of insect, including 454 species of Lepidoptera, 38 species of Coleoptera and 1 species of Odonata in 3 Schedules namely I, II and IV (Sharma and Ramamurthy, 2010). Details are provided family-wise in Table–7.

Table 7. Numbers of threatened insect species in India

S. no.	Schedule	Order	Family	Total number of species/ subspecies
1.	Schedule I, Part IV	Lepidoptera		128 species
			Amathusiidae	3
			Danaidae	3
			Lycaenidae	47

			Nymphalidae	37
			Papilionidae	14
			Pieridae	6
			Satyridae	18
		Odonata	Epiophlebiidae	1
2.	Schedule II, Part II	Lepidoptera		307
			Amathusiidae	10
			Danaidae	2
			Erycinidae	1
			Hesperidae	3
			Lycaenidae	116
			Nymphalidae	173
			Papilionidae	21
			Pieridae	21
			Satyridae	156
		Coleoptera		38
			Carabidae	13
			Chrysomelidae	16
			Cucujidae	8
			Inopeplidae	1
3.	Schedule IV, Part IV	Lepidoptera		19
			Danaidae	4
			Hesperidae	9
			Lycaenidae	1
			Nymphalidae	1
			Pieridae	4

The relict Himalayan dragonfly species of Anisozygoptera, Epiophlebia laidlawi, occurring in isolated hill streams in Darjeeling is a great taxonomic curiosity. This species has characters that link the two suborders of the Odonata, namely Zygoptera and Anisoptera, and is protected under the Wildlife (Protection) Act, 1972.

Detailed population studies have not been carried out on many groups of insects. As a result, the distribution ranges of the majority of insects are not yet clearly known. Hence, many species whose populations may be declining and which may be rare are not listed in the threatened category. Documentation of biodiversity is the prerequisite for appropriate conservation strategies, as has been highlighted at the Convention of Biological Diversity (CBD), held in 1992. Taxonomists are at the crossroads since they have no incentive to take up taxonomic studies. With further environmental degradation and increasing deforestation, several taxa of insects will be endangered soon if they are not protected. Many species will become extinct before they are made known to the world.

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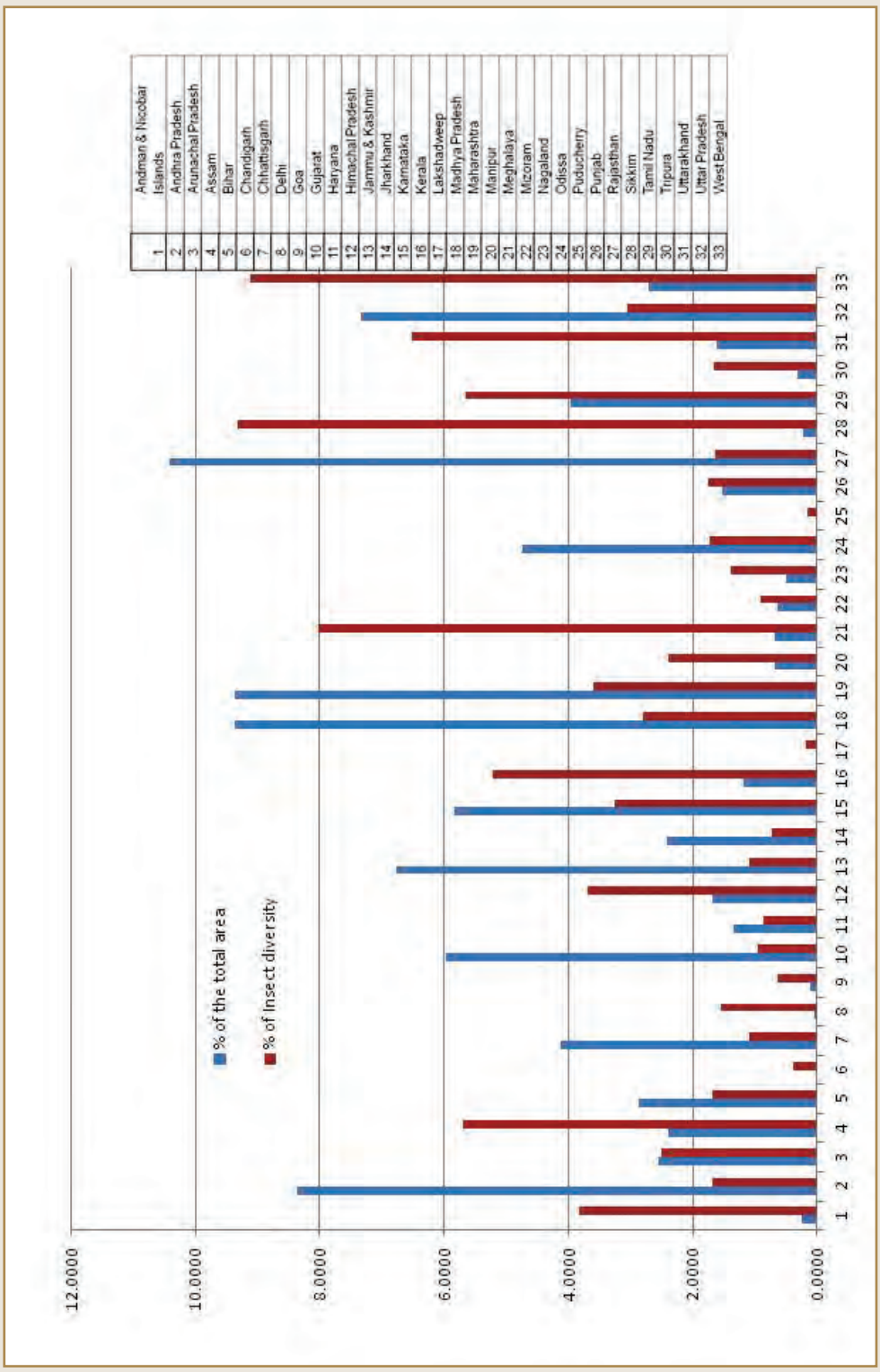
Figure 1.

Comparison of area and insect diversity in states and union territories of India



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