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Chronology of appearance pattern and colonization of nutrient recycling forensic flies on house rat carcasses (*rattus rattus*) in urban and semi-urban habitats of southern part of west Bengal

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Abstract
Carrion flies used to colonize dead and decomposed carcasses soon after death thus aids in estimating Post-mortem interval (PMI) during forensic investigations. By recruiting and engaging huge microbial fauna, they also accelerate decomposition process which in turn helps in the maintenance of the proper saptio-temporal functioning of the food web. Thus, this carrion flies not only assist in forensic investigations but also in nutrient recycling. During this study the species composition, abundance and succession patterns of carrion flies were thoroughly studied on house rat (*Rattus rattus*) carcasses in two different habitats and during two different months of the year (March and November, 2020). Kolkata, West Bengal was chosen as the urban habitat whereas Hooghly district of West Bengal was selected as the suburban study site. The succession wave of carrion flies on house rat carcasses started with muscids, *Synthesiomyia nudiseta* in the urban habitat and ended with *Atherigona orientalis* in the urban study site during March and November, 2020. In the suburban habiat, the colonization wave of carrion flies commenced with Calliphoridae, *Chrysomya megacephala* and *Atherigona orientalis* (Muscidae) was the last species found on decomposed carcasses in March 2020. In contrast, Sarcophagidae, *Sarcophaga albiceps* was the first species to visit the rat carcasses whereas, Phoridae, *Megaselia scalaris* was the last species to colonize the decomposed carcasses during November 2020. *Synthesiomyia nudiseta* was the most abundant species in the urban habitat during March and November 2020 whereas; *Chrysomya megacephala* and *Sarcophaga ruficornis* were found to be the most abundant species of house rat carcasses during March and November 2020, respectively. This study represent a detailed research on succession patterns of carrion flies on house rat carcasses (a mammalian model) in different times of the year 2020, which will assist in future research on medico-legal investigations specifically from Southern part of West Bengal.

Keywords: carrion flies, carcass, forensic investigations, succession, abundance

Introduction

Utilization of carrion flies in medico-legal investigations has long been fascinated as these flies used to colonize dead and decomposed carcasses soon after demise. They aids in the estimation of time since death which is known as Post Mortem Interval (PMI). PMI can be estimated in two ways – a) Collection of flies from the rotten and decomposed carcasses at early stages of decomposition and estimation of their development time in the laboratory can be useful in detecting PMI. b) Observation of arthropod successional patterns and relating them with preexisting data for the similar arthropods in the pertinent geoclimatic zone during an advance stage of decomposition (Barnes, 2000) [1]. Diptera and Coleoptera account for 60% of the insect fauna associated with putrefying carcasses thus they aids in forensic investigations (Moretti *et al.* 2008) [19]. It has been witnessed that calliphorid diptera of the genera Lucilia, Chrysomya, Cochliomyia and Calliphora, and various other genera of Sarcophagidae are abundant and undergo a successional change during decomposition (Bornemissza, 1957; Payne, 1972, Moretti *et al.* 2008) [2, 16, 19]. The very early studies on carrion flies from West Bengal was conducted by Joseph and Parui, 1980 [13] and the diversity studies of forensic indicator flies from three different districts of West Bengal by means of several parameters was performed by Majumdar *et al*., 2008 [14]. Another study of carrion flies succession patterns on Indian mole-rat carcasses (*Bandicota bengalensis*) from two different habitats of West Bengal, during early summer was done by Hore *et al*., 2017 [12]. But no studies from West Bengal have been performed in different time frames of the year to address the differences in the species composition, relative abundance and diversity of dipterofauna that colonizes the house rat carcasses (*Rattus rattus*).

Insects demands particular environmental parameters to colonize a carcass and by studying their colonization and succession patterns on a particular type of carcass may provide indications if the remains have been relocated from an rural to urban habitat (Erzinclioglu 1989; Catts and Haskell 1990; Hore *et al*., 2017) [9, 6, 12].

Carrion represents exceedingly remarkable and transient microhabitat specificity as it is rapidly degraded by the actions of the carrion flies which voraciously feed on it. The number of species that visits these microhabitats largely varies according to the geoclimatic factors from one patch to another and also with time (Galante and Marcos-Garcia 2004) [10]. Depending on the specific stage of decomposition, a chronological sequence of colonization tends to occur among these carrion flies (Byrd and Castner 2010). A rapid ecological succession can be traced during the decomposition of carrion. Adult flies feed on the fluid that oozes out from the decomposed carcasses and larvae

aids in nutrient recycling by secreting enzymes directly into the corpse, thus promotes liquefaction of the corpse tissue and accelerates microbial activity (Galante and Marcos-Garcia 2004; Hore *et al*. 2017) [10, 12]. Thus, observing the differences in species composition of carrion flies that colonize carcasses during each decomposition stage in different regions provides deeper insights about the differences of carrion decomposition in relation to biogeography and ecology of insects (Hore *et al*. 2017) [12].

The objective of our study is to elucidate the species composition and succession patterns of carrion flies that act as forensic indicators and aids in estimating Post-mortem interval (PMI) during medico-legal investigations from particular habitat and during specific time of the year. Thus, an urban habitat Bhowanipur, Kolkata and Bhadreswar (Hooghly, a suburban (semi-urban) habitat was selected for pursuing the research work. The house rat (*Rattus rattus*) carcasses were used to carry out the research work. During March and November of the year 2020, the species composition and succession patterns of carrion flies on house rat (*Rattus rattus*) carcasses were thoroughly studied to evaluate the differences in the colonization of dipterofauna from both of the selected localities and during two different months (March and November, 2020) of the year. The data generated during this in-depth study will benefit forensic investigations from these regions during specific times of the year.

Materials and Method

Study area and time of sample collection

The study was performed concurrently in two localities-Bhowanipur, Kolkata (urban locality) and Bhadreswar, Hooghly, a semi-urban (suburban) area under Kolkata metropolitan area, West Bengal, India during the month of March 2020 and November 2020. The urban locality is with less greenery and has dense human population and the suburban study area is less congested and has more greenery. Study sites were situated approx. 45 km from each other.

Carcass

Four rotten carcasses of house rat (*Rattus rattus*) weighing approx. 90g each was used for both of the study sites during March and November 2020. The rotten rat samples at fresh stage of decay were collected from vat near each of the urban and semi-urban research sites. Four carcasses were used for each of the study sites during March and November 2020. The samples were allowed to decompose until they reach the dry remains stage of decay. The time required to reach the remains stage was variable for each of the study site and during each of the study month. The carcasses were kept in natural environmental conditions.

Meteorological data collection

The climate of Kolkata and Hooghly during March 2020 was hot and humid and during November was moderately hot during 2020. Daily weather reports during March and November 2020 were collected online from the website of Regional meteorological Department, Alipur, Kolkata. The relative humidity and maximum and minimum air temperatures of each of the study sites during each of the study months were measured using a digital hygrometer with temperature gauge meter (Model- ThermoPro TP-60S)

Colonization and succession pattern of carcass by Dipterofauna

The house rat carcasses were observed from the fresh stage to the dry remains stage of decay during the study in March and November 2020 and the colonization of the different types of forensic flies were recorded. The carcasses and the appearance pattern of forensic diptera were observed thrice a day (Morning, afternoon and evening). The photo documentation of the appearance and colonization of various forensic flies on each type of carcasses were done using a high resolution camera (NIKON D-7000).

Collection of samples

An aerial sweep net was used to collect adult live flies which were immediately killed in a killing jar containing ethyl acetate and then they were dry preserved in insect envelops.

Preservation

The samples were relaxed in a relaxing chamber for 24 hours and then the insects were pinned and kept in a dry chamber for approx. 5-6 days before being dry preserved in the insect gallery of Diptera section, Zoological Survey of India (HQ), Kolkata.

Morphological identification of the collected insect specimens

By gathering relevant taxonomic information and consulting reputed research articles (Senior-White *et al*. 1940; Emden 1965; Smith 1986; Nandi 2002) morphological identification was done in the Laboratory of Diptera Section, Zoological Survey of India (ZSI), HQ, Kolkata, India. All the specimens were labeled before dry preservation in the insectorium.

Observation of Succession pattern of carrion flies

The adult flies and dipteran larvae that were collected from the rat carcasses in different stages of decay during March and November 2020 assisted the establishment of specific pattern and sequence of colonization of dipterofauna in both of the research sites.

Results

Weather conditions of the selected urban and semi-urban research sites

Urban study site

The maximum air temperature in the urban research site varied from 36 to 30°C with an average of 33.10±0.4°C during March 2020 and during November 2020 it ranged from 32 to 25°C with an average of 29.14±0.57°C (17 days Study period for each month). The minimum air temperature varied from 26 to 18°C with an average of 21.32±0.70°C and 22 to 14°C with an average of 18.24±0.54°C during March and November 2020 respectively in the urban study site. The relative humidity during March 2020 ranged from 77.10 to 52.70% with a mean of 67.96±1.76% and it ranged from 89.30 to 57.20% with an average of 68.22±1.77% during November 2020 in the urban research site.

Suburban study site

The maximum air temperature in the suburban research site varied from 35 to 28°C with an average of 31.20±0.50°C during March 2020 and during November 2020 it ranged from 30 to 24°C with an average of 27.10±0.40°C (20 days

study period for each month). The minimum air temperature varied from 25 to 17°C with an average of 21.10±0.40°C and 21 to 14°C with an average of 17.90±0.5°C during March and November 2020 respectively in the urban study site. The relative humidity during March 2020 ranged from 77.10 to 52% with a mean of 66.70±1.82% and it ranged from 89.30 to 57% with an average of 67.60±1.66% during November 2020 in the suburban research site.

Stages of decomposition

During the study on house rat carcass samples in March 2020 and November 2020**,** five types of decomposition stages including fresh stage, bloated stage, active-decay stage, advanced decay stage and the dry or remains stage were observed for both of the research sites. Thus it is quite obvious that the number and the types of decomposition stages are same for both of the study sites with no remarkable differences.

During the fresh stage less amounts of dipterofauna were observed to visit the carcass. Odor of necrosis was not significant.

During the bloated stage larger number of forensic flies started to invade and colonize the rotten carcass samples as the odor of putrefaction was distinct. Inflation of the abdomen was evident of the bloated stage of decay. Dipteran larvae were also found to appear on the carcasses.

During the active decay stage maggots were observed to feed on soft carcass tissues voraciously. Strong rotten smell of decay as the tissue fluids coming out of the rotten carcass samples was found. Carrion flies of diverse dipteran family continue to visit the rotten carcass samples.

During the advance decay stage odor of the rotten carcass samples were greatly reduced as most of the flesh masses were consumed by the forensic dipterofauna. Very less amounts of adult flies were observed to visit the carcasses but larger numbers of dipteran larvae stared to migrate.

During the dry/remains stage no tissue mass of the carcass samples found. Body mass reduced heavily. Only decomposed skin, small part of the body with separated tail were observed in case of rotten house rat (*Rattus rattus*) samples with no odor of decay.

Rate of decomposition

Remarkable differences in the rate of decomposition of the rotten carcass samples were observed between the urban and semi-urban research sites during both of the study months (March & November, 2020).

During March 2020, the rate of decomposition was comparatively faster for both types of carcasses in each study sites than March 2020. The advanced decay and dry/remains stages in urban and semi-urban sites have shown significant differences for the rat carcass samples. In urban locality, the advanced decay stage lasted for four days and dry/remains stage lasted for two days in case of rat sample whereas in case of the suburban area advanced decay stage lasted for five days and dry remains stage lasted for three days. Complete decomposition of the rat carcasses in urban and semi-urban localities until they reached the dry/remains stage took 15 days and 17 days respectively in March 2020 as shown in Figure 1.

During November 2020, the rate of decomposition was comparatively slower for both types of carcasses in each study sites. Substantial differences was observed for the bloated stage, advance decay stage and dry/remains stages in urban and semi-urban study site for both types of carcasses. Bloated stage lasted for four days in urban locality, the advance decay stage lasted for five days and dry/remains stage lasted for two days in case of rat samples. In case of suburban study site, the bloated stage, advanced decay stage and dry/remains stage lasted for five days, six days and three days respectively. The rat carcasses in urban and semi-urban sites were found to be completely decomposed in 17 days and 20 days respectively during November 2020 as shown in Figure 1.

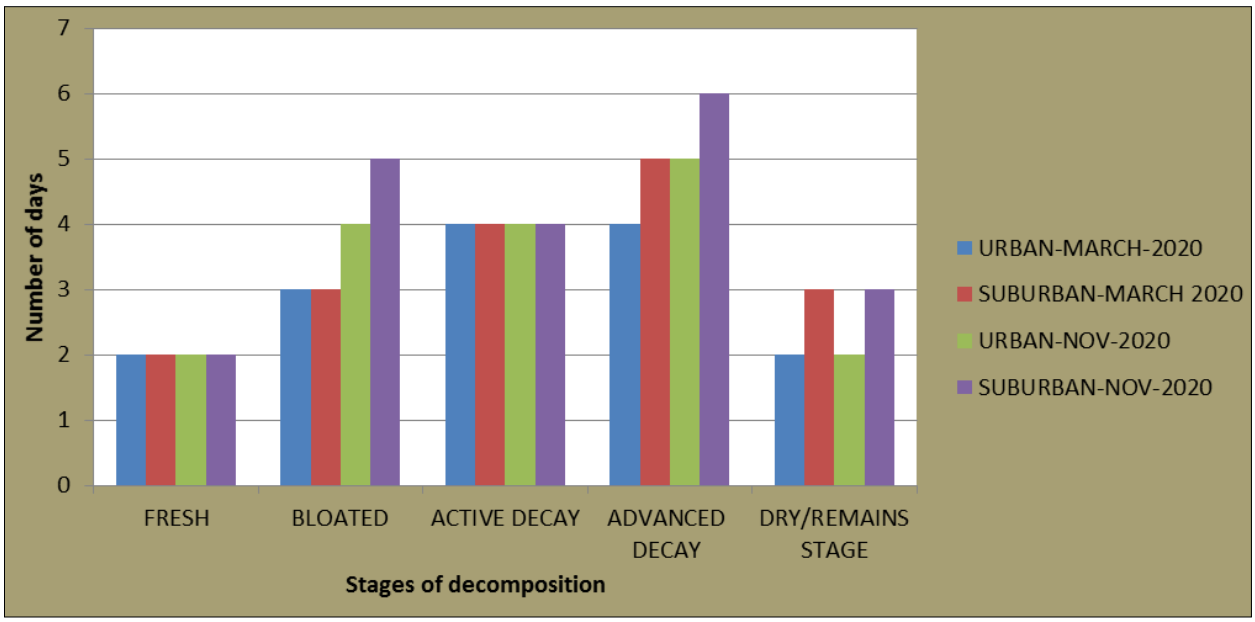

Fig 1: Graphical representation of the difference in the rate of decomposition including different decomposition stages of the house rat (Rattus rattus) carcasses in two different study sites during March and November 2020.

Carrion insects that colonized the carcasses

Carrion insects that dominate the rat and goat carcasses in urban and semi-urban study sites have shown remarkable differences in appearance pattern and species composition during each of the study months During March 2020, muscids were the most diverse group that colonized the

carcasses in urban sites and Calliphorids were the most diverse and dominant group in semi-urban research site. During, Sarcophagids were the dominant and most diverse group that colonized the carcasses in the semi-urban localities during November 2020 and muscids were the most diverse and dominant group in the urban research sites.

Two species of calliphorids and one species of sarcophagids were found during the study at urban site in March 2020. The diversity of muscid species in case of urban site during both of the study months were much higher and includes three and four species of muscidae during March 2020 and November 2020 respectively. In contrast, one species each of sarcophagids and muscids were found whereas four species of calliphorids were recorded from the semi-urban site during March 2020.

One species of Calliphoridae and two species Sarcophagidae were recorded from the urban research site during November 2020 whereas sarcophagids were found to be the most diverse group in the semi-urban site that includes four species during November 2020.

Chronology of succession of carrion dipterofauna

Variations in appearance and successional patterns were recorded from both the urban and semi-urban research sites. Variations in terms of the most diverse and dominant group that colonized the carcasses in each of the study sites have also been observed before and after COVID-19 situation.

Succession waves of carrion dipterofauna in the urban study site during March 2020

During March 2020, muscids were recorded as the first line colonizers of the rotten rat carcasses at the urban study site. *Synthesiomyia nudiseta* (Wulp, 1883) and *Musca domestica* (Linnaeus, 1758) and *Musca sorbens* (Wiedemann, 1830) colonized the carcasses sequentially at the fresh stage followed by *Chrysomya rufifacies* (Macquart, 1843) and *Sarcophaga albiceps* (Meigen, 1826). During the bloated stage two other species of Muscidae, *Hydrotaea chalcogaster* (Wiedemann, 1824) were recorded in addition to all the three types of muscid species that colonized the carcasses on the fresh stage. Larva of *Musca domestica*, *Chrysomya rufifacies* and *Sarcophaga albiceps* and different species of forensic diptera were observed during the active decay stage. *Atherigona orientalis* (Schiner, 1868) was the only species that visited the carcass during dry/remains stage.

Succession waves of carrion dipterofauna in the semi-urban study site during March 2020

Blow flies were found to be the first line colonizers as well as the most diverse group that visited the rotten carcasses at the semi-urban study site. The succession of carrion flies that colonized the carcasses started with *Chrysomya megacephala* (Fabricius, 1794) and continued chronologically with *Chrysomya rufifacies* (Macquart, 1843) during the fresh stage. Sarcophagids, *Sarcophaga* (*Liosarcophaga*) *dux* (Thomson, 1869) and *Sarcophaga ruficornis* (Fabricius, 1794) were to next to arrive at the carcasses. During the bloated stage, two more species of Calliphoridae *Chrysomya nigripes* (Aubertin, 1932) and *Chrysomya albiceps* (Wiedemann, 1819) were observed to visit the carcasses in addition to the two species that were recorded during the fresh stage. Muscids arrived later to visit the carcasses and includes one species of Muscidae, *Musca domestica* (Linnaeus, 1758). Apart from the calliphorids, Larva and adult diptera of Sarcophagidae and Muscidae were also recorded during this stage. Adult diptera continued to arrive at the rotten carcasses due to strong odor of decay during the active decay stages. The number of adult flies started to decrease gradually during the advanced decay stage. *Atherigona orientalis* (Schiner, 1868) was only recorded during the dry/remains stage of succession.

Substantial differences were observed in terms of the dominant and most diverse group of carrion flies during the study between the urban and semi-urban localities in March 2020. However, more or less uniformity in terms of abundance was observed during the dry remains stage in each of the study sites.

Succession waves of carrion dipterofauna in the urban study site during November 2020

During November 2020 muscids were found to be the most dominant and diverse group which colonized the carcasses in the urban habitat. *Synthesiomyia nudiseta* (Wulp, 1883) and *Musca domestica* (Linnaeus, 1758) colonized each of the carcasses successively during the fresh stage. Blow flies, *Chrysomya megacephala* (Fabricius, 1794) and *Chrysomya rufifacies* (Macquart, 1843) were the next group that arrived at the carcasses followed by *Sarcophaga albiceps* (Meigen, 1826). During the bloated stage all the five species were observed to visit the carcasses and in addition one other species of muscids, *Musca confiscata* (Speiser, 1924) found to colonize the decomposed carcasses. Dipteran larvae of *Chrysomya rufifacies, Sarcophaga albiceps and Musca domestica* were also observed to feed voraciously on the decomposed carcasses. Adult diptera of various species continued to visit both of the carcasses and some larval stages of muscids and calliphorids were also found during the active decay stage. The number of adult diptera were greatly reduced that visit the rotten carcasses during the advanced decay stage as there were very faint/no odor of decay coming out from the carcasses. In the dry/remains stage *Atherigona orientalis* was recorded to visit the decomposed carcasses. Thus, colonization during the advanced decay stage and remains stage in the urban site was almost similar to that of the succession study during March 2020.

Succession waves of carrion dipterofauna in the semi-urban study site during November 2020

During November 2020, a great change in the species composition of dipterofauna was observed from the semi-urban research site. Sarcophagids were the first to arrive at the decomposed rat carcasses. During the fresh stage two species of Sarcophagidae, *Sarcophaga albiceps* and *Sarcophaga ruficornis* (Fabricius, 1794) arrived at the carcasses. Blow fly, *Chrysomya megacephala* arrived the carcass following sarcophagids. No muscids were found to visit the rotten carcasses during the fresh stage. During the bloated stage, *Sarcophaga orientaloides* and *Sarcophaga* fuscicauda were recorded along with the other two species that colonized the carcasses during the fresh stage. *Chrysomya megacephala* colonized the carcasses in sequence following Sarcophagdae. *Musca domestica* started to visit the carcasses next. During the active decay stages larva and adults of different species of forensic flies were recorded along with one species that belongs to the family

Fannidae, *Fannia calicularis* (Linaeus, 1761). In the advance decay stage numbers of adult flies that visit the carcasses were greatly reduced but larval migration was still there. During the dry/remains stage no adult flies except phorids, *Megaselia scalaris* (Loew, 1866) were recorded from the almost dry and skeletonized rat carcasses.

The relative abundance of different dipteran families that colonized the rat carcasses at urban and semi-urban research sites during March and November 2020 is shown in the Figure 2. Though, the species composition and relative abundance of all the adult forensic flies recorded from two different habitats on rat carcasses shown noteworthy differences during March and November 2020, the species composition of carrion flies varied substantially in the semi-urban region during March and November 2020. On the other hand, variations in species composition are not that significant in the urban region during March and November 2020. The relative abundance of the forensic flies that were recorded from the urban and semi-urban study sites during March and November 2020 were analyzed comparatively as shown in Figure 3.

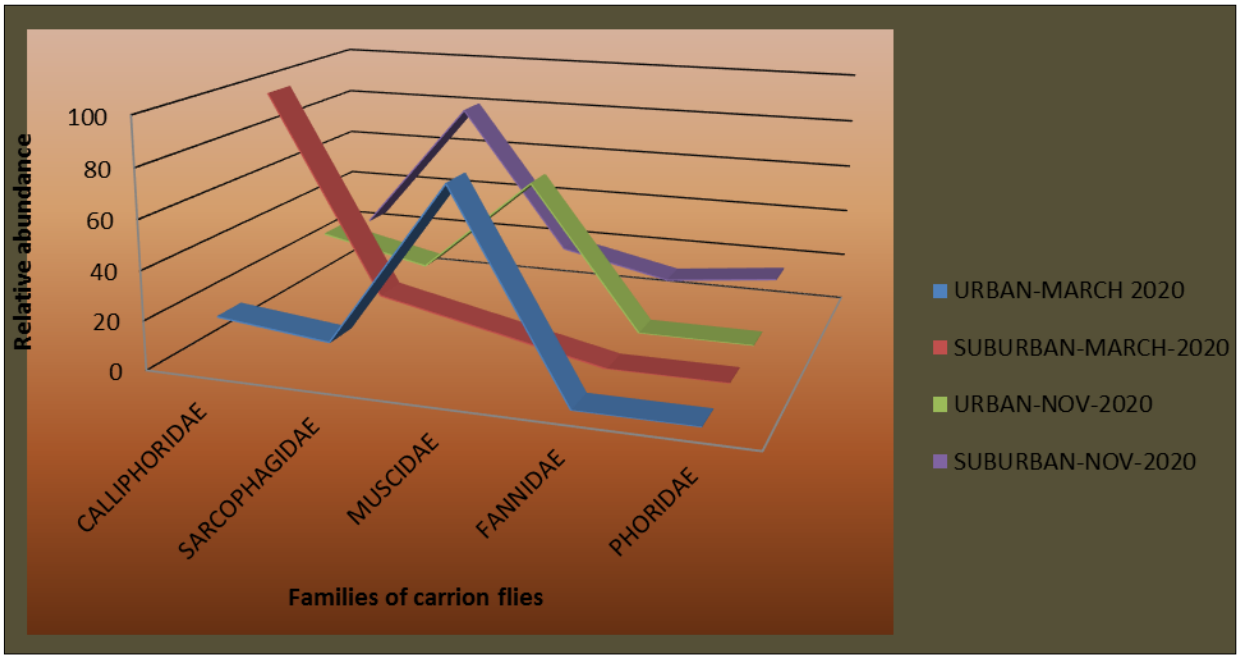

Fig 2: Graphical representation of the comparative analysis of relative abundance of different families of carrion flies recorded from two different habitats during March and November 2020 on house rat (Rattu rattus) carcasses.

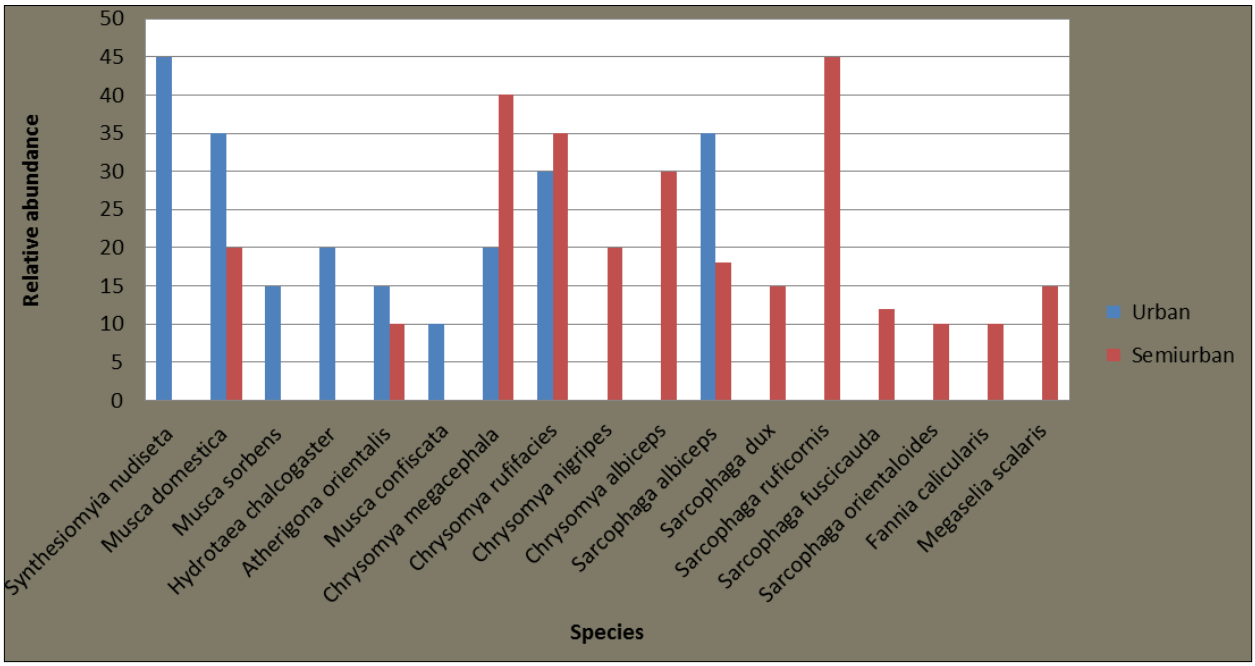

Fig 3: Comparative analysis of relative abundance of all the carrion flies recorded from two different study sites during March and November 2020 on house rat (Rattus rattus) carcasses.

Abundance of carrion flies at different decomposition stages in two different research sites

Almost 17 species of carrion flies were recorded during the study of their succession patterns on rat carcasses in two different localities (urban and suburban) in March and November 2020. It was found that *Synthesiomyia nudiseta*

was the most dominant species in the urban habitat during the fresh and bloated stage of decomposition in both of the study months. During the fresh and bloated stage in the suburban study site, *Chrysomya megacephala* and *Chrysomya albiceps* were the most abundant species during March 2020 respecyively whereas in November 2020**,** *Sarcophaga ruficornis* dominated the rat carcass during fresh and bloated stages. During active decay stage, *Hydrotaea chalcogaster* and *Musca domestica* were found to be the most abundant species in the urban locality during March 2020 and November 2020 respectively. Carrion flies showed remarkable evenness in terms of diversity and abundance in the urban region during both of the study months. During active decay stage, *Chrysomya rufifacies* was found to be most abundant during March 2020 whereas during November 2020, *Sarcophaga fuscicauda* was the most abundant species in the suburban area. During advanced decay stage, *Synthesiomyia nudiseta* was found to be the most dominant species during March 2020 whereas *Musca domestica* was the most abundant speices during November 2020, in the urban habitat. In the suburban habitat, *Chysomya rufifacies* and *Fannia calicularis* was found to be the most abundant species during the advanced decay stage during March and November 2020 respectively. During the dry/remains stage, *Atherigona orientalis* was recorded to be the only species that visited the completely decomposed rat carcasses in the urban study site during March and November 2020 and in the suburban locality during March 2020. In contrast, *Megaselia scalaris* was reported to be the most dominant species during the dry/remains stage in the suburban habitat in November 2020. The abundance of different carrion flies on rat carcasses at different stages of decomposition from the urban and suburban study sites during March 2020 is shown in Figure 4 and Figure 5 respectively and during November 2020 is shown in Figure 6 and Figure 7 respectively.

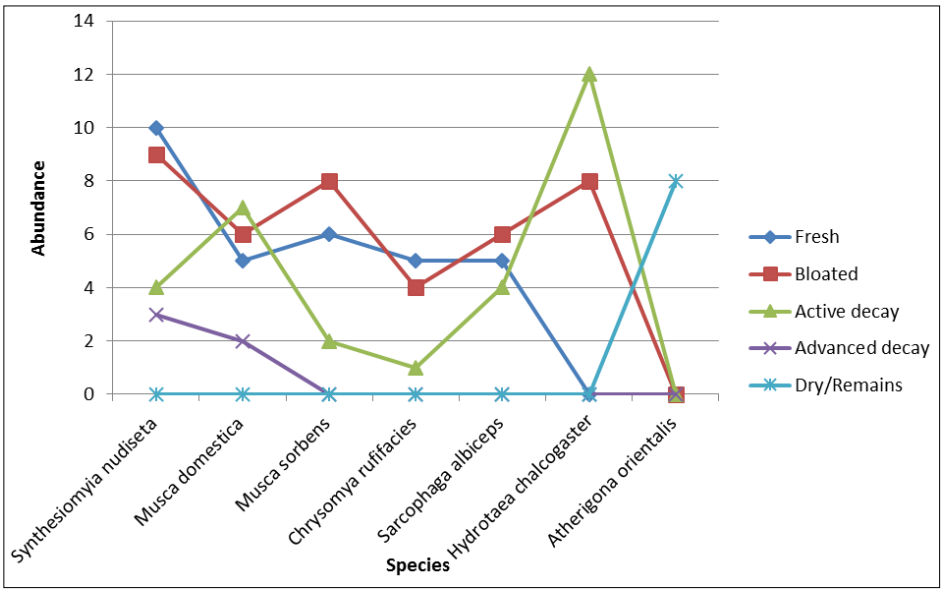

Fig 4: Abundance of different fly species in different stages of decomposition of house rat (Rattus rattus) carcasses at urban study site during March 2020.

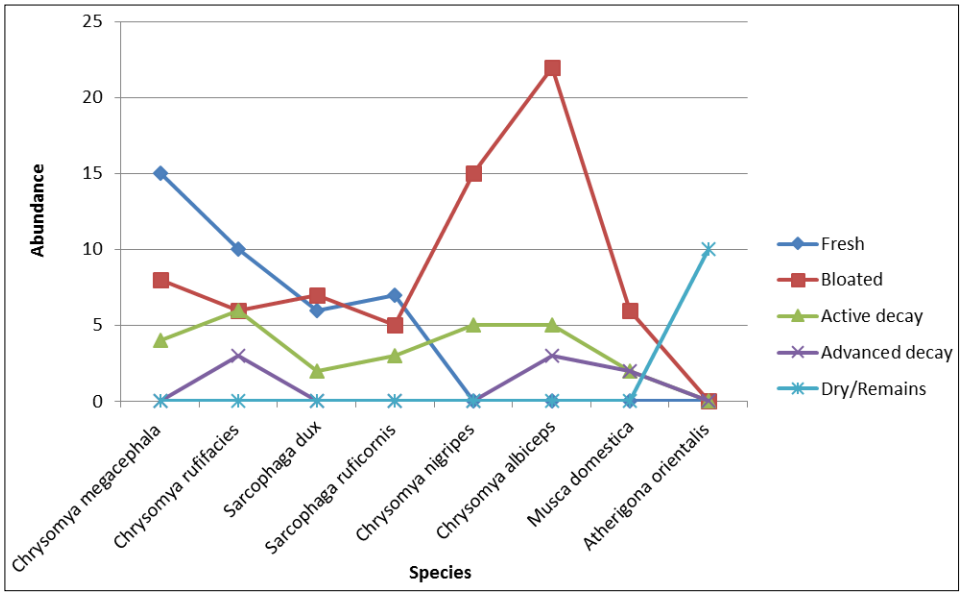

Fig 5: Abundance of different fly species in different stages of decomposition of house rat (Rattus rattus) carcasses at suburban study site during March 2020.

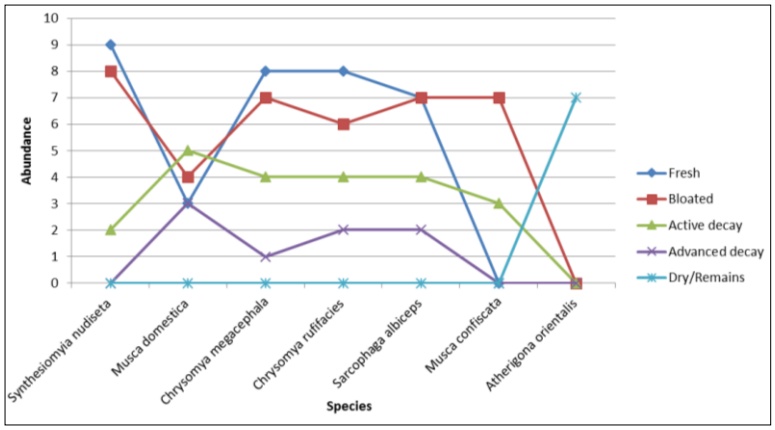

Fig 6: Abundance of different fly species in different stages of decomposition of house rat (Rattus rattus) carcasses at urban study site during November 2020.

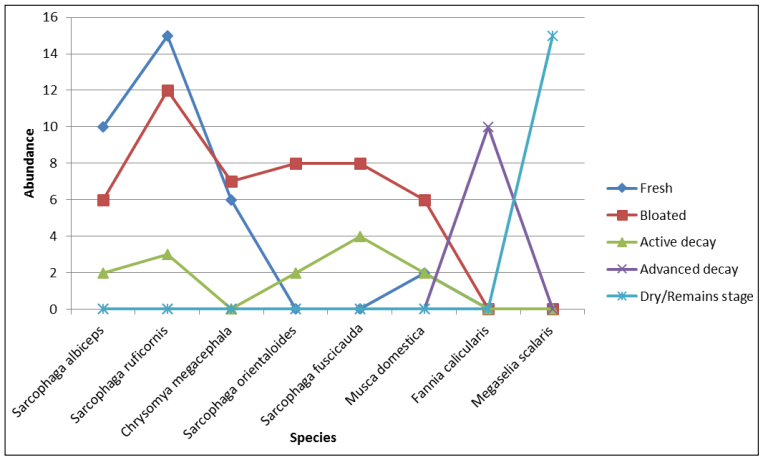

Fig 7: Abundance of different fly species in different stages of decomposition of house rat (Rattus rattus) carcasses at suburban study site during November 2020.

Fig 8: Decomposition stages of house rat (Rattus rattus) carcass (Note: (A) Fresh Stage, (B) Bloated Stage, (C) Active Decay STAGE, (D) Advanced Decay Stage, (E) Dry/Remains Stage).

Discussion

During March and November 2020, the number of carrion flies that colonized the decomposed rat carcasses not only varied in abundance but also in their successional stages. Species composition of the urban and suburban locality during March and November 2020 showed remarkable dissimilarities in terms of the number of carrion flies collected. The differences are much higher in terms of the most abundant species and the successional sequences in the suburban locality between March and November 2020. In comparison with the suburban area, the number of species and their successional stages as well as the most abundant family in the urban area was found to be almost similar.

Marked differences in the rate of decomposition of the rat carcasses were also recorded during March and November 2020. The rate of decomposition of the rat carcasses was much faster in the urban locality during both of the study months but during March 2020 the decomposition was more enhanced and completed within 15 days whereas in November 2020, the complete decomposition of the rat carcasses took 17 days in the urban locality. Decomposition stages of rat carcass (*Rattus rattus*) were photo documented during the study as shown in Figure 8. A wide range of environmental variables, carcass biomass, insect activities and abundance greatly affect the rate of decomposition (Campobasso *et al*., 2001; Charabidze *et al*., 2017). The rate of decomposition also depends on the number and types of the species that invade and colonize the carcasses. In the urban area, with higher human population density as well as higher anthropogenic activities, muscids were recorded as the most dominant species during both the study months whereas in suburban scenario, less human density facilitated Sarcophagids to colonize the carcasses most abundantly during November 2020. Sarcophagids were found to be the most diverse and dominant group with four different species that colonized the carrion successively in the suburban region during November 2020.In contrast, calliphorids were found to be the most abundant species in the suburban area during March 2020. As a whole, total six species of muscids were reported from the urban research site (four species during March 2020 and five species during November 2020) whereas from the suburban research site only two species of muscids (*Musca domesticate and Atherigona orientalis*) were reported. However, *Atherigona orientalis* was only reported from the suburban area only during March 2020. Sarcophagids always prefer less congested habitats and minimum disturbances as found in the suburban areas, which is proved during this study and were also reported from the previous studies on carrion flies (Joseph and Parui, 1980; Majumdar *et al*., 2008; Hore *et al*., 2017) [13, 14, 12]. In addition to Sarcophagidae, Calliphoridae and Muscidae and one species each of two other families (Fannidae and Phoridae) of carrion flies were accounted during our study from the suburban region during November, 2020.

Moreover during March 2020, comparatively higher environmental temperature enhanced the decomposition process thus the diversity of the carrion flies that visited the carcass was lower for both the study sites whereas regardless of the same carcass type, the species diversity was greater during November 2020 as the temperature is comparatively lower than in March 2020. During November 2020, the delayed decomposition of the rat carcasses due to comparatively lower air temperature allowed diverse array of several species of carrion flies to invade the carcasses in the suburban habitat.

The species composition, succession patterns and the rate of decomposition of the rat carcasses of same biomass provided deeper insights about the species abundance of the urban and suburban study sites during March and November 2020 in our present study. The change in the dominant species composition was mostly reflected in the suburban area between March and November 2020. Thus, in our present study, it was concluded that the community abundance of the dipterofauna in the same study area (suburban) and for the same carcass changed significantly during different times of the year.

Conclusion

There are several studies on the succession patterns of forensic diptera on the decomposed carcasses which elucidates the role of these important families of flies as forensic indicators as they aids in estimating PMI intervals (Carvalho *et al*., 2004; Heo *et al*., 2008; Azmi and Lim, 2013). As all the species recorded from our study has utmost importance in medico-legal investigations and as the chronology of those forensically important species on rat carcass (*Rattus rattus*) was established, they can be used as the indicator species for forensic investigations during two different time frames of the year. Our study will aid in future research on carrion ecology. Calliphorids and Sarcophagids were highly implicated in nutrient recycling, thus variations in the ecological niche of different species that belong to these families from both of the study sites and during both of the study months may also help to correlate the activities of different forensic fly species.

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