



MUSCIDAE (DIPTERA)- A HISTORICAL PERSPECTIVE

PRAVAS HAZARI, SHUVRA KANTI SINHA*, NANDAN JANA, AMITA HAJRA¹ AND SANTANU MAHATO²

Calyptrate Research Laboratory, Department of Zoology, Sree Gopal Banerjee College,
Hooghly 712148, West Bengal, India

¹Department of Zoology, Government General Degree College, Kharagpur II 721149, West Bengal, India

²Biopsychology Laboratory and Institution of Excellence, University of Mysore,
Mysuru 570006, Karnataka, India

*Email: suvrosinha@gmail.com (corresponding author)

ABSTRACT

In India, the history of biological research on muscid flies has never been thoroughly reviewed. There is no useful documentation of their recent and past taxonomic, medical, veterinary, and forensic research trends, as well as natural history and ecology studies. In the 75 years since independence, efforts have mostly focused on faunistic surveys. However, new study avenues have emerged in agricultural, medical, and forensic fields, as well as other areas such as molecular, ecological, and microbial research. In order to develop a state-wise perspective, we reviewed all the available old and recent studies on family Muscidae (Diptera) throughout the country and suggested areas for future research.

Key words: Muscidae, Diptera, faunistic survey, agricultural importance, medical importance, forensic importance, molecular taxonomy, ecological study, microbial study, India

At various points throughout history, different taxonomists around the world have proposed various classificatory schemes for the Muscidae family. Linnaeus (1758) described 11 species of *Musca* and *Conops*. Those 11 specimens are now placed in the families *Fanniidae*, *Anthomyiidae*, and *Muscidae* (Pont, 1981). Brunetti (1917) described many *Muscinae* and *Anthomyiinae* as new records from India, when *Anthomyiinae* were treated as one of the subfamilies of the family *Muscidae*. Townsend (1917) synonymized the family *Calliphoridae* with the family *Muscidae*. He divided the family *Muscidae* into two subfamilies, viz., *Muscidae* and *Rhiniinae*. Zimin (1951) classified the family *Muscidae* into two tribes, namely *Muscini* and *Stomoxydini*. In the early phases of the nineteenth century, *Anthomyiinae* were regarded as one of the subfamilies of *Muscidae*. Hennig (1955), on the basis of anal vein reaching the wing margin and the presence of fine cilia on the ventral surface of the scutellum, separated Subfamily *Anthomyiinae* as a different family, as *Anthomyiidae* from the family *Muscidae*. He also proposed a classification describing the family *Muscidae* into five subfamilies: *Eginiinae*, *Fanniinae*, *Mydaeinae*, *Phaoniinae*, and *Muscinae*. Emden (1965) divided the family *Muscidae* into seven subfamilies, viz., *Muscinae*, *stomoxydinae*, *Phaoninae*, *Coenosiinae*, *Lispinae*, *Faniinae*, and *Anthomyiinae*. Fonseca (1968) excluded *Anthomyiinae* from the earlier described

classification and presented six subfamilies. Shinonaga and Kano (1971) divided the family *Muscidae* into seven subfamilies: *Muscinae*, *Stomoxydinae*, *Phaoniinae*, *Coenosiinae*, *Lispinae*, *Faniinae*, and *Eginiinae*. In continuation of the previous classification, Pont (1980) divided the family *Muscidae* into six subfamilies, viz., *Atherigoninae*, *Muscinae*, *Azeliinae*, *Phaoninae*, *Mydaeinae*, and *Coenosiinae*. Later, Shinonaga and Singh (1994) divided the family *Muscidae* of Nepal into five subfamilies: *Stomoxyinae*, *Phaoninae*, *Muscinae*, *Coenosiinae*, and *Mydaeinae*. They included *Atherigona* as a genus in subfamily *Phaoninae*, also mentioned *Stomoxyinae* as a subfamily, and included *Azellia* as a genus under subfamily *Muscinae*. The two classificatory schemes given by Pont and Shinonaga and Singh were mostly followed by Indian taxonomists. The *Muscidae* family contains over 5000 described species spread across 170 genera (Kutty et al., 2008). Presently, there are 263 species in 35 genera of the family *Muscidae* in India (Bharti, 2008). Research on *Muscidae* is quite scanty in India except for a comprehensive work by Emden.

Muscidae research in India

A few faunistic surveys were carried out by various researchers in India. Only a few regions of the country were covered by the above-mentioned researchers, and most parts of India are still uncovered by muscid fly

researchers. There is still no taxonomic work regarding the family Muscidae in a few states of India. Therefore, the muscid fauna of the states of India has not been properly presented yet. Muscid flies are very important in agriculture as only a few species act as pests to many crops and vegetables. *Atherigona soccata* is one of the main pests on sorghum, tomato, rice, wheat, etc. There are many studies regarding the management of *A. soccata* as it is known to cause dead heart in a number of tropical grass species (Deeming, 1971; Pont, 1972). Sorghum shoot fly causes an average loss of 50% in India (Jotwani, 1983). *Atherigona (Acritochaeta) orientalis* Schiner often plays a role as a primary pest of a few agricultural crops (Hibbard et al., 2012). In India, *A. orientalis* infests maize (Panwar and Sarup, 1985), wheat (Singh, 1975), sorghum (Ramachandra, 1923), melon (Chughati et al., 1985) and soyabean (Singh and Chibber, 1972). In India, there are several works on the subject of shoot flies. Research on the medical importance of muscid flies was carried out by a few scientists in India. Dogra et al. (2009) worked on oral myiasis caused by *Musca domestica* larvae in a child. Bhagat (2016) worked on the biodiversity of dipterous flies (Insecta) of Myiasis regarding its importance to animals and humans in Jammu & Kashmir and the Ladakh Himalayas. A few studies were also carried out on the forensic importance of muscid flies, and a few molecular studies were also carried out by some workers.

Research on the family Muscidae was started years before independence in India. Fabricius (1794) mentioned eleven calyptrate species under the genus *Musca*, collected from India. Brunetti (1907) described *Limnophora* and *Anthomyia* in India for the first time. Sixteen species belonging to the group Stomoxinae were reported and described by him (1910–1922) from India for the first time. Also, Brunetti (1913) identified many calyptrate specimens of the families Tachininae, Muscinae, and Anthomyiinae from the collection of the Indian Museum in 1911–1912. Townsend (1917) synonymized the family Calliphoridae with the family Muscidae. He divided the family Muscidae into two subfamilies, viz., Muscidae and Rhiniinae. Distributional records of Indian Calyptrate Muscoids, comprising 16 species under five genera in Muscinae, were published by Senior-White in 1930. Meanwhile, the first journal of the Entomological Society of India, 'The Indian Journal of Entomology', was published in 1939 under the chief editorship of Hem Singh Pruthi. A comprehensive study was started in independent India by workers like Von Emden, Satoshi Shinonaga, J.C. Reddy, K.V. Reddy, B.C. Nandi, and a few others who worked

on the family Muscidae in the last century. Emden (1965) worked on Muscidae in India. A book, "Diptera Vol7: Muscidae Part I" by Von Emden, was published by the Zoological Survey of India, Kolkata, regarding the fauna of the family Muscidae in India. In his work, the author described the family Muscidae divided into seven subfamilies, namely Muscinae, Stomoxydinae, Phaoninae, Coenosiinae, Lispiinae, Faniinae, and Anthomyiinae, providing keys to identify Diptera, Calyptrata, and the subfamilies mentioned above. This particular publication dealt with three subfamilies, including Muscinae, Stomoxydinae, and Phaoninae. The author describes the external morphology of the species and also provides a comparative account of early stages such as larva, pupa, and egg. A key to each genus of subfamilies and the species under each genus is given in this publication. A total of 63 species of subfamily Muscinae, 12 species of subfamily Stomoxidinae, and 219 species of subfamily Phaoninae are dealt with in this volume. This was the first major work on the family Muscidae in independent India. Shinonaga (1970) worked on muscid flies of India and recorded *Orthelia fletcheri* from India. Recently, following taxonomists like B.C. Nandi, Bulganin Mitra, Devinder Shing, G.P. Gupta, K. Chandra, K.C. Verma, M. Mendki, Meenakshi Bharti, P. Parui, R. Achint, R.R. Tewari, S. Halder, S. Roy, S. Prakash, S.C. Majumder, S.K. Sinha, and V. Veer have been working on the family of Muscidae in India.

State-wise progress

In Andhra Pradesh, researchers concentrated mostly on shoot flies. Reddy and Davies (1981) recorded fly species of *Atherigona* from graminaceous species, including Sorghum. Three new species of *Atherigona* have been found. Singh et al. (2002) investigated the natural enemies of the sorghum shoot fly (*Atherigona soccata* Rondani). The parasitoids, predators, and pathogens attacking different stages of *Atherigona soccata* Rondani are reported. Dhillon et al. (2006) worked on host plant resistance as an effective component for the management of *Atherigona soccata* Rondani, developing a sorghum hybrid to increase the productivity of the crop. Resistance to *Atherigona soccata* Rondani is influenced by a factor associated with cytoplasmic male sterility and the interaction between nuclear and cytoplasmic genes. Aruna et al. (2009) evaluated the genetic potential of shoot fly resistance sources in sorghum (*Sorghum bicolor* (L.) Moench). Using a completely randomised block design with three replications, 36 hybrids and 15 parental genotypes were raised. Utilization of the resistant lines belonging to different clusters in improving shoot

fly resistance in sorghum is discussed. Thakur et al. (2019) reported field screening of sorghum genotypes for resistance to shoot fly, *Atherigona soccata*, and stem borer, *Chilo partellus*. Different genotypes were screened but in the cases of SPH-1564 and SPH-1571, there were no infestations of dead hearts but there was strong resistance to shoot flies.

From Arunachal Pradesh faunistic surveys were conducted by many taxonomists, Joseph and Parui, Dutta and Chakraborti, Mitra in this state. The muscid diversity of Arunachal Pradesh is quite significant. Joseph and Parui (1977) surveyed Diptera of the Tirap division. Six species of flies belonging to three genera were recorded by them, with four species under the genus *Musca* and one each of *Orthellia* and *Stomoxys*. Dutta and Chakraborti (1985) investigated faunal composition in Arunachal Pradesh. Four species under three genera, viz., *Musca* (*Viviparomusca*) *bezzii* Patton and Cragg, *Musca* (*Viviparomusca*) *convexifrons* Thomson, *Orthellia coerulea* (Wiedemann), and *Atherigona* sp., were recorded. Mitra (2006) reported 32 species belonging to 11 genera under four subfamilies. Six species from this state of India were recorded for the first time. A short survey was carried out in Assam. Borah et al. (2015) investigated the diversity of dipteran insects in the Jorhat district of Assam. *Musca domestica* L. was reported, as well as other dipteran families.

There are only a few studies on Muscid flies in Bihar. Vishwakarma et al. (2017) worked on the foraging activity of insect pollinators and their impact on the yield of rapeseed mustard. One species of the family Muscidae (*Musca domestica* L.) was reported as a visitor to Rapeseed-Mustard in the flowering season. From Chhattisgarh, Halder et al. (2015) worked on Muscid fauna diversity, zoogeography, and biogeographical analysis in this state. Their study provided 34 housefly species, of which subfamily Muscinae shares 17 species, Coenosiniinae shares five species, Atherigoninae shares five, Phaoninae shares four, and Mydaiinae shares three. Halder et al. (2019) conducted a faunistic survey in Achanakmar Wildlife Sanctuary in this state. They reported nine species under six genera in three subfamilies. From Gujarat, Lahiri and Mitra (2004) worked on Diptera diversity, mentioning two species, viz., *Musca domestica* L. and *Atherigona* (*Atherigona*), approximate under two genera, were reported. *Atherigona* was placed in the subfamily Phaoninae by the authors. A key to species, genera, and subfamily levels was provided.

A faunistic survey was carried out in Himachal

Pradesh by Mitra et al. (2015) and Sengupta et al. (2019). Mitra et al. (2015) worked on diversity and endemism. 43 Muscid fly species were reported from there, of which three species, namely *Limnophora perkensis* Malloch 1929, *Phaonia curviseta* Emden 1965, and *Phaonia simulans* Malloch 1931, were endemic to Himachal Pradesh. Sengupta et al. (2019) worked on a taxonomic account of dipteran flies from the Renuka Wetland and adjacent sanctuary. Four Muscidae species [*Musca* (*Musca*) *domestica* L., 1758; *Neomyia timorensis* Robineau-Desvoidy, 1830; *Stomoxys calcitrans* (L., 1758); *Gymnodia tonitrui* (Wiedemann, 1824)] from two subfamilies were reported. Besides the faunistic survey, Dogra and Mahajan (2009) worked on oral myiasis caused by *Musca domestica* larva in a child. Two cases of oral myiasis due to *Musca domestica* larva were reported in their study.

No survey was done in Jharkhand until Sinha (2014) focused on calyptrate flies of Jharkhand. Seven species of Family Muscidae including (*Musca* (*Byomya*) *ventrosa* Wiedemann, 1830, *Musca* (*Byomya*) *conducens* Walker, 1859, *Musca* (*Eusca*) *hervei* Villeneuve, 1922, *Orthellia timorensis* (Robineau-Desvoidy, 1830), *Ophyra leucostoma* (Wiedemann, 1817), *Gymnodia tonitrui* (Wiedemann, 1824), *Stomoxys calcitrans* (L., 1758) under five genera and three subfamilies were reported for the first time from Jharkhand. Key to the subfamily, Genus and Species was provided. Joseph and Parui (1977) worked on Diptera diversity of Chota Nagpur. Eleven species under four Genera were reported. *Musca* (*Byomyia*) *lucens* (Villeneuve) was reported for the first time from India. No faunistic survey has been carried out in Jammu & Kashmir. Bhagat (2016) worked on the biodiversity of dipterous flies of Myiasis, causing importance to animals and humans in Jammu & Kashmir, and the Ladakh Himalayas. *Musca domestica* L., *Musca* (*Musca*) *domestica nebula* (F.), *Musca* (*Musca*) *vicinia* Macquart, *Muscina stabulans* (Fallen), and *Stomoxys calcitrans* (L.) were known to cause myiasis in Jammu & Kashmir and the Ladakh Himalayan region.

There are no faunistic surveys of muscid flies in Karnataka. Belamkar and Jadesh (2014) carried out a preliminary study on the abundance and diversity of insect fauna in Gulbarga District, Karnataka, India. One species of the family Muscidae was reported. Diversity indices for insect orders are also presented. Hosamani et al. (2016) worked on pollinator diversity, abundance, and their stay times in the onion, *Allium cepa* L. *Musca domestica* was reported as one of the

pollinators. Bawer et al. (2014) worked on biocontrol of *Haematobia irritans* with entomopathogenic fungi (*Beauveria bassiana* and *Metarhizium anisopliae*). A high concentration of (1X10⁸ conidia/ml) *B. bassiana* and *M. anisopliae* showed mortality at different levels against eggs, larva, pupa, and adults of *Haematobia irritans*. Some molecular work on muscid flies has been carried out in Karnataka. Archana et al. (2016) presented DNA barcoding of flies commonly prevalent in poultry farms in Bengaluru district. Cytochrome oxidase I (COI) barcoding sequences were used to discover cryptic, closely related, and morphologically similar species. The barcoding of the COI gene of *Musca domestica*, *Chrysomya megacephala*, *Hydrotaea capensis*, *Hermetia illucens*, and *Sarcophaga ruficornis* was mentioned in their work. Using DNA barcoding based on the COX1 gene, Ojha et al. (2016) attempted to identify flies from the Salt Lake of the Great Rann of Kutch. Three species were identified as a result of this study (*Musca autumnalis*, *Atherigona varia*, and *Lispe orientalis*).

Very little work has been done in Kerala except by Joseph and Parui (1986), who worked on Diptera from the Silent Valley in Kerala. In their study, three species, viz., *Musca (Viviparomusca) bezzi* Patton and Cragg, *Orthellia claripennis* Malloch, and *Orthellia timorensis* (Robineau-Desvoidy) were reported. Some faunistic surveys on muscid flies were carried out in Maharashtra. Bharamal (2016) conducted a survey on the order Diptera in the Sindhugarg district of Maharashtra and reported *Musca domestica* and *M. nebulo* of the family Muscidae from there. Sathe et al. (2013) worked on the diversity of dipterous forensic insects from western Maharashtra. Three flies of the family Muscidae (*M. domestica*, *M. nebulo*, and *Fannia scalaris*) were reported as forensically important throughout the year. Kale et al. (2007) worked on flowering phenology and pollination in *Cajanus cajan* L. and *M. domestica* (House fly) and reported it as one of the flower visitors. Their observations indicated that house flies spent two to four seconds during their visit to the flower. A microbial study on muscid flies was also carried out in this state. Gupta et al. (2012) worked on bacteria associated with the gut of house flies. A total of 22 genera of bacteria were found. The majority of genera reported from house fly guts included *Klebsiella*, *Aeromonas*, *Shigella*, *Morganella*, and *Staphylococcus*.

There was no study regarding muscid flies from Manipur except by Mitra (2004), who studied the diversity of the family Muscidae. Ten species belonging

to five genera under four subfamilies were reported from Manipur for the first time. The author provided a key to the species, genus, and subfamily level for identification of the species. A diversity of muscid flies in Mizoram was presented in 2007. Mitra (2007) worked throughout the state. Eight species belonging to seven genera were reported. That was the first ever diversity study from Mizoram. All the species were reported for the first time from Mizoram. Mitra (2006) carried out a faunistic survey on muscid flies in Nagaland and studied the diversity of the family Muscidae. For the first time, six species belonging to three genera were reported from Nagaland. Parui and Dutta (1987) worked on the family Muscidae in Odisha. *Orthellia coerolea* (Wiedemann) and *Atherigona (Atherigona) pulla* (Wiedemann) were discovered in Timadehi, Sundargarh district, Sambalpur district, and Mayurbhanj district.

From Pondicherry, Srinivasan et al. (2003) studied the effectiveness of insect parasitoids and insect growth regulators against the house fly (*Musca domestica*). Their study concluded that the combined use of parasitoid and IGR was effective in reducing puparia and fly density. The diversity of muscid flies in Punjab is still unknown. There was no study on the diversity of muscid flies in Punjab except a survey by Parui et al. (2006) who worked on the diptera fauna of Punjab and the Himachal Shiwalik Hills. Two species under two genera and two subfamilies [*Orthellia timorensis* (Robineau-Desvoidy), *Stomoxys calcitrans* (L.)] were reported. A key to the subfamily, genus, and species is also provided by them. Molecular work on muscid flies was carried out by Malviya et al. (2011, 2012, and 2015), and Singh and Achint (2017). Malviya et al. (2012) conducted a study on genetic relatedness among different muscid fly species. During their study, they used the RAPD-PCR technique to show the genetic relatedness among muscid fly species. Singh and Achint (2017) studied the molecular identification of muscid flies. On the basis of the mitochondrial COII gene, five flies of the family Muscidae were identified. The identified flies were *Musca domestica*, *M. sorbens*, *M. crassirostris*, *Haematobia irritans*, and *Stomoxys calcitrans*. Besides this, the work on the forensic importance of muscid flies was also carried out in Punjab. Bharti and Singh (2003) focused on insect faunal succession on decaying rabbit carcasses. Ten species of family Muscidae: *Musca domestica nebulo* (F. 1784); *M. ventrosa* (Wiedemann 1830); *M. sorbens* (Wiedemann 1830); *M. pattoni* (Austen 1910); *Hydrotaea capensis* (Wiedemann 1818); *H. chalogaster* (Wiedemann 1818); *H. occulta* (Meigen 1825); *Atherigona orientalis* (Malloch 1928);

Atherigona sp. nr. *orientalis* (Malloch 1928); *A. savia* (Pont and Magpayo 1996) were reported. All the species were reported from the decaying rabbit carcasses. Bharti (2009) also investigated the life cycles of forensically important flies. The life cycle of *M. domestica nebula* F., 1784 at different temperatures was studied. Kaur et al. (2018) studied insect faunal succession on pork carrion in Punjab. Three species of the family Muscidae (*M. domestica*, *M. autumnalis*, and *M. sorbens*) were recorded in all stages (fresh stage, bloated stage, advanced decay stage, and decay stage).

Taxonomic research on the family Muscidae is very scanty in Rajasthan. Mitra et al. (2005) conducted a study on the diversity of muscid flies in the Thar Desert. Nine species (under three genera and three subfamilies) were collected from the Thar Desert. Prakash et al. (2005) worked on the diversity of Diptera from the Thar Desert and reported two flies (*Stomoxys calcitrans* L., *Musca crassirostris* Stein.) of the family Muscidae. Besides this, some work on the agricultural importance of muscid flies was carried out in Rajasthan. Joshi et al. (2016) worked on the management of the sorghum shoot fly, *Atherigona soccata* Rondani (Diptera: Muscidae) through botanicals. An effect of different botanicals (neem oil, karanj oil, and Nirgundi oil) on *Atherigona soccata* (Rondani) was reported. Srivastava and Bhardwaj (2012) conducted a study on insect visitors to certain cucurbit vegetable crops in an agroecosystem near Bikaner, Rajasthan. *Musca domestica* were found in large numbers on Lagenaria flowers in October. Research on muscid flies is very scanty in Sikkim. Mitra (2003) worked on the diversity of the family Muscidae in Sikkim, India. In the state fauna series, Fauna of Sikkim, part III, the author reports 22 species belonging to 11 genera under six subfamilies, with two species from Sikkim for the first time. Till 2000, there were no species of the family Muscidae reported from Tripura. In 1991 and 1992, ZSI undertook a few surveys in Tripura. Mitra (2000) reported six species under three genera in two subfamilies from Tripura in 2000. The distribution of each species in India and around the world has also been added.

From Uttar Pradesh, except for Tewari et al. (2012), who worked on temporal variation among the population of house fly (*Musca domestica*), no detailed faunistic survey has taken place. Mitra (2011) published a report on muscid flies from Uttarakhand. There were 22 species of muscid fly belonging to 10 genera and three tribes under four subfamilies reported. Six species under two genera were recorded for the first time in

Uttarakhand. More faunistic surveys, bionomics, and life cycles of muscid flies were studied by various taxonomists in West Bengal in comparison to other parts of India. Sundarbans Biosphere Reserve (hereinafter, SBR) of West Bengal is rich in diverse flora and fauna. A great diversity of muscid flies was observed here in the Sundarbans. Sinha (2009) investigated the systematics and bionomics of Sarcophagid, Calliphorid and Muscid flies of SBR. A total of 13 species under six genera and two subfamilies were reported. Nandi and Sinha (2004) worked on muscid flies of SBR. 16 species of muscid flies under seven genera were included from there. The bionomics and distributional records of that species are also presented from SBR. The impact of that species on human beings and other animals was also discussed. A new species of *Musca* (*Byomya*) *emdeni* was described and illustrated. Sinha and Mondal (2013) worked on the life history of *Musca* (*Byomya*) *emdeni* Sinha-Nandi, the dung-breeding flies from SBR in 2013. In that particular study, they described three larval instars of that fly in detail. Sinha and Nandi (2005) studied the life history of the dung-breeding muscoid fly, *Neomyia indica* (R-D) (Diptera, Muscidae) from SBR. Mitra et al. (2016) conducted a faunistic survey in SBR. They reported 13 orders of insects from the Sundarbans. The Muscidae family accounted for 17% of all Diptera species.

Dutta et al. (1997) worked on the diversity of order Diptera in West Bengal. In the state fauna series of West Bengal, six species from three genera were reported. Majumder and Parui (2001) recorded four species of *Musca*, one of *Lispe* and two *Stomoxys* from SBR, along with a key to the collected specimens. Mitra and Parui (2012) reported four species of the family Muscidae, namely *Musca* (*Musca*) *domestica* L., *Orthellia indica* (Robineau-Desvoidy), *Orthellia lauta* (Wiedemann), and *Stomoxys calcitrans* (L.) from the Bibhutibhusan Wildlife Sanctuary situated in the district of North 24-Parganas, West Bengal, India. Mitra et al. (2016) conducted a survey in 12 different fish markets in North, South, and Central Kolkata and reported six species of the family Muscidae along with a few Calliphoridae and Sarcophagidae. Three *Musca* species (*Musca conducens* Walker, 1859; *Musca sorbens* Wiedemann, 1830; *Musca domestica* L., 1758; *Neomyia indica* Robineau-Desvoidy, 1830; *Neomyia lauta* Wiedemann, 1830) were reported. Mitra et al. (2016) worked on the insect faunal diversity of Salt Lake City, Kolkata, India. Six species of family Muscidae [*Atherigona* (*Atherigona*) *simplex* (Thomson, 1869), *Musca domestica* L., 1758, *Musca ventrosa* Wiedemann, 1830, *Neomyia lauta* (Wiedemann, 1830), *Neomyia*

timorensis (Robineau-Desvoidy, 1830), *Neomyia indica* (Robineau-Desvoidy, 1830)] were reported. Gayen et al. (2019) worked on true flies (Diptera: Insecta) diversity in the recently urbanised areas (Saltlake and Newtown) of West Bengal, India. Nine Species of family Muscidae [*Atherigona* (*Atherigona*) *simplex* (Thomson, 1869), *Musca domestica* L. 1758, *Musca ventrosa* Wiedemann 1830, *Musca* (*Byomya*) *sorbens* (Wiedemann), *Musca* (*Byomya*) *pattoni* (Austen) *Morellia hortensia* (Wiedemann), *Orthelia timorensis* (Robineau-Desvoidy), *Orthelia indica* (Robineau-Desvoidy), *Orthelia lauta* (Wiedemann)] were reported. Sinha et al. (2021) worked on the diversity of muscid flies in Neora Valley National Park. They reported 31 species of muscid flies under 13 genera in three subfamilies. They reported *Limnophora* (*Heliographa*) *ceylanica* (Emden, 1965) and *Neomyia pacifica* (Zimin, 1951) from West Bengal as well as from India for the first time.

Besides the faunistic survey, a little work on the medical importance, agricultural importance, and forensic importance of Muscid flies was carried out in West Bengal (Sinha et al., 2003; Mitra et al., 2005; Mitra, 2010; Das et al., 2015; Bhadra et al., 2015; Mitra et al., 2017; Parui et al., 2017). Sinha et al. (2003) worked on the presence of bacteria on the body surface of *Musca domestica vicina* Macquart. A total of six types of bacteria (*E. coli*, *Klebsiella* sp., *Salmonella* sp., *Pseudomonas* sp., *Shigella* sp., *Proteus* sp.) were reported. Mitra et al. (2005) worked on flower visitors and pollinators (Diptera, Insecta) of Kolkata. Three species of the family Muscidae (*Musca domestica*, *Musca ventrosa*, and *Orthellia timorensis*) were reported along with the plant visited. Mitra et al. (2010) worked on the diversity of flower-visiting flies (Insecta: Diptera) in India and their role in pollination. Altogether, 19 species of house flies are reported as flower visitors or pollinators from India. Das et al. (2015) worked on forensically important dipteran species from West Bengal. *Musca* (*Byomya*) *sorbens* Wiedemann was reported as one of the forensically important species of the family Muscidae. Bhadra et al. (2015) worked on insect pollinators and their role in crop yield and quality of sunflower (*Helianthus annuus*, PAC-361) from West Bengal. One species of the family Muscidae (*Musca indica*) was recorded as one of the pollinators. Mitra et al. (2017) worked on true flies (Insecta: Diptera) and their association with tea plants in the Dooars, West Bengal, India. *Musca domestica* L., 1758 and *Neomyia indica* (Robineau Desvoidy, 1830) have been found visiting the flower throughout

the day. In 2017, Parui et al. (2017) showed variation in colonisation and succession patterns of Dipteran flies of forensic importance on Indian Mole Rat carcasses in the Sundarban. Six species of Family Muscidae [*Musca domestica* (L., 1758), *Musca sorbens* (Wiedemann, 1830), *Ophyra capensis* (Wiedemann, 1818), *Hydrotaea chalcogaster* (Wiedemann, 1824), *Synthesiomyia nudiseta* (Wulp, 1883), *Atherigona orientalis* (Schiner, 1868)] at different stages of decomposition.

CONCLUSIONS

In India, there were very few studies on the Muscidae family. Most of the researchers from independent India contributed to a faunistic survey in different states. In recent years, very little effort has been made in describing new species of muscidae. After a comprehensive work by Von Emden (1965), no precise taxonomic work has been done here in India. A precise taxonomic study on the family Muscidae is very much needed as well, because the amount of taxonomic work done here in India is not up to the mark. Until today, small-sized muscid flies were not described. Molecular taxonomy may reveal a new horizon in the identification of Muscidae because the identification of many small-sized muscid flies is very difficult on the basis of morphological characters. Unfortunately, the amount of molecular taxonomy in the family Muscidae is very low here in India. This is the huge field to be nourished here in India. Most of the studies related to the family Muscidae in terms of faunistic surveys, though these works did not cover most of the places in various states of India (Fig. 1). So the actual picture of the diversity of muscid flies in different states of

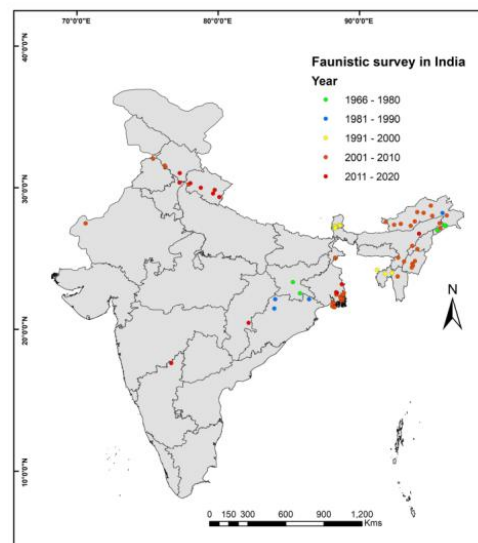


Fig. 1. Faunistic surveys (1966-2020)

India is not up to date. Besides the faunistic survey, only a few studies on agricultural importance, medical importance, forensic importance, molecular taxonomy, and ecological and microbial studies have been done on the family Muscidae. The life cycle of many species is still unknown, which needs more attention. Work on larval study and larval taxonomy is very much needed as this is very important in the cases of forensic, agriculture, medical, as well as ecological aspects. In Table 1, the number of species described from different states of India after 1965 is presented.

On the basis of the discussion, it can be concluded that there is an inadequate number of taxonomic works on the family Muscidae in different states of India. Scientists carried out mainly faunistic surveys in different states of India. Besides the faunistic survey, a few studies on agricultural importance, medical importance, forensic importance, molecular taxonomy, ecological studies, and microbial studies were conducted in Independent India (Fig. 2). From 1960-1980, the main focus of study on the family Muscidae was a faunistic survey and the agricultural importance of the family Muscidae. From 1980 to 2000, the same trend was followed in India. But in this century, many fields of study have emerged, especially in ecological, molecular, medical, and forensic studies (Fig. 2). Many projects on shooting flies have been completed in Andhra Pradesh, Arunachal Pradesh, and Rajasthan. Many states, like Bihar, Goa, Haryana, Karnataka, Meghalaya, Mizoram, and Telangana, have no comprehensive study on the

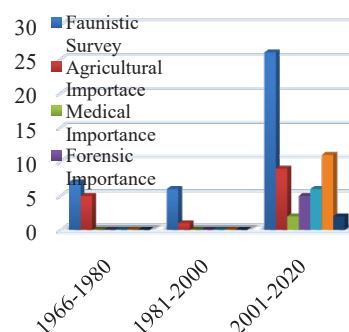


Fig. 2. Subject-wise work on Muscidae (1966-2020)

family Muscidae. Having great importance in medical, veterinary, and agriculture, it is very important to know about the systematics and bionomics of Muscid fauna. As an agricultural pest, there should be more precise taxonomic work on shoot flies (*Atherigona* sp.), so new species of shoot flies having agricultural importance may be reported in the future. A few researchers also studied the myiasis and disease relationship of muscid flies. More studies should be done on stable flies as they have great veterinary importance. Muscidae as a potent pollinator is also very important. On the basis of the discussion, it can be concluded that only a few studies on muscid flies have been conducted. A lot of work on muscid flies regarding agricultural importance, medical importance, forensic studies, molecular taxonomy, ecological and microbial studies still has to be done in India. Therefore, more attention will be required in the coming years to this important but understudied field of study concerning the Muscidae.

Table 1. Muscidae- described species after 1965

No.	State	Period	Described species	No.	State	Period	Described species
1	Andhra Pradesh	1981, 2002, 2006, 2009, 2019	19	17	Meghalaya	No Survey	-
2	Arunachal Pradesh	1977, 1985, 2001	32	18	Mizoram	2007	8
3	Assam	2015	1	19	Nagaland	2006	6
4	Bihar	2017	1	20	Odisha	1987	2
5	Chhattisgarh	2015, 2019	37	21	Punjab	2003, 2006, 2011, 2015, 2018	16
6	Goa	No Survey	-	22	Rajasthan	2005, 2012, 2016	10
7	Gujarat	2004	2	23	Sikkim	2003	22
8	Haryana	No Survey	-	24	Tamil Nadu	2006, 2009	3
9	Himachal Pradesh	2015, 2019	43	25	Telangana	No Survey	-
10	Jammu & Kashmir	2016	5	26	Tripura	2000	6
11	Jharkhand	1977, 2014	15	27	Uttar Pradesh	2012	1
12	Karnataka	2007, 2014, 2016	4	28	Uttarakhand	2011	22
13	Kerala	1986	3	29	West Bengal	1997, 2001, 2003, 2004, 2005, 2009, 2010, 2012, 2013, 2015, 2016, 2017, 2019, 2021	31* <i>Musca</i> (<i>Byomya</i>) <i>emdeni</i> Sinha and Nandi (2004)
14	Madhya Pradesh	No Survey	-				
15	Maharashtra	2007, 2013, 2016	3				
16	Manipur	2004	10				

*New species (1966- 2021)

ACKNOWLEDGEMENTS

The authors acknowledge the West Bengal Biodiversity Board (WBBB), for the financial assistance from the project [863/3K (Bio)-1/2019; Dated: 22/07/2019]. Thanks are also due to the Principal and Head, Department of Zoology, Sreegopal Banerjee College for constant support for research work and laboratory facilities.

REFERENCES

- Archana M, D'Souza P, Ojha R, Jalali S K. 2016. DNA barcoding of flies commonly prevalent in poultry farms of Bengaluru District. *Journal of Entomology and Zoology Studies* 4(4): 230-235.
- Aruna C, Padmaja P G. 2009. Evaluation of genetic potential of shoot fly resistant sources in sorghum (*Sorghum bicolor* (L.) Moench). *Journal of Agricultural Science* 147(1): 71-80.
- Bawer Md, Placid E D, Pradeep B S. 2014. Biocontrol of *Haematobia irritans* horn flies with entomopathogenic fungi (*Beauveria bassiana* and *Metarhizium anisopliae*). *Journal of Biological Control* 28(2): 112-114.
- Belamkar M V, Jadesh M. 2014. A Preliminary study on abundance and diversity of insect fauna in Gulbarga District, Karnataka, India. *International Journal of Science and Research (IJSR)* 3(12): 1670-1675.
- Bhagat R C. 2016. Biodiversity of dipterous flies (Insecta) of myiasis - causing importance in animals and human of Jammu, Kashmir and Ladakh Himalayas (India). *Journal of Global Biosciences* 5(7): 4341-4349.
- Bharamal D L. 2016. A Preliminary survey of dipterans in Sindhudurg District, Maharashtra, India. *International Journal of Current Microbiology and Applied Sciences* 5(1): 396-398.
- Bhardwaj H, Srivastava M A. 2012. Study on insect visitors of certain cucurbit vegetable crops in an agroecosystem near Bikaner, Rajasthan, India. *Journal Academica* 2(3): 99-126.
- Bharti M. 2008. Current status of family Muscidae Diptera from India. *Journal of Entomological Research* 32(2): 171-176.
- Bharti M. 2009. Studies on life cycles of forensically important flies, *Calliphora vicina* and *Musca domestica* *nebulosa* at different temperatures. *Journal of Entomological Research* 33(3): 273-275.
- Bharti M, Singh D. 2003. Insect faunal succession on decaying rabbit carcasses in Punjab, India. *Journal of Forensic Sciences* 48(5): 1133-1143.
- Bhawmik V, Bhadra K. 2015. Insect pollinators and their role on crop yield and quality of sunflower (*Helianthus annuus*, PAC-361) from West Bengal, India. *International Journal of Current Science* 18(E): 76-87.
- Borah N, Hazarika M, Rehman A, Patgiri P. 2015. Diversity of dipteran insects in Jorhat district of Assam, North East India. *Insect Environment* 20(4): 109-110.
- Brunetti E. 1907. On some Indian species of *Limnophora* and *Anthomyia* with a description of a new species of the former genus. *Records of the Indian Museum* 1: 381-385.
- Brunetti E. 1907. Revision of the Oriental blood sucking Muscidae (Stomoxinae, *Philaematomyia* Aust. and *Pristirhynchomyia* gen. nov.). *Records of the Indian Museum* 4: 59-93.
- Brunetti E. 1913. New and interesting Diptera from the eastern Himalayas. *Records of the Indian Museum* 9: 255-277.
- Brunetti E. 1913. Diptera. *Records of the Indian Museum* 8: 149-190.
- Brunetti E. 1917. Diptera of Shimla district. *Records of Indian Museum* 13(1917): 66.
- Brunetti E. 1920. The Fauna of British India including Ceylon and Burma, Diptera, Brachycera. Taylor and Francis, London 2: 1-424.
- Chughati G H, Khan S, Baloch U K. 1985. A record of infestation of melon fruits by an anthomyid fly in Indus River Beach areas of D.I. Khan. *Pakistan Journal of Zoology* 17(2): 165-168.
- d'Assis-Fonseca E C M. 1968. Diptera Cyclorrhapha Calyptrata, Muscidae. Handbook for the identification of British insects. Royal Entomological Society, London 10(4b): 118 pp.
- Das P, Majumder S, Imam I, Mallick K, Bhattacharya M. 2015. Additional record of some forensically important dipteran species from West Bengal. *Bionotes* 17(2): 51.
- Datta M, Chakraborti M. 1985. Insecta: Diptera. *Records of the Zoological Survey of India* 82(1-4): 231-252.
- Davies J C, Seshu Reddy K V. 1981. Shoot fly species and their graminaceous hosts in Andhra Pradesh, India. *International Journal of Tropical Insects Science* 2: 33-37.
- Deeming J C. 1971. Some Species of *Atherigona* Rondani (Diptera, Muscidae) from northern Nigeria with special reference to those injurious to cereal crops. *Bulletin of Entomological Research* 61: 133-190.
- Dhillon M K, Sharma H C, Shing R, Naresh J S. 2006. Influence of cytoplasmic male sterility on expression of physico-chemical traits associated with resistance to sorghum shoot fly *Atherigona soccata* Rondani. *SABRAO Journal of Breeding and Genetics* 38(2): 105-122.
- Dogra S S, Mahajan V K. 2009. Oral myiasis caused by *Musca domestica* larvae in a child. *International Journal of Pediatric Otorhinolaryngology* 5: 105-107.
- Dutta M, Parui P. 1987. Fauna of Orissa: State Fauna Series 1: 241-255.
- Dutta M, Parui P, Mukherjee M. 1997. Insecta: Diptera. State Fauna Series 3: Fauna of West Bengal 3(7): 1-76.
- Emden V. 1965. The Fauna of India and the adjacent countries. Diptera, Muscidae. Baptist Mission Press, Calcutta 7(1): 1-647.
- Fabricius J C. 1794. *Entomologia Systematica emendata et aucta Entomologia* 4: 472.
- Gayen A K. 2019. True flies (Diptera: Insecta) diversity in the recently urbanized area of West Bengal, India. *The Pharma Innovation Journal* 8(6): 831-834.
- Gupta K, Nayduch D, Verma P, Shah B, Ghate H V, Patole M S, Shouche Y S. 2012. Phylogenetic characterization of bacteria in the gut of house flies (*Musca domestica* L.). *FEMS Microbiology Ecology* 79(3): 581-593.
- Halder S, Chandra K, Roy S, Parui P. 2015. Diversity, zoogeography and biogeographical analysis of muscid fauna (Diptera: Muscidae) of Chhattisgarh, India. *Prommalia* 3: 60-66.
- Halder S, Parui P, Chandra K, Banerjee D. 2019. Diptera fauna of Achanakmar WLS, Chhattisgarh. *Fauna of Achanakmar Tiger Reserve, Chhattisgarh*. 11: 255-274.
- Hennig W. 1955. Los insectos de las Islas Juan Fernandez. *Revista Chilena de Entomologia* 4: 21-34.
- Hibbard K L, Overholt W A, Cuda J P. 2012. Pepper fruit fly *Atherigona orientalis* (Schiner) (Insecta: Diptera: Muscidae). IFAS Extension. University of Florida EENY 539: 1-3.
- Hore G, Parui P, Saha G K, Banerjee D. 2017. Variations in colonization and succession pattern of dipteran flies of forensic importance on

- Indian mole rat carcasses in urban and Sundarban localities of Kolkata, West Bengal. *Malaysian Journal of Medical Research* 1(3): 52-62.
- Hosamani V, Reddy M S, Venkateshalu, Hanumanthaswamy B C, Lingamurthi K R, Ravikumar B, Ashoka N. 2016. Pollinator diversity, abundance and their stay time in onion, *Allium cepa* L. *Journal of Entomology and Zoology Studies* 7(6): 158-161.
- Joseph A N T, Parui P. 1977. Diptera from Arunachal Pradesh and Assam foothills, part V, Tirap Division. *Records of the Zoological Survey of India* 72: 333-339.
- Joseph A N T, Parui P. 1977. On a small collection of Diptera from Chota Nagpur, Bihar. *Records of the Zoological Survey of India* 72: 227-238.
- Joseph A N T, Parui P. 1986. Diptera from Silent Valley. *Records of the Zoological Survey of India* 84(1-4): 157-163.
- Joshi S, Hussain T, Kiran V S, Nagar R. 2016. Management of sorghum shoot fly, *Atherigona soccata* Rondani (Diptera: Muscidae) through botanicals. *Journal of Biopesticides* 9(1): 23-26.
- Jotwani M G. 1983. Losses due to shoot fly in high yielding sorghum cultivars, in crop losses due to insect pests. Special issue. *Indian Journal of Entomology*. pp. 213-220.
- Kale P J, Tidke J A, Dahat A S. 2007. Study of flowering phenology and pollination in *Cajanus cajan* L. *International Journal of Applied Research* 3(3): 211-214.
- Kaur P, Bala M. 2018. Insect faunal succession studies on pork carrion in Punjab, India. *Journal of Entomological Research* 42(2): 287-294.
- Kutty S N, Pape T, Pont A, Wiegman B M, Meier R. 2008. The Muscoidea (Diptera: Calyptrata) are paraphyletic: Evidence from four mitochondrial and four nuclear genes. *Molecular Phylogenetics and Evolution* 49(2008): 639-652.
- Lahiri A R, Mitra B. 2004. Insecta: Diptera. Fauna of Gujarat, State Fauna Series 8(2): 127-159.
- Linnaeus C. 1758. *Systema naturae per regna tria naturae, secundum classes, ordines, genera, speciescum caracteribus, differentiis, synonymis, locis*.
- Maity P, Roy S, Chakraborti U, Biswas O, Ghosh J, Gayen A K, Mitra B. 2016. Insect faunal diversity of Salt Lake City- an urbanized area adjacent to Kolkata, India. *Bioscience Discovery* 7(2): 101-112.
- Malviya S, Bajpai N, Tewari S S. 2011. Genetic relatedness among three populations of house fly *Musca domestica* L. using RAPD-PCR marker. *Molecular Biology* 2(4): 198-204.
- Malviya S, Tewari R, Agarwal U R. 2015. Genetic relationship between the muscids using RAPD-PCR as marker. *International Research Journal of Biological Sciences* 4(1): 66-70.
- Malviya S, Tewari R R, Bajpai N. 2012. RAPD-PCR based genetic relationship of muscid flies (Diptera: Muscidae). *International Journal of Pharma and Biosciences* 3(3): 1018-1024.
- Mazumder GC, Parui P. 2001. Diptera (Insecta) from Sundarban, West Bengal. *Records of the Zoological Survey of India* 99(1-4): 171-199.
- Mitra B. 2000. Diptera: Muscidae. Fauna of Tripura, State Fauna series 7(3): 261-269.
- Mitra B. 2003. Diptera: Muscidae. Fauna of Sikkim. State Fauna series 9(3): 401-411.
- Mitra B. 2004. Diptera: Muscidae. Fauna of Manipur, State Fauna series 10(2): 503-508.
- Mitra B. 2006. Diptera: Muscidae. Fauna of Arunachal Pradesh. State Fauna series 13(2): 355-367.
- Mitra B. 2006. Diptera: Muscidae. Fauna of Nagaland, State Fauna series 12: 193-197.
- Mitra B. 2007. Fauna of Mizoram. State Fauna Series 14: 375-378.
- Mitra B. 2010. Diversity of flower visiting flies (Insecta: Diptera) in India and their role in pollination. *Records of the Zoological Survey of India* 110(2): 95-107.
- Mitra B. 2011. On a collection of Insecta: Diptera: Muscidae from Uttarakhand. *Records of the Zoological Survey of India* 111(2): 67-74.
- Mitra B, Biswas O, Roy S, Chakraborti U, Panja B. 2016. Insect faunal diversity of the Sunderban Biosphere Reserve, West Bengal, India. *International Journal of Current Research and Academic Review* 4(9): 87-98.
- Mitra B, Parui P, Banerjee D, Mukherjee M, Bhattacharjee K. 2005. A report on flies (Diptera: Insecta) as flower visitors and pollinators of Kolkata and its adjoining areas. *Records of the Zoological Survey of India* 105(3-4): 1-20.
- Mitra B, Parui P. 2012. Diversity of true flies (Diptera: Insecta) in the Bibhutibhusan Wildlife Sanctuary. *Records of the Zoological Survey of India* 112(2): 57-64.
- Mitra B, Roy S, Biswas O, Chakraborti U. 2015. True flies (Insecta: Diptera): Diversity and endemism in Himachal Pradesh, India. *International Journal of Advanced Research in Biology and Biotechnology* 1(1): 46-59.
- Mitra B, Roy S, Das P, Parui P. 2016. True flies (Diptera: Insecta) from fish markets of Kolkata Metropolitan Region. *Envis Newsletter* 22(3): 3-6.
- Mitra B, Roy S, Shah S K, Mishra P. 2017. Inventorisation of true flies (Insecta: Diptera) and their association with tea plants in Dooars, West Bengal, India. *International Journal of Entomology Research* 2(5): 21-26.
- Mitra B, Sharma R M, Parui P. 2005. Inventory of the true flies (Diptera) of the Thar Desert. *Records of the Zoological Survey of India* 104(1-2): 147-155.
- Ojha R, Jalali S K, Shivalingaswamy T M, Verghese A. 2016. Mitochondrial COX1 gene based delineation of putative insect species from Salt Lake of Great Rann of Kutch, India. *Journal of Entomology and Zoology Studies* 4(5): 166-170.
- Panwar V P S, Sarup P. 1985. Distribution and host plants of shoot fly species attacking maize in different parts of the world. *Journal of Entomological Research* 9(2): 207-217.
- Parui P, Mitra B, Sharma R M. 2006. Diptera Fauna of Punjab and Himachal Shiwalik Hills. *Records of the Zoological Survey of India* 106(1): 83-108.
- Pont A C. 1972. A review of the Oriental species of *Atherigona* Rondani (Diptera, Muscidae) of economic importance. *Control of the sorghum shoot fly*. Jotwani M G, Young W R (eds). Oxford & IBH Publishing. pp.27-104.
- Pont A C. 1980. Family Muscidae. *Catalogue of Diptera of the Afrotropical region* Crosskey R W, Cogan B H, Freeman P, Pont A, Smith K G V (eds) British Museum (Natural History), London (UK). pp. 721-761.
- Pont A C. 1981. The Linnaean species of the families Fanniidae, Anthomyiidae, and Muscidae (Insecta: Diptera). *Biological Journal of the Linnean Society* 15(2): 165-175.
- Prakash S, Veer V, Mendki M J, Gupta G P, Verma K C. 2005. Some new records of mosquitoes (Culicidae) and hematophagous flies of Tabanidae and Muscidae from the Thar Desert (Rajasthan, India). *Changing faunal ecology of Thar Desert*. pp. 135-142.
- Ramachandra R Y. 1923. The genitalia of certain anthomyid flies (*Atherigona* sp.). Report of the proceeding of the 5th entomologists meeting at Pusa. pp. 330-335.

- Sathe T V, Sathe A, Sathe N T. 2013. Diversity of dipterous forensic insects from western Maharashtra, India. *International Journal of Pharma and Biosciences* 4(2): 173-179.
- Sengupta J, Naskar A, Maity A, Homechaudhuri S, Banerjee D. 2019. A short taxonomic account of dipteran flies from the Renuka Wetland and adjacent Sanctuary, Himachal Pradesh, India. *Munis Entomology and Zoology* 14(1): 224-231.
- Senior-White R. 1930. Distributional records of Indian muscoids, with description of two new species. *Records of the Indian Museum* 32: 65-75.
- Shinonaga S. 1970. Notes on *Orthellia* R.-D. from the Oriental region (Diptera: Muscidae). *Pacific Insects* 12(2): 291-295.
- Shinonaga S, Kano R. 1971. *Fauna Japonica. Muscidae* (Insecta: Diptera). Academic Press of Japan 1: 1-233.
- Shinonaga S, Singh M. 1994. Muscidae of Nepal (Diptera) I. Muscinae, Stomoxyinae and Phaoniinae. *Japanese Journal of Sanitary Zoology* 45: 99-177.
- Singh O P. 1975. Record of new pests infesting high yielding wheat varieties. *Indian Journal of Entomology* 37(1): 97-98.
- Singh D, Achint R. 2017. Molecular identification of some Indian muscid flies (Diptera: Muscidae) based on mitochondrial gene COII. *International Journal of Zoology Studies* 2(6): 101-105.
- Singh J P, Chibber R C. 1972. Outbreaks and new records. *FAO Plant Protection Bulletin* 20(3): 69-70.
- Singh B U, Sharma H C. 2002. Natural enemies of sorghum shoot fly, *Atherigona soccata* Rondani (Diptera: Muscidae). *Biocontrol Science and Technology* 12: 307-323.
- Sinha S K. 2009. Sarcophagidae, Calliphoridae and Muscidae (Diptera) of the Sunderbans Biosphere Reserve, West Bengal, India. *Records of the Zoological Survey of India* 308: 1-46.
- Sinha S K. 2014. New records of Calyptrate flies (Diptera) from the State of Jharkhand, India. *Prommalia* II: 1-22.
- Sinha S K, Hazari P, Mahato S. 2021. Diversity of Muscidae (Diptera) in Neora Valley National Park, West Bengal. *Indian Journal of Entomology* e21069. pp. 1-11.
- Sinha S K, Mondal R P. 2013. Life history of *Musca (Byomya) emdeni* (Sinha & Nandi) (Diptera: Muscidae), a dung breeding fly in the Sunderbans Biosphere Reserve. *Records of the Zoological Survey of India* 113(4): 29-33.
- Sinha S K, Nandi B C, Pandey B K, Chowdhury A. 2003. Report of some enteric bacteria on the body surface of the common house fly, *Musca (Musca) domestica* vicina Macquart (Diptera: Muscidae). *Proceedings of the Zoological Society Calcutta* 56(2): 87-88.
- Sinha S K, Nandi B C. 2004. On a small collection of muscid flies (Diptera: Muscidae) of Sunderbans Biosphere Reserve. India. *Records of the Zoological Survey of India* 102(1-2): 11-26.
- Sinha S K, Nandi B C. 2005. Studies on life history on dung breeding muscoid fly *Neomyia indica* (R-D) (Diptera, Muscidae) from Sunderbans Biosphere Reserve, West Bengal, India. *Journal of natural history* 1(2): 44-49.
- Srinivasan R. 2003. Efficiency of insect parasitoid *Dirhinus himalayanus* (Hymenoptera: Chalcididae) and triflumuron against house fly, *Musca domestica* (Diptera: Muscidae). *Indian Journal of Medical Research* 118: 158-66.
- Srivastava S, Singh R, Tewari R R. 2012. Temporal variation among populations of House fly *Musca domestica* (Diptera: Muscidae). *International Journal of Pharma and Biosciences* 3(1): 254-260.
- Thakur S R, Devasthali S, Upadhyay S N, Marabi R S. 2019. Field screening of sorghum genotypes for resistance to shoot fly, *Atherigona soccata* and stem borer, *Chilo partellus*. *Bulletin of Environment, Pharmacology and Life Sciences* 8(5): 62-67.
- Townsend C H T. 1917. Indian flies of the Subfamily Rhiniinae. *Records of the Indian Museum* 13: 185-202.
- Vishwakarma R, Chand P. 2017. Foraging activity of insect pollinators and their impact on yield of rapeseed-mustard. *Bioinfolet* 14(3): 222-227.
- Zimim L S. 1951. Family Muscidae (Tribes Muscini and Stomoxydini). *Fauna USSR (n.s)* 45: 1-286.

(Manuscript Received: March, 2022; Revised: May, 2022;

Accepted: May, 2022; Online Published: June, 2022)

Online First in www.entosocindia.org and indianentomology.org Ref. No. e22397