

BIOSYSTEMATIC APPROACH: TO INVENTORIZATION OF UBIQUITIOUS MYIASIS CAUSING FLIES OF VETERINARY IMPORTANCE IN INDIA

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Abstract. Dipterans are a diverse order of insect of which Calliphoridae and Sarcophagidae are the most ubiquitous, as several species of these families immature stages have been known to cause a deleterious condition of human and animal tissue, viz., collectively termed as myiasis. Therefore it is essential to gather information and to setup a biosystematic species inventory on the common and most ubiquitous myiasis causers along with their synonyms and notes on type localities to generate information about their distribution and substrate preferences for causing myiasis. The current study reveals, a total of 21 species of flies which are responsible for causing myiasis in India, out of which 17 species cause myiasis in animals, out of which 8 species belong to the family Calliphoridae and 9 species belong to the family Sarcophagidae, respectively. The present study provides a synopsis of the regional biosystematic and taxonomical work carried out until now, and can serve as a baseline data for future studies.

Keywords: *medico-legal entomology, Myiasis, Calliphoridae, Sarcophagidae, India.*

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1. Introduction

India is one of the world's most biodiverse regions with a total area of about 3,287,263 km². The faunal diversity of India is rich and diversified because of a variety of ecozones ranging from deserts to high mountains and tropical to temperate forests. The Indian myiasis causers, especially the family Calliphoridae and Sarcophagidae has been poorly known as most species were described in the 19th century; apart from treatment by (Senior White et al, 1940) [77].

This taxonomically and medico legally important faunal group have been neglected till date. The study indicates that most of the species have been collected in selected regions of India, typically from West Bengal. The term "myiasis," was introduced by Hope in 1840, is now in general use to indicate the condition resulting from the invasion of tissues or organs of man or animals by dipterous larvae. Somewhat earlier; Kirby and Spence, had proposed the name "scoleichiasis" for such invasions by insect larvae in general. Hope proposed to limit the term "scoleichiasis" by proposing "myiasis" for dipteran larvae; "scoleichiasis" for lepidopterous larvae and "canthariasis" for coleopteran larvae [17].

Patton in 1921 extended the use of the term myiasis to include all stages of Diptera including that eggs, pupae, and even adults may occasionally be found in the human or

animal body. Thus the need for a species inventory or a general guide to the subject became evident, only after the progress of World War II in Europe and America [42, 43]. But no such study was conducted in India.

The family Calliphoridae and Sarcophagidae flies are the most ubiquitous due to their trade mark appearance on wounds and dead bodies. The family Calliphoridae is represented currently in the world by 1,520 species and out of which 59 species has been recorded from India and the family Sarcophagidae is represented currently in the world by 3,079 species and out of which 126 species are recorded from India [33, 34].

The current interest in these flies is due to the fact that these flies wreck havoc on cattle health, by both in terms of product quality and quantity, viz., deteriorating cattle biomass there by tremendously reducing the quantity and quality of meat, milk, wool and leather in ungulates. Therefore the current study is important in the fact that it will provide a list of all the myiasis causing flies of the two most ubiquitous groups, which are taxonomically distinctly different but ecologically similar on basis of utilization of similar resources.

The current study focuses on the generation of base line data for India, which is so far not been attempted yet and this will seemingly be the pioneering study to generate a species inventory of myiasis causing Calliphorids and Sarcophagids in India of veterinary importance, also synonyms are given to avoid misidentification and distribution is given in this biosystematic checklist.

2. Materials and methods

2.1. Status survey

Taxonomic nomenclature used for the checklist follows (Evenhuis, 2014). Indian distribution and elsewhere are also given; along with synonyms of the species. The study is based on the available literature rather than on extensive new taxonomic work. Most of the names of the described species presented are in accordance with the most recent Stratiomyidae classification following Systema Dipteroorum (Woodley, 2001 and Pape and Evenhuis, 2013).

2.2. Museum survey

Dipterans collected from tissues of animals (adults and/or immature) and stored in the repository of National Zoological Collection in the Zoological Survey of India, Kolkata, were studied and utilized for the preparation of the checklist. The registration numbers of the flies are from 2080/H6 to 2364/H6, 2374/H6 to 4140/H6, 4321/H6 to 4647/H6 and 6935/H6 to 7836/H6.

2.3. Literature survey

Taxonomic literatures were reviewed for extracting out Indian species of the medico-legally important dipteran from internet resources and other relevant literatures such as Catalog of Life (updated on September, 2016) [55], Systema Dipteroorum (updated on June, 2013) [40], Oriental catalog [28], Fauna of British India [77] and Catalog of Diptera from Australasian and Oceania regions [10], Zoo records series (2011 to 2016) and State fauna series and Open search for papers on myiasis causing dipterans and allied disciplines from the Internet, were consulted for extraction of the

current taxonomic position of the myiasis causing species, for the preparation of biosystematic inventory and proper in-hand identification of the specimens as all the synonyms are clubbed under the current taxonomically accepted name, their biogeographic distribution and thereby ultimately curving all these data into the first of its kind checklist of Indian dipteran species of medico legal (veterinary) interest, the work, especially mentions the species from West Bengal. Besides this other major contributors of the field along with their contributions are cited and current status of the Indian variety is elucidated along with survey locations.

2.4. Descriptive statistics

Basic numerical taxonomy a classification system in biological systematics which deals with the grouping by numerical methods of taxonomic units based on their character. It aims to create a taxonomy using numeric algorithms like cluster analysis rather than using subjective evaluation of their properties. This is achieved by dividing on criteria basis and utilizing graphs to visualize data [69]. This will give us an idea of the types of groups that are encountered due to substrate preference.

2.5. Biometric analysis and AHC

Previous collections (from National Zoological Collection, General Diptera Collection were taken) and microscopic measurements of the genital capsules of the various specimens of these myiasis causing flies were undertaken in Lecia M 205 and Lecia EZ4 HD microscopes. Based on the body biometrics (length of genital capsule of $n = 10$ individuals of each species) and current nomenclature AHC was done to see relation between the various levels of taxa to assess phylogenetic relationships between species, using the length of genital capsule. This method uses comparative statistical analyses that assumes the independence of data points and phylogenetically independent contrasts (Felsenstein, 1984), in Wards method [3, 12, 16, 14, 27, 30].

3. Results

The list is arranged systematically to subgenus and genus level and alphabetically thereafter, to make the search easier for a given taxon. Main references to the original distribution and host preference are listed. The acronyms used for collections follow the standard of the Systema Dipteroorum (Woodley, 2001 and Pape and Evenhuis, 2013), and their equivalents are as follows; *Calliphora (Calliphora) vicina* Robineau-Desvoidy, 1830: CV; *Lucilia cuprina* (Wiedemann, 1830) : LC; *Lucilia illustris* (Meigen, 1826): LI; *Lucilia sericata* (Meigen, 1826) : LS ; *Chrysomya albiceps* (Wiedemann, 1819): CA; *Chrysomya bezziana* Villeneuve, 1914 : CB; *Chrysomya megacephala* (Fabricius, 1794): CM; *Chrysomya rufifacies* (Macquart, 1843): CR; *Wohlfahrtia nuba* (Wiedemann, 1830):WN; *Sarcophaga (Bellieria) melanura* Meigen, 1826: SBM; *Sarcophaga (Liopygia) argyrostoma* (Robineau-Desvoidy, 1830):SLA; *Sarcophaga (Liopygia) ruficornis* (Fabricius, 1794): SLR; *Sarcophaga (Liosarcophaga) dux* Thomson, 1869: SLD; *Sarcophaga (Parasarcophaga) albiceps* (Meigen, 1826) SPA; *Sarcophaga (Parasarcophaga) hirtipes* (Wiedemann, 1830): SPH; *Sarcophaga (Parasarcophaga) macroauriculata* (Ho,1932): SPM; *Sarcophaga (Parasarcophaga) misera* (Walker,1849): SP.

Checklist of myiasis causing flies of India (based on immature stage development model)

ORDER Diptera (Linnaeus, 1758)

SUBORDER Brachycera (Macquart, 1834)

INFRAORDER Muscomorpha (Woodley, 1989)

SECTION Schizophora (Becher, 1882)

SUB SECTION Calyptratae (Robineau-Desvoidy, 1830)

SUPER FAMILY Oestroidea (Leach, 1815)

FAMILY Calliphoridae (Brauer & Bergenstamm, 1889)

SUB FAMILY Calliphorinae Brauer & Bergenstamm 1889

TRIBE Calliphorini Lopes, 1968

GENUS *Calliphora* Robineau-Desvoidy

SUB GENUS *Calliphora* Robineau-Desvoidy, 1830

1. *Calliphora (Calliphora) vicina* Robineau-Desvoidy, 1830.

Distribution in India: Chandīgarh (Singh & Sidhu, 2004), Haryāna (Singh & Sidhu, 2004), Himāchal Pradesh (Bharti & Singh B., 2017; Singh & Sidhu, 2004), [Shimla (Senior-White, Aubertin & Smart, 1940; Sinha & Nandi, 2004)], Punjab (Aggarwal, 2005; Bharti & Singh B., 2017; Bharti & Singh D., 2002; Singh & Bharti, 2000; Singh & Sidhu, 2004), Sikkim (Senior-White, Aubertin & Smart, 1940; Singh & Sidhu, 2004) [Mangan, Phensang (Sinha & Nandi, 2004)], Uttaranchal (Singh & Sidhu, 2004) [Dehra Dun (Senior-White, Aubertin & Smart, 1940); Nainital (Sinha & Nandi, 2004)], Uttar Pradesh [Mussooree (Senior-White, Aubertin & Smart, 1940)], Cherat? (Senior-White, Aubertin & Smart, 1940)] West Bengal (Singh & Sidhu, 2004) [Alipurduar, Birpara, Darjeeling, Ghoramara I., Kalimpong, Kurseong, Rajabhatkhawa (Sinha & Nandi, 2004); Sundarbans Biosphere Reserve (Sinha, Ghosh & Nandi, 2002; Sinha & Nandi, 2004)].

Host: Sheep (14).

TRIBE Luciliini Shannon 1924

GENUS *Lucilia* Robineau-Desvoidy, 1830

2. *Lucilia cuprina* (Wiedemann, 1830).

Synonyms

Lucilia amica Robineau-Desvoidy, 1830

Lucilia argyricephalata Macquart, 1846

Lucilia dorsalis Robineau-Desvoidy, 1830

Lucilia elegans Robineau-Desvoidy, 1830

Lucilia leucodes Frauenfeld, 1867

Lucilia nigricornis Senior-White, 1924

Lucilia pseudosericata Gaminara, 1930

Lucilia pubens Macquart, 1843

Lucilia usta Robineau-Desvoidy, 1830

Musca fucina Walker, 1849

Musca serenissima Walker, 1853

Musca temperata Walker, 1853

Musca varians Wiedemann, 1830

Phaenicia pallescens Shannon, 1924

Somomya pallifrons Bigot, 1877

Strongyloneura nigricornis Senior-White, 1924

Distribution in India: Assam [Sadiya], Arunachal Pradesh [Pasighat], Chandīgarh (Singh & Sidhu, 2004), Haryāna (Singh & Sidhu, 2004), Himachal Pradesh [Shimla], Jammu & Kashmir [Gulmarg], Rajasthan (Singh & Sidhu, 2004; Singh & Singh, 2002), Sikkim [Jorethang] (Senior-White, Aubertin & Smart, 1940), Karnataka (Valandikar, 1982), West Bengal (Aloke, Roy & Dasgupta, 1989; Singh & Sidhu, 2004) [Burdwan, Coochbehar, Dhabalhat, Shibpur, Rajabhatkhawa, Ranaghat, Shibpur Botanical Garden (Sinha & Nandi, 2004)].

Host: Sheep (22).

3. *Lucilia illustris* (Meigen, 1826).

Distribution in India: Haryāna (Singh & Sidhu, 2004), Himachal Pradesh (Senior-White, Aubertin & Smart, 1940; Singh & Sidhu, 2004), Punjab (Bharti, 2009; Shah & Sakhawat, 2004; Singh & Bharti, 2000; Singh & Sidhu, 2004), Uttaranchal (Singh & Sidhu, 2004; Singh & Singh, 2002).

Host: Canine (foxes and dogs).

4. *Lucilia sericata* (Meigen, 1826).

Synonyms

Pyenozonia sericata (Meigen, 1826).

Lucilia barberi Townsend, 1908

Lucilia capensis Robineau-Desvoidy, 1830

Lucilia flavipennis Macquart, 1843

Lucilia frontalis Brauer & Bergenstamm, 1891

Lucilia giraulti Townsend, 1908

Lucilia lagyra Walker, 1849

Lucilia latifrons Schiner, 1861

Lucilia pruniosa Meigen, 1838

Lucilia sayi Jaennicke, 1867

Musca lagyra Walker, 1849

Musca nobilis Meigen, 1826

Musca tegularia Wiedemann, 1830

Phaenicia concinna Robineau-Desvoidy, 1863

Distribution in India: Almost throughout India” (Sinha, 2014), Himachal Pradesh (Bharti & Singh B., 2017), Jharkhand (Sinha, 2014), Punjab (Senior-White, Aubertin & Smart, 1940; Singh & Singh, 2002), West Bengal [Bamankhali, Darjeeling, Ganga Sagar, Ghoramara I., Kalimpong, Malda, Siliguri, Sukna, Takvar (Sinha & Nandi, 2004)]

Host: Sheep (22).

SUB FAMILY Chrysomyinae Roback, 1951

TRIBE Chrysomyini Shannon 1923

GENUS *Chrysomya* Robineau-Desvoidy, 1830

5. *Chrysomya albiceps* (Wiedemann, 1819).

Synonyms

Chrysomyia indica Patton, 1934

Compsomyia flaviceps Seguy, 1927

Compsomyia mascarenhasi Seguy, 1927
Lucilia arcuata Macquart, 1851
Lucilia testaceifacies Macquart, 1851
Musca bibula Wiedemann, 1830
Musca elara Walker, 1849
Musca emoda Walker, 1849
Musca felix Walker, 1853
Musca himella Walker, 1849
Paracompsomyia verticalis Adams, 1905
Somomyia annulata Brauer, 1899
Somomyia arussica Corti, 1895
Somomyia nubiana Bigot, 1877

Distribution in India: Kerala (Radhakrishnan et al., 2012), Punjab (Bharti, 2014), Uttaranchal (Singh & Singh, 2002), West Bengal (Sinha, Mondal & Mahato, 2016).

Host: Bovine (22).

6. *Chrysomya bezziana* Villeneuve, 1914.

Distribution in India: widespread (Bharti, 2014; James, 1947; Chhabra & Pathak, 2008; Krajewski, Allen, Hoss, Patel & Chandawarkar, 2009; Lane & Crosskey, 1993; Norris & Murray, 1964; Singh & Singh, 2002; Sood, Kakar & Wattal, 1976; Verves, 2005),); Andhra Pradesh (Norris & Murray, 1964): Kadapa (Kumar, 2012), Assam (Nene et al. 2015), Calicut (Joseph et al., 2014), Chandīgarh (Singh & Sidhu, 2004), Chhattisgarh (Norris & Murray, 1964), Dadra & Nagar Haveli (Norris & Murray, 1964), Delhi (Singh & Sidhu, 2004), Goa (Internet state fauna series), Haryana (Kumar & Ruprah, 1984), Himāchal Pradesh (Singh & Sidhu, 2004), Jammu (Katoch et al., 2014), Karnataka (Norris & Murray, 1964; Sharma, A. & Hedge, 2010), Kerala (Norris & Murray, 1964; Radhakrishnan et al., 1994, 2012), Madhya Pradesh (Norris & Murray, 1964; Thomas, Nair, Hegde & Kulkarni, 2010), Maharashtra (Kulkarni et al., 2012; Norris & Murray, 1964): Puna (Sowani et al., 2004), New Delhi (Sachdev, Kumar, Roop, Arora & Dada, 1990), Odisha [=Orissa] (Norris & Murray, 1964), Pondicherry (Gopalakrishnan, Srinivasan, Saxena & Shanmugapriya, 2008; Radhakrishnan et al., 1994), Punjab (Singh, A. & Sing, D. 2007; Singh, A. & Sing, D. 2006, 2007, 2016; Singh & Sidhu, 2004), Rajasthan (Internet), Tamil Nadu (David, Rupa, Mathai & Nair, 1996; Gopalakrishnan, Srinivasan, Saxena & Shanmugapriya, 2008; Norris & Murray, 1964; Sankari & Ramakrishnan, 2010), Uttar Pradesh (Aggarwal et al., 2014; Ahamd & Khan, 2012; Husain, A., Husain, S., Malaviya & Bahadur, 1993; Rathore et al., 2016; Sharma, Dayal & Agrawal, 1989), West Bengal (Norris & Murray, 1964).

Host: Bovine (16, 17, 18, 19).

7. *Chrysomya megacephala* (Fabricius, 1794).

Synonyms

Chrysomya megacephala (Fabricius, 1794).
Pyenosonia flaviceps (Berg)
Lucilia flaviceps Macquart, 1843
Chrysomya duvaucelii Robineau-Desvoidy, 1830
Chrysomya gratiosa Robineau-Desvoidy, 1830
Lucilia flaviceps Macquart, 1843

Musca bata Walker, 1849
Musca combrea Walker, 1849
Musca dux Eschscholtz, 1822
Musca remuria Walker, 1849
Pollenia basalis Smith, 1876
Somomya cyaneocincta Bigot, 1888
Somomya pfefferi Bigot, 1877
Somomyia cyaneocincta Bigot, 1887
Somomyia dives Bigot, 1887
Somomyia saffrana Bigot, 1877

Distribution in India: Arunachal Pradesh, Assam, Bihar (Sinha, 2014), Calcutta (Das et al., 1978), Chandīgarh (Singh & Sidhu, 2004), Delhi (Singh & Sidhu, 2004), Haryāna (Singh & Sidhu, 2004), Himāchal Pradesh (Bharti & Singh, 2017; Singh & Sidhu, 2004; Verves, 2005), Jammu & Kashmīr (Singh & Sidhu, 2004), Jharkhand (Sinha, 2014; Singh & Sidhu, 2004), Karnataka (Valandikar, 1982), Kerala (Bharti & Singh, 2017), Maharashtra (Abd-ALGalil & Zambare, 2015), Meghalaya, Orissa (Sinha, 2014), Punjab (Aggarwal, 2005; Bharti & Singh B., 2017; Bharti & Singh D., 2002; Singh & Bharti, 2000; Singh & Singh, 2002; Singh & Sidhu, 2004), Rājasthān (Singh & Sidhu, 2004), Sikkim (Sinha, 2014), Tamil Nadu (Ramaraj et al., 2014; Sinha, 2014), Tripura (Datta & Parui, 2000; Sinha, 2014), Uttaranchal (Singh & Sidhu, 2004), West Bengal (Aloke, Roy & Dasgupta, 1989; Dey, Bhattacharya, Pal, Das & Pal, 2012; Mondal, Biswas, Banerji, Bose, Biswas & Mandal, 2014; Mondal, Mahato, Chakraborty. & Sinha, 2015; Sinha, Mondal & Mahato, 2016) [Sundarbans Biosphere Reserve (Sinha, Ghosh & Nandi, 2002); Alipurduar, Bamankhali, Begnakhali, Bijanbari, Chandanpiri, Ghoramara I., Jaigaon, Kalyani, Kurseong, Madarihat, Panitanki, Rajabhatkhawa, Ranaghat, Shibpur, Singala Bazar, Siliguri (Sinha & Nandi, 2004)].

Host: Animal, generally canine (25).

8. *Chrysomya rufifacies* (Macquart, 1843).

Distribution in India: Andaman Is. (Sinha, 2014), Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Chandīgarh (Singh & Sidhu, 2004), Goa, Haryāna (Singh & Sidhu, 2004), Himāchal Pradesh (Singh & Sidhu, 2004; Verves, 2005), Jammu & Kashmīr (Singh & Sidhu, 2004), Jharkhand (Sinha, 2014), Karnataka, Kerala (Bharti & Singh, 2017), Madhya Pradesh (Verves, 2005), Maharashtra (Abd-ALGalil, F. M. A. & Zambare, S. P., 2015; Verves, 2005), Manipur, Meghalaya, Nagaland (Verves, 2005), Nicobar Is. (Sinha, 2014), Orissa, Pondicherry, Punjab (Aggarwal, 2005; Bharti & Singh, 2017; Singh & Sidhu, 2004), Rājasthān (Singh & Sidhu, 2004), Sikkim (Sinha, 2014), Tamil Nadu, Tripura, Uttar Pradesh (Vernma, 2013), Uttaranchal (Singh & Sidhu, 2004), West Bengal (Aloke, Roy & Dasgupta, 1989; Séguy, 1941; Singh & Singh, 2002) [Sundarbans Biosphere Reserve (Sinha, Ghosh & Nandi, 2002); Alipurduar, Bamankhali, Begnakhali, Bijanbari, Chandanpiri, Ghoramara I., Jaigaon, Kalyani, Kurseong, Madarihat, Panitanki, Rajabhatkhawa, Ranaghat, Shibpur, Singala Bazar, Siliguri (Sinha & Nandi, 2004)].

Host: Sheep (22).

SUBORDER Brachycera (Macquart, 1834)

INFRAORDER Muscomorpha (Woodley, 1989)

SECTION Schizophora (Becher, 1882)
SUB SECTION Calyptratae (Robineau-Desvoidy, 1830)
SUPER FAMILY Oestroidea (Leach, 1815)
FAMILY Sarcophagidae Haliday, 1853
GENUS Wohlfahrtia Brauer & Bergenstamm, 1889

9. *Wohlfahrtia nuba* (Wiedemann, 1830)

Synonyms

Tachina nuba Wiedemann, 1830

Wohlfahrtia volucris Seguy, 1941

Wohlfahrtia nuba Rohdendorf, 1956

Distribution India: Punjab (Chakraborty et al., 2017; Pape, 1996; Verves, 1985), Rajasthan (Chakraborty et al., 2017; Nandi, 2002).

Host: Bovine and Canine (29).

SUB FAMILY Sarcophaginae Schiner 1861
GENUS Sarcophaga Meigen, 1826
SUB GENUS *Bellieria* Robineau-Desvoidy 1863

10. *Sarcophaga (Bellieria) melanura* Meigen, 1826

Synonyms

Sarcophaga melanura Meigen, 1826

Distribution India: Bihar (Chakraborty et al., 2017; Verves, 2001), Jammu & Kashmir (Chakraborty et al., 2017; Rohdendorf, 1937), Tamil Nadu (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001).

Host: Avian, Bovine and Canine (12, 13, 23).

SUB GENUS *Liopygia* Enderlein, 1928

11. *Sarcophaga (Liopygia) argyrostoma* (Robineau-Desvoidy, 1830)

Synonyms

Sarcophaga barbata Thomson, 1869

Distribution India: Gujarat (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Haryana (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Maharashtra (Khan, L., Zambare & Fahd, 2016), Rajasthan (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Uttar Pradesh, Uttarakhand (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001).

Host: Sheep (12, 13).

12. *Sarcophaga (Liopygia) ruficornis* (Fabricius, 1794)

Synonyms

Parasarcophaga ruficornis (Fabricius, 1794)

Distribution India: Andaman Is. (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Andhra Pradesh (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Assam (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Bihar (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Dādra and Nagar Haveli (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Dehli (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Goa (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Gujarat (Chakraborty et al.,

2017; Nandi, 2002; Verves, 2001), Haryana (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Himachal Pradesh (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Karnataka (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Kerala (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Lakshadweep Is. (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Madhya Pradesh (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Maharashtra (Abd-Algalil, Zambare & Mashaly, 2016; Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Manipur (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Meghalaya (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Mizoram (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Nagaland (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Orissa (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Pondicherry (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Punjab (Chakraborty et al., 2017; Nandi, 2002; Rohdendorf, 1930; Singh, A. & Singh, D., 2016; Verves, 2001), Rajasthan (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Tamil Nadu (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Uttar Pradesh (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), West Bengal (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001): Sundarbans Biosphere Reserve (Sinha, Ghosh & Nandi, 2002).

Host: Dog & Poultry, *Bufo melanostictus* (12, 13, 22, 29).

SUB GENUS *Liosarcophaga* Enderlein, 1928

13. *Sarcophaga* (*Liosarcophaga*) *dux* Thomson, 1869

Synonyms

Sarcophaga dux. var *harpax* Pandelle, 1896

Sarcophaga subtuberosa Parker, 1917

Distribution India: Andaman Is. (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Andhra Pradesh (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Arunachal Pradesh (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Assam (Chakraborty et al., 2017; Nandi, 1982, 2002; Verves, 2001), Bihar (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Chandigarh (Verves, 2001), Delhi (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Goa (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Gujarat (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Jammu & Kashmir (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Karnataka (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Kerala (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Lakshadweep (Chakraborty et al., 2017), Madhya Pradesh (Nandi, 2002; Verves, 2001), Maharashtra (Chakraborty et al., 2017; Fahd & Zambare 2016; Nandi, 2002; Verves, 2001), Manipur (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Meghalaya (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Mizoram (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Nagaland (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Orissa (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Punjab (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Rajasthan (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Tamil Nadu (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Tripura (Chakraborty et al., 2017; Datta & Parui, 2000), Uttar Pradesh (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), West Bengal (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001): Sundarbans Biosphere Reserve (Sinha, Ghosh & Nandi, 2002).

Host: Bovine (Cows, Camels and Bullocks) (12, 13, 22).

SUB GENUS *Parasarcophaga* Johnston & Tieg, 1921

14. *Sarcophaga* (*Parasarcophaga*) *albiceps* (Meigen, 1826)

Distribution India: Andaman Is. (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Andhra Pradesh (Chakraborty et al., 2017; Nandi, 2002; Senior-White, Aubertin & Smart, 1940; Verves, 2001), Arunachal Pradesh (Chakraborty et al., 2017; Nandi, 2002; Senior-White, Aubertin & Smart, 1940; Verves, 2001), Assam (Chakraborty et al., 2017; Nandi, 2002; Senior-White, Aubertin & Smart, 1940; Verves, 2001), Bihar (Chakraborty et al., 2017; Nandi, 2002; Senior-White, Aubertin & Smart, 1940; Verves, 2001), Chandigarh (Chakraborty et al., 2017; Nandi, 2002), Dādra & Nagar Haveli (Nandi, 2002), Damān and Diu (Chakraborty et al., 2017; Nandi, 2002), Delhi (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Goa (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Gujarat (Chakraborty et al., 2017), Haryana (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Himachal Pradesh (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Jammu & Kashmir (Verves, 2001; Nandi, 2002), Jharkhand (Sinha, 2014), Karnataka (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Kerala (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Laccadive Is. (Parui & Datta, 1991; Verves, 2001; Nandi, 2002), Madhya Pradesh (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Maharashtra (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Manipur (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Meghalaya (Verves, 2001; Nandi, 2002), Mizoram (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Nagaland (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Nicobar Is. (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Orissa (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Pondicherry (Chakraborty et al., 2017; Nandi, 2002), Punjab (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Rajasthan (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Sikkim (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Tamil Nadu (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Tripura (Chakraborty et al., 2017; Datta & Parui, 2000; Nandi, 2002; Verves, 2001), Uttar Pradesh (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), West Bengal (Aloke, Roy & Dasgupta, 1989; Chakraborty et al., 2017; Nandi, 1982a, b, 2002; Verves, 2001) [Sundarbans Biosphere Reserve (Sinha, Ghosh & Nandi, 2002)]

Host: Bovine (Bull) (12, 13, 22).

15. *Sarcophaga* (*Parasarcophaga*) *hirtipes* (Wiedemann, 1830)

Synonyms

Sarcophaga hirtipes.var *orchidea* Bottcher, 1913

Distribution India: Andaman Is. (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Andhra Pradesh (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Bihar (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Delhi (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Gujarat (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Haryana (Nandi, 2002; Pape, 1996; Verves, 2001), Jharkhand (Sinha, 2014), Karnataka (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Kerala (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Madhya Pradesh (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Maharashtra (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Manipur (Verves, 2001), Mizoram (Verves, 2001), Nagaland (Verves,

2001), Orissa (Sinha, 2014), Punjab (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Rajasthan (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Tamil Nadu (Chakraborty et al., 2017; Nandi, 1988, 2002; Verves, 2001), Tripura (Sinha, 2014), Uttar Pradesh (Chakraborty et al., 2017; Nandi, 1990, 2002; Verves, 2001), West Bengal (Chakraborty et al., 2017; Joseph & Pauri, 1980; Nandi, 2002; Verves, 2001).

Host: Sheep (12, 13).

16. *Sarcophaga (Parasarcophaga) macroauriculata* (Ho, 1932)

Distribution India: Manipur (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Meghalaya (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Nagaland (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Sikkim (Chakraborty et al., 2017; Nandi, 1990, 2002; Verves, 2001), Uttar Pradesh (Chakraborty et al., 2017; Nandi, 1990, 2002; Verves, 2001), West Bengal (Chakraborty et al., 2017; Dasgupta, Roy & Guin, 1972; Nandi, 2002; Senior-White, Aubertin & Smart, 1940; Verves, 2001).

Host: Feline (12, 13).

17. *Sarcophaga (Parasarcophaga) misera* (Walker, 1849)

Distribution India: Andaman Is. (Nandi, 2002), Andhra Pradesh (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Arunahal Pradesh (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Assam (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Bihar (Chakraborty et al., 2017; Nandi, 1988, 2002; Verves, 2001), Chandigarh (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Dādra and Nagar Haveli (Nandi, 2002), Damān and Diu (Nandi, 2002), Delhi (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Goa (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Gujarat (Chakraborty et al., 2017; Nandi, 1992 a, b, 2002; Verves, 2001), Haryana (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Himachal Pradesh (Chakraborty et al., 2017; Nandi, 1990 a, b, 2002; Verves, 2001), Jammu & Kashmir (Chakraborty et al., 2017; Nandi, 1992 a, b, 2002; Verves, 2001), Jharkhand (Sinha, 2014), Karnataka (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Kerala (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Laccadive Is. (Nandi, 2002), Madhya Pradesh (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Maharashtra (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Manipur (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Meghalaya (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Mizoram (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Nagaland (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Nicobar Is. (Sinha, 2014), Orissa (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Pondicherry (Nandi, 2002), Punjab (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Rajasthan (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Sikkim (Nandi, 2002), Tamil Nadu (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), Tripura (Chakraborty et al., 2017; Datta & Parui, 2000; Nandi, 1992 a, b, 2002; Verves, 2001), Uttar Pradesh (Chakraborty et al., 2017; Nandi, 1988, 1990 a, 2002; Verves, 2001), West Bengal (Chakraborty et al., 2017; Nandi, 2002; Verves, 2001), [Sundarbans Biosphere Reserve (Sinha, Ghosh & Nandi, 2002)].

Host: Domesticated & Poultry animals, sheep (12, 13).

Biometric analysis and AHC

The biometric data was run through AHC which yielded 5 distinctly different groups, as specific biometric lengths points to specific substrate preference. As shown below. The bovine sub group consisting of CV, LC, CS, CB, WN, SBM, SLD, SPA and the feline sub group SPM, seems to have diverged from a common stock and the canine sub group consist of LI, CM; the caprine and ovine sub group consist of LS,CR,SLA,SPH and lastly the non specific sub group consists of SLR, SP.

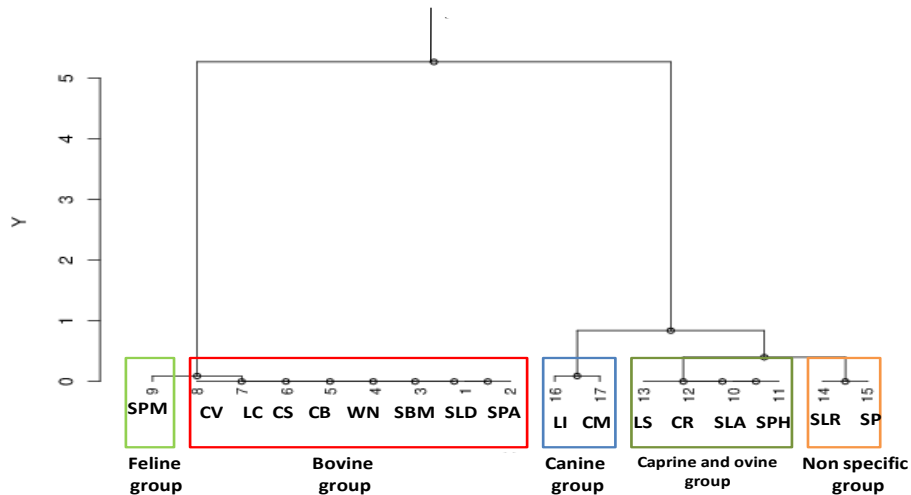


Fig. 1. AHC of the Sarcophagids and Calliphorids of Veterinary importance in India

3. Conclusion

The current study shows that the genus *Sarcophaga* is the major contributor to myiasis in India, as per previous literatures, as they amount for 44% (8 species) of the myiasis cases in India. The genus *Chrysomya* and *Lucilia* seems to be 22% (4 species) of the myiasis cases in India, as is the second largest contributor. The genus *Wohlfahrtia* and *Calliphora* amounts for 6% (1 species) of the myiasis cases in India, as is the third largest contributors, each cases of myiasis each in India (Fig.2, 3).

We show that the taxonomically less studied species designated as NMF (No mention found) on sub genus is the largest contributor to myiasis in India, with an astounding 44% (8 species), which re establishes the belief that taxonomic study along with biosystematic studies are needed for generation of base line data for these myiasis causing flies on the sub genus level. The sub genus *Parasarcophaga* amounts for 17% (3 species) of the myiasis cases in India, as is the second largest contributor. The sub genus *Liopygia* amounts for 11% (2 species) each of the myiasis cases in India, as is the third largest contributor. The sub genus *Bellieria*, *Bercaea*, *Liosarcophaga* and *Prionophalla* amounts for 6% (1 species) each. The sub genus *Squamotodes* and *Calliphora* amounts for 5% (1 species) each. (Fig. 4, 5).

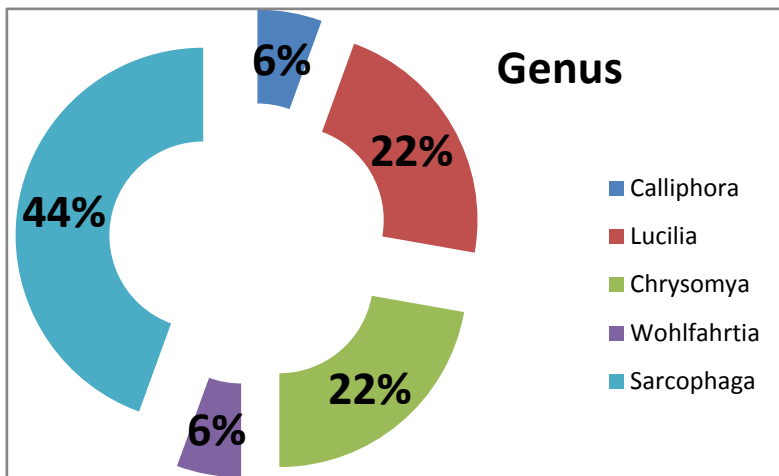


Fig. 2. The % of Genus of various flies in their contribution to myiasis cases in India

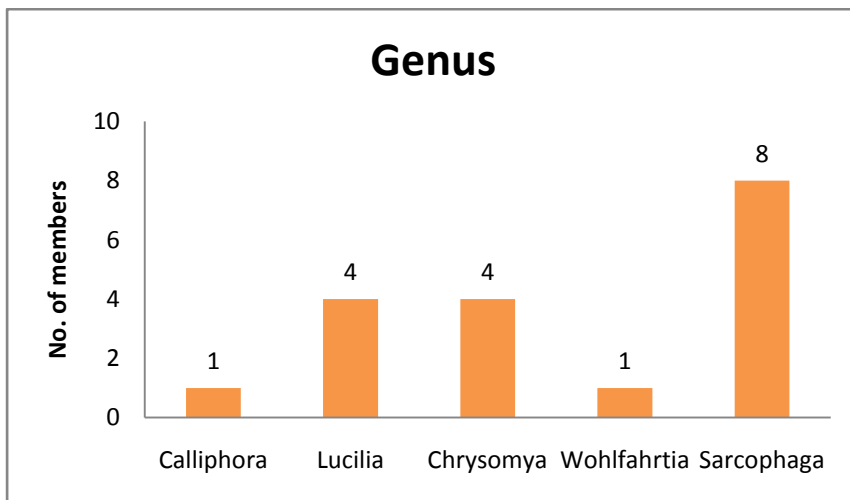


Fig. 3. The number of species of Genus of various flies in their contribution to myiasis cases in India

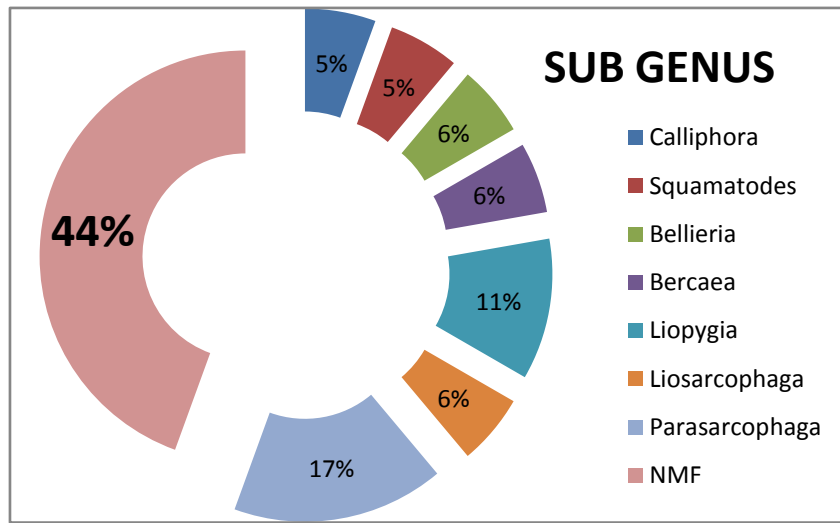


Fig. 4. The % of Genus of various flies in their contribution to myiasis cases in India

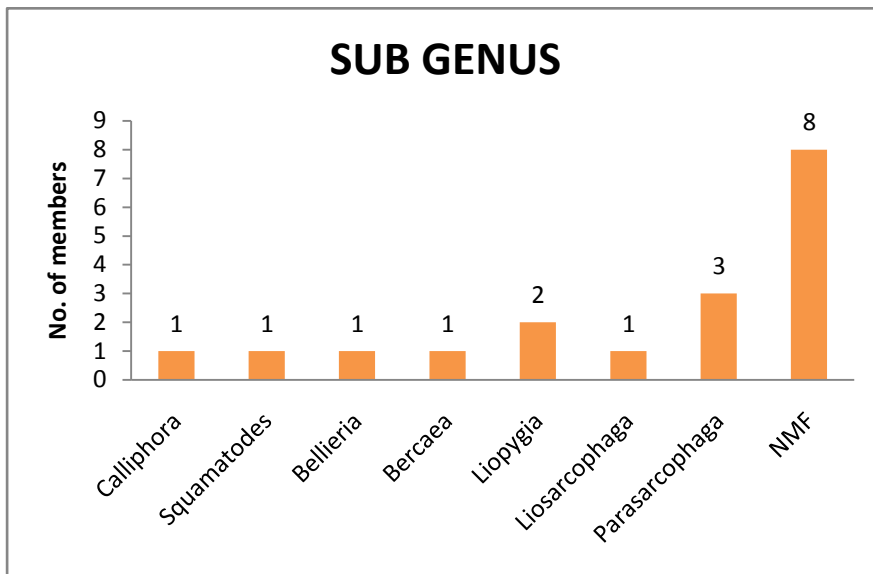


Fig. 5. The number of species of Sub genus of various flies in their contribution to myiasis cases in India

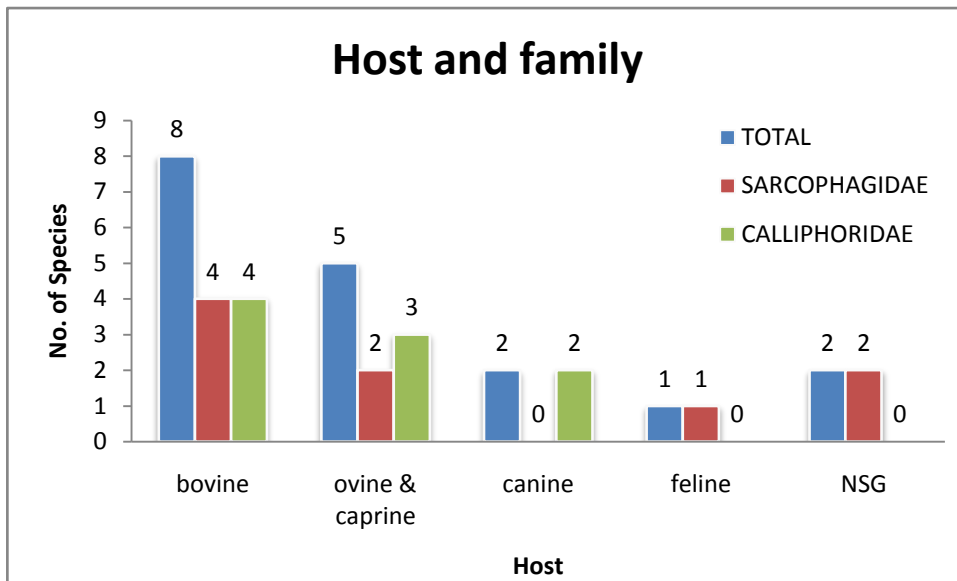


Fig.6.a. Show the hosts and family of myiasis causers and their hosts in myiasis cases

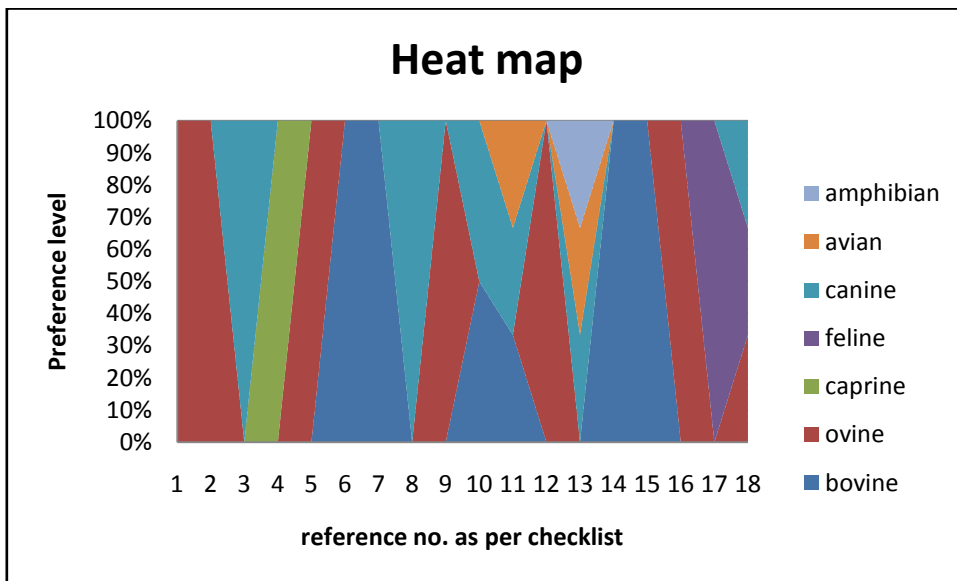


Fig.6.b. The types of hosts and their substrate preference of the two families

It seems bovine is equally preferred for both families at 45% each, while ovine and caprine is more preferred by Calliphoridae at 33%, than Sarcophagidae at 22%, canine is specifically preferred by Calliphoridae at 22% and feline is specifically preferred by Sarcophagidae at 11%, also Sarcophagidae at 22% of sometimes tend to be non specific also, thereby showing flexibility in substrate utilization.

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