REVIEW OF LITERATURE

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The bees are probably the most beneficial group of insects to man. They are placed in the series Apiformes within the superfamily Apoidea. Apoidea includes both sphecoid wasps and bees. They are treated as two informal series, Spheciformes and Apiformes respectively, following classification suggested by BROTHERS (1975). Studies on bees mainly centred around certain specialized fields such as behaviour, sociobiology, communication, social parasitism etc. and very little study has been done on their systematics especially in India. The world fauna of Apiformes has at least 20,000 species. Here an attempt has been made to review the literature on the systematics of the family Apidae relevant to the present work, with particular emphasis to the oriental region. Recently MICHENER (2000) divided the series Apiformes into 7 families viz., Stenostrictidae, Collectidae, Andrenidae, Halictidae, Melittidae, Megachilidae and Apidae. The family Apidae is divided into three subfamilies viz., Xylocopinae, Nomadinae and Apinae.

The study of bees started with LINNAEUS (1758). He was followed by SCOPOLI (1770), FABRICIUS (1775), LATREILLE (1802), ILLIGER (1802), WESTWOOD (1840), LEPELETIER (1841), SMITH (1854), MICHENER (1944) and many others. In India remarkable works on systematics of bees has been done by BINGHAM (1897).

Studies done by LINNAEUS stood first in the systematics of bees. In his "Systema nature" (1758), he erected the genus Apis with the type species Apis mellifera Linnaeus (designation of Latreille, 1758). He also described the first anthophorine bee as Apis retusa. In 1770, SCOPOLI erected the genus Nomada from Europe with the type species Apis ruficornis Linnaeus (designated by Curtis
1832). In the same year Scopoli also erected the genus *Eucera* with type species *Apis longicornis* Linnaeus (designated by Latreille 1810). Two oriental species of *Ceratina* had been described by Fabricius (1787, 1798) viz., *C. smaragdula* and *C. aenea* under the generic name *Apis* from 'Tranquebar' and 'India orientali' respectively. LATREILLE (1802a) erected the genera *Anthophora* with the type species *Apis pilipes* Linnaeus and *Xylocopa* (1802b) with the type species *Apis violacea* Linnaeus (Designation of Westwood 1840a).

KIRBY (1802) gave the first major account of the bees of any area (Britain), placed all bees in the two genera, *Melitta* Kirby for short-tongued and *Apis* Latreille for long tongued bees. In the same period he erected the genus *Bombus* with the type species *Apis terrestris* Linnaeus (Monobasic designation). LATREILLE (1802b) recoganised the above two groups as families, with certain subgeneric subdivisions. LATREILLE in the year 1805 erected the genus *Ceratina* from Europe with the type species *Ceratina albilabris* Fabricius (based on Monotypy). ILLEGER erected the genus *Melipona* with the type species *Melipona favosa* Fabricius from South-America and oriental region in the year 1806.

PANZER (1806) erected the genus *Nomada* with the type species *Nomada scutellaris* Fabricus. JURINE (1807) described the genera *Pasites* with the type species *Pasites maculata* Jurine (original designation) and *Trigona* with type species *Apis amalthea* Olivier (designation by Latreille 1810). KLUG (1807b) gave a summary listing 32 bee genera. Again LATREILLE in 1809 erected the genus *Ammobates* with the type species *Ammobates rufiventris* Latreille (designation by Latreille 1810).

LEPELETIER (1835, 1841) presented his own classification of bees. He separated the social apinae (*Bombus, Melipona, Apis*) in a separate account (1835). Other bees (1841) were divided into two major groups, the solitary nesters and the parasites. DAHLBOM (1835) placed *Anthophora* in his tribe Anthophorini.
SMITH from 1840 to 1865 gave important contributions to the systematics of bees. SMITH (1854) erected the genus Habropoda with the type species Habrophora ezonata Smith (inversed autobasic designation). The first detailed study of the genus Apis was done by GERSTACKER (1862), in which he included 3-24 species and treated the four subgenera as distinct genera. SCHENCK (1861, 1869) gave an account of bees of Germany and provided classification. DOURS in 1869 published a monograph of Anthophora. THOMSON (1872) prepared a system of classification for bees. SMITH in 1879 described Ceratina sexmaculata from Hong Kong.

ASHMEAD (1890) described some new species of Hymenoptera from Colorado. In 1895 MORAWITZ erected a new genus Tarsalia with the type species Tarsalia hirtipes Morawitz (Monobasic designation). Period from 1895-1949 COCKERELL published several papers pertaining to bee systematics and biology, especially from North America. FRIESE in 1896 published a monograph of Ceratina.

In the year 1897 BINGHAM revised the bees of the Indian subcontinent. He gave key to genera and species, with description of each taxon in his 'Fauna of British India'. FRIESE (1897) erected a genus Amegilla with the type species Apis quadrifasciata Villers (designated by Cockerell). CAMERON in the same year made contributions to systematics of Hymenoptera of the Oriental region. ASHMEAD (1899) modified the classification of the bees and described a new genus Tetraloniella with type species Macrocera graja Evermann (original designation).

CAMERON (1901) described three new genera and seven new species of Hymenoptera from Eastern Asia and Australia. ASHMEAD (1904b) listed Hymenoptera of Philippine Islands, with the description of a new species. In 1904(a) ASHMEAD revised the genus Apis. ROBERTSON (1904) thoughtfully
developed a new classification of bees and his families which was widely accepted by North American hymenopterologists.

MICHENER (1944) revised the classification of the bees of the world. In the same year LIEFTINCK prepared some notes on Malaysian bees of the family Anthophoridae. MICHENER (1944) and SCHWARZ (1948) recognized only two principal genera, *Melipona* and *Trigona* from the tribe Meliponini. RODECK (1945) described two new subgenera of *Nomada* Scopoli viz. *Pachynomada* with the type species *Nomada vincta* Say and *Laminomada* with the type species *Nomada hesperia* Cockerell. RAYMENT (1947) critically revised the species of *Zonata* group of *Anthophora* based on new characters.

POPOV (1950) published a paper on genus *Amegilla* Friese and mentioned the taxonomic position of *Ammobates* Latreille. VAN DER VECHT in 1952 published a preliminary revision of the oriental species of the genus *Ceratina* Latreille. In 1953 MAA revised the classification of the bee genus *Apis*. YU (1954) reported *Xylocopine* bees from Formosa. LIEFTINCK (1956a) revised some oriental anthophorine bees of the genus *Amegilla* Friese. Again LIEFTINCK in the same year (1956b) revised *Xylocopine* bees from Moluccan Islands with notes on the other Indo-Australian species. HURD described subgenera of the world carpenter bees of the genus *Xylocopa* Latreille in the year 1956.

MICHENER and MOURE (1957) studied about the classification of the more primitive and non-parasitic Anthophorine bees. LIEFTINCK in 1958 revised the Indo-Australian species of the genus *Thyreus* Panzer. In this paper he prepared a check list for the species. WILLE (1959a) gave comparative morphology and classification of stingless bees and in 1959b he described a new species of fossil stingless bee from Mexico.
ENDERLEIN and BUTTEL-REEPEN (1906) separately revised the genus *Apis*. BROWN in 1906 reported *Trigona biroi* Friese and *Trigona laeviceps* Smith from Philippine Islands. COCKERELL (1908-1937) published the descriptions of about 30 new species of *Ceratina* in more than a dozen different papers. Again COCKERELL (1911c) described two new species along with few subspecies of *Anthophora*. STRAND (1914) erected the genus *Tetralonioidella* with the type species *Tetralonia hoozana* Strand. DOVER (1924) described the blue banded bees of the *Anthophora zonata* group in British Museum.

In 1928 FRISON mentioned the bumble bees of the Philippine Islands. SKORIKOV (1929b) revised the genus *Apis*. POPOV (1931) erected the genus *Parammabatodes* with the type species *Philarius minutus* Mocsary.

The older classification of bees were based largely on various characters of mouthparts, wings, legs, and scopa. BISCHOFF (1934) was among the first to call attention to various little used characters of the body such as subantenna1 sutures, episternal groove, as well as jugal and vanal lobes of hind wing etc. MAA (1938) reported Indian species of the genus *Xylocopa* Latreille. SCHWARZ in 1939 described the Indo-Malayan speceis of *Trigona* Jurine with a key to their identification. In the same year LINSLEY erected some new subgenera and described some species of epeoline and nomadine bees. He again revised the genus *Oreopasites* Cockerell in 1941.

MOURE in the year 1961 erected the genus *Lisotrigona* with the type species *Melipona cacciae* Nurse. He also classified the old world melioponine bees on the same paper. In the same year MILLIRON revised the classification of the bumble bees. HURD on 1961 prepared a synopsis of the carpenter bees belonging to the subgenus *Xylocopoides* Michener.
LIEFTINCK (1962) revised the Indo-Australian species of the *Thyreus* Panzer. In this paper he gave separate identification key to East Asiatic species and Australo-pauan species and prepared a catalogue of Indo-Australian region. Again in 1963 HURD and MOURE modified the classification of the large carpenter bees. LIEFTINCK in 1966 gave notes on some Anthophorine bees, mainly from the old world.

MICHENER (1966b, 1969, 1970, 1975a,b, 1976, 1977a,b) and MICHENER and SCHEIRING (1976) revised the tribe Allopatini at the generic level, as well as the species of Africa, using character of both adults and immature stages. RICHARDS (1968) divided the genus *Bombus* Latreille subgenerically.

MICHENER (1969) erected the genus *Braunsapis* with the type *Apis faciatus* Gerstaecker. Asian species were placed on the genus *Allodapula* Cockerell for a time (Michener, 1966a); Michener (1969, 1975a) recognized *Allodapula* as a strictly African group and proposed the name *Braunsapis*. The only allodapin bee found in the Oriental region is the genus *Brannsapis*. ROZEN (1969) described a new species of African *Thyreus* with life history of two species of *Anthophora*. SHIOKAWA and SAKAGAMI in 1969 published some additional notes on the genus *Pothitis* in the Oriental region, with descriptions of two new species from India such as *Pithitis indica* and *Pithitis waini*.

MAA (1970) revised the subgenus *Ctenoxylocopa* and treated seven species and a subspecies, in two groups. MILLIRON in 1971 published a monograph of the western hemisphere on the bumble bees of the genera *Megabombus* and *Bombus* Latreille in the same period. HIRASHIMA (1971a) made subgeneric classification of the genus *Ceratina* of Asia and West Pacific with comments on remaining subgenera of the world. He recognized eight subgenera from Asia and West Pacific. In the same year HIRASHIMA (1971b) introduced a new genus *Megaceratina* from Africa with the type species *Ceratina bouyssoui* Vachal. MOURE
(1971) elevated some of the subgenera of Meliponini to the genus level, making his classification of New World Meliponinae were nearly comparable to that of the Old World.


SAKAGAMI (1975) published a paper on continental South east Asiatic stingless bees. BROTHERS in 1975 gave an account of phylogeny and classification of aculeate hymenoptera, with special reference to the Muttilidae. MICHENER (1975a) made a taxonomic study of African allodapine bees. LIEFTINCK in the same year reported the bees of the genus *Amegilla* Friese from Korea and described the new species *Amegilla parhypate*. TSUNEKI in the year 1975 studied the genus *Nomada* Scopoli of Japan.

MARIKOVSAYA (1976) gave the systematics of the tribe anthophorini. ZEUNER and MANNING published a monograph of fossil bees on the year 1976 from Baltic amber. KERR and CUNHA (1976) mentioned taxonomic position of two fossil bees, *Meliponorytes devictus* and *Electrapis proava*, by numerical taxonomic methods. WILLE in the same year reported 5 species of *Melopona* Illeger from Costa Rica.

BATRA (1977) reported bees of India and included their behaviour, management and identification key to the genera. MICHENER (1977a) gave the discordant evolution and classification of allodapine bees. Again MICHENER in 1978 revised the allodapine bees of Madagascar and this included keys,
descriptions and illustrations. SAKAGAMI in 1978 described the stingless bee *Tetragonula* Moure from Continental Asia and Sri Lanka. DRESSLER in the year 1978 described and classified *Euglossa* Latreille with notes on some features of special taxonomic importance. He divided *Euglossa* into 12 species groups and 4 subgenera. HURD (1978a) prepared an annotated catalogue of the *Xylocopa* Latreille of the Western hemisphere. He also made a notes on bamboo-nesting carpenter bees of the subgenus *Stenoxylocopa* Hurd and Moure in the same year (1978b).

HIRASHIMA and TADAUCHI in 1979 reported three species of *Colletes* Latreille and two species of *Epeolus* Latreille and described a new species of *Colletes* from Japan. WANG (1979) described three new species of bumble bees from Tibet viz., *Bombus xizangensis*, *Bombus chayaensis* and *Bombus convexus*.

MARIKOVSKAYA (1980) erected a new genus *Solamegilla* with type species *Anthophora prschwalskyi* Morawitz (by original designation). PLOWRIGHT and STEPHEN in the same year re-investigated the taxonomic status of *Bombus franklini*. SAKAGAMI, MATSUMURA and ITO (1980) described *Apis laboriosa* Smith the little known world's largest honey bee from Himalayas and morphologically compared with *Apis dorsata* Fabricius.

SHIOKAWA and HIRASHIMA (1982) made a synopsis of the *Flavipes* group of the bee genus Ceratina of eastern Asia. It includes 3 species of which two viz., *Ceratina takasagona* and *Ceratina maai* were described as new from Taiwan and Fukein respectively. WARNCKE in 1982 analysed the systematics of bees of the subfamily Nomadinae. PEKKARINEN (1982) gave the morphology and specific status of *Bombus laponicus* (Fabricius) and *Bombus monticola* Smith.

BROOKS in 1983 gave systematics and bionomics of *Anthophora*, the bomboides group and species groups of the new world. ALPATOV made a
contribution to the study of variation in the honey bees, carnolia and crimean bees and their place among other forms of *Apis mellifera* Linnaeus in the year 1983. CAMARGO and MOURE (1983) erected a genus of Meliponinae the *Trichotrigona* from Amazonas, Brazil with the type species *Trichotrigona extranea* Camargo and Moure, by original designation.

In 1984 LAVERTY, PLOWRIGHT and WILLIAMS erected a new subgenus *Digressobombus* with type species *Megabombus digressus* Milliron by original designation and described the male of the rare *Bombus digressus* from Costa Rica. MARIKOVSAYA (1985) studied systematics of the genus *Paramegilla* Friese. This article contains a detailed morphological characteristics of the genus *Paramegilla* and 28 included species with data concerning distribution, phenology, tropic links and a conclusion about supposed evolution of the group. SNELLING and BROOKS at the same period reviewed the genera of cleptoparasitic bees of the tribe *Eriococini*. WILLIAMS made a preliminary cladistic investigation or relationships among the bumble bees in the same year (1985).


KIMSEY in 1987 studied the relationships among the englossine genera and arranged it into two natural groups, *Exaerete* + *Euglossa* and *Eufriesa* (*Eulaema* + *Agale*). SCHWARZ (1987a) made contribution to the clarification of some *Nomada* species described by Morawitz and 7 lectotypes were designated. SCHWARZ in the same year (1987b) described five new species from USSR. They were *Nomada ashabadensis*, *N. kocourekii*, *N. margelanica*, *N. pesenkoi* and *N. spinicosta*. 
WU and KUANG (1987) reported two species of small honeybee of genus *Micrapis*.

DALY in 1988 erected a genus *Ctenoceratina* with the type *Ceratina armata* from Africa south of the Sahara. RUTTNER (1988) revised the taxonomy of honey bees. BROOKS (1988) studied systematics and phylogeny of the Anthophorine bees. He reviewed the subgenera and genera of Cosmopolitan tribe Anthophorini. He reported two genera and 14 subgenera, of which seven were new. YAN RUWU described a new species, *Anthophora antennalis* from China in the same year. McEVOY (1988) made a taxonomic history of the Himalayan honeybee *Apis laboriosa*. In this article he reviewed the morphological and biological characters that distinguish *Apis laboriosa* from *Apis dorsata*. BROEMELING (1988) revised the subgenus *Pachynomada* Rodeck of *Nomada* Scopoli, fourteen species were recognised.

SAKAGAMI and INOUE in 1989 described a new species of *Trigona* viz., *Trigona incisa* from Sulawesi. MOURE (1989a) described *Glossuropoda*, a new subgenus of *Euglossa* with the type species *Euglossa intersecta* Latreille. In this paper he also described two new species from Amazonia. LA BERGE in the same year reviewed the bee genus *Pectinapis* La Berge and described a new species *Pectinapis salviae* from London. He also provided a key to species in the above article. MOURE (1989b) described two new species of *Paratrigona* from Amazon region viz., *Paratrigona myrmecopila* and *P. pannosa*. PESENKO et al. (1989) described in detail the Chinese wax bee *Apis cerana cerana* in the Soviet Far East. Again MOURE in the same year (1989c) erected a new genus *Sakagamilla* with type species *Sakagamilla affabra* from Brazil. MCGINLEY reviewed the immature Apoidea and prepared a catalog in 1989.

MICHENER (1990a) reviewed the classification of the family Apidae. Here alternative phylogenies for the subfamilies are presented. The Meliponinae is
considered in greatest detail and 21 genera were recognized. Keys were provided for genera and subgenera. REYES in 1990 studied parasitic allodapine bee and its hosts in Java and Malaysia. Again MICHENER in 1990b described a new species Liotrigona nilsoni.

REYES revised the Bee genus *Braunsapis* in the Oriental region in the year 1991. 19 species were treated. Eight species were described, as new, namely, *B. flaviventris*, *B. malliki*, *B. clarithirta*, *B. apicalis*, *B. lateralis*, *B. signata*, *B. aurantipes* and *B. indica*. In this work he synonymised many species of *Allodaphe* with *Braunsapis*. CUNHA (1991) made phenetic review of the taxonomy of some Meliponine bees. CAMARGO and ROUBIK (1991) made a systematic revision and gave biological account of *Trigona hypogea* group, along with descriptions of a new species *Trigona necrophaga* and the *Trigona crassipes* (Fabricius) from Amazon area. ROIG-ALSINA (1991) gave a cladistic analysis of the Nomadinae with description of the new genus *Rhopalolemma* with type species *Rhopalolemma robertsi* Roig-Alsina.

CUNHA (1992) studied the relationship among 42 subgenera of the genus *Xylocopa* using phenetic techniques applied to male and female data sets. SCHOLL et al. in 1992 analysed the specific distinctiveness of *Bombus nevadensis* Cresson and *Bombus auricomus* (Robertson) by enzyme electrophoretic data. CAMARGO and PEDRO (1992) revised systematics, phylogeny and biogeography of the Meliponinae. In the same year BRAVO gave the systematics and distribution of *Parapartamona* (Schwarz). In the same paper he recognized two species *P. zonata* (Smith) and *P. brevipilosa* (Schwarz) and *Trigona zonata tungurahuana* Schwarz and *T. z. caliensis* Schwarz were considered as synonyms of *P. zonata* (Smith).

ROIG-ALSINA and MICHENER in 1993 studied the phylogeny and classification of long tongued bees proposed for a previously misidentified species (*P. binghami* Cockerell of Shiokawa & Sakagami; *P. comberi* Cockerell of
Hirashima). WANG and YAO studied the Chinese species of the subgenus *Alpigenobombus* Skorikov in the year 1993. This paper dealt 9 species with a new subspecies viz., *Bombus grahami melani*. MICHENER provided morphology, biology, distribution etc. of Apiformes, including classification and diagnosis upto family level in the book on Hymenoptera edited by GOULET and HUBER (1993). In this work Apiformes are arranged in 9 families. MICHENER et al. (1994) revised the Bee genera of North and Central America. He also provided identification keys to families. CUNHA (1994) made a phenetic study of the Old World Genera, Trigonini at supra-specific level. Phenetic relationship among 23 genera of Trigonini bees, 13 coming from Oriental and Australian regions and ten coming from Ethiopian region were discussed and proposed. CAMARGO and MOURE (1994) revised Neotropical genera, *Paratrigona* Schwarz and *Aparatrigona* Moure, and described eleven new species and one new subspecies.

TERZO and RASMONT (1996) redescribed *Ceratina gravidula* Gerstaecker and *C. nigraenea* Gerstaecker from West-paleartic region, with their synonyms and distribution maps. TINGEK et al. described a new honey bee *Apis nuluensis* from mountain regions of Borneo in 1996. The differences with *Apis cerana* Fabricius and *Apis koschevnikovi* Buttel-Reepen were also analysed in the above publication.

BAKER in 1997(b) described *Pithitis* Klug species from Indian subcontinent. In this paper *Ceratina comberi* Cockerell was synonymized with *Pithitis smaragdula* (Fabricius); a lectotype was designated for *Ceratina binghami* Cockerell.

MICHENER (1997) designated a neotype *Eucera antennata* Fabricius for the Genus *Tetralonia* Spinola. SHEPPARD et al. described a new subspecies of honey bee viz., *Apis mellifera ruttneri* from Malta island in the same year.
TERZO and RASMONT (1997) revised the carpenter bees of the genera *Copoxyla* Maa and *Xylocopa* Latreille from Mediterranean countries. CHEN and WANG (1997) studied phylogenetic relationships among 28 subgenera of bumble bees using morphological and behavioural characters. BAKER in 1997(a) erected a new genus of Melictini viz., *Sinomelecta* with type species *Sinomelecta oreina* Baker by original designation from Western China. ROUBIK et al. described a new stingless bee genus endemic to Central America, *Meliwillea* with type species *Meliwillea bivea* Roubik by original designation. ENGEL et al. (1997) analysed the phylogeny and behaviour in honey bees by using morphological and molecular data sets.

ENGEL (1998) published a note on fossil honeybees and evolution in the genus *Apis*. MINCKLEY (1998) did phylogenetic analysis of the genera and subgenra of the tribe Xylocopini by using morphological characters. KOCOUREK and SCHWARZ (1998) described 4 species and one subspecies of the genus *Ceratina* under the authorship of Kocourek from Western palaertic region and Turkistan basin. They are the followings, *C. hakkarica*, *C. hadii*, *C. schwazi*.

ENGEL in 1999a made an attempt to clarify the complicated and error fraught taxonomic history of the honey bees (*Apis*) by cataloguing the numerous names proposed for *Apis*. In this work 178 species and 10 genus group names were brought for the first time into accord with the modern classification of the honey bees. The same author in the same year (1999b) described the first fossil *Euglossa* Latreille and figured from Miocene Dominican amber as *Englossa moronei* new species. The distribution of the euglossines, particularly in the West Indies, and their associations with orchids were briefly considered. TADAUCHI et al. described a new species *Epeolus ishikawai* from Japan. REYES et al. analysed species phylogeny of the Bee genus *Exoneurella* Michener by using molecular and morphological data sets. JOBIRAJ (1999) made a preliminary revision of the bee genera of Kerala and prepared a key to bee genera of India.
ENGEL reviewed the Indo-Malayan meliponine Genus *Lisotrigona* Moure (2000a). He described two new species from northern Vietnam and Thailand as *L. carpentri* and *L. furva* respectively. The type species *L. cacciae* (Nurse) redescribed and *L. scintillans* (Cockerell) considered to the junior synonym of it. ENGEL (2000b) described the oldest fossil bee *Trigona prisca* Michener and Grimaldi in the cretaceous amber from New Jersey, was redescribed and figured. Differences between *T. prisca* and extent *Trigona* were noted and the fossil was transferred into a new genus, *Cretotrigona*. The same author in the same year (2000c) also analysed the relationship between fossils, phylogeny and social bee evolution.

MICHENER (2000) published a world revision of Bee Genera in his classical book 'The Bees of the World'. This is the only comprehensive, world wide treatment of all groups of bees - 1,200 genera and subgenera, including more than 16,000 species. The greater part of the work consists of the systematics, with keys (many of them regional) for identification at the sub genus level. For each genus or subgenus, Michener included a brief natural history describing geographical range, number of species, and information pertaining to nesting or floral biology.

NARENDRAN, JOBIRAJ and MOHANDAS (2000) described a new species of the genus *Halictus* Latreille viz., *Halictus tectonae* from India.