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Seasonal variation of the species complex of necrophagous fly communities from a dry deciduous forest landscape

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Abstract

A plethora of necrophagous insect species exist on or around a cadaver, and a certain chronological sequence of colonization is expected to occur based on their preference, enabling microbial decomposition and aiding in maintaining ecosystem balance. Necrophagous flies comprise the foremost and often the most significant carrion entomofauna, playing crucial ecological roles in the decomposition process. They are therefore significant from both forensic entomological and ecological standpoints. Calliphorids, sarcophagids, and muscids constitute the predominant families of necrophagous flies to colonize carcasses. In the present study, a total of 24 species of necrophagous flies belonging to six dipteran families from three sites of Sonamukhi Protected Forest, Bankura have been documented seasonally. The dipteran families documented in the present study are Calliphoridae, Sarcophagidae, Muscidae, Phoridae, Stratiomyidae, and Sepsidae. The present research, a comprehensive account of the seasonal variations of necrophagous fly communities from a dry, deciduous forest landscape, the first of its kind conducted from this region displayed a diverse necrophagous species composition, consisting of 24 species under 12 genera from 6 families. Notably, out of the 24 species recorded in the present study, a total of 4 species were recorded for the first time from this state. Taxa richness tends to decline as environmental quality, favourable climatic conditions decline. The current study reveals that, on a seasonal note, pre-monsoon > monsoon > post-monsoon is favourable for necrophagous community growth and development. Thus, the relevance of the present study is not only limited to the medico-legal forensic entomological context but is also focused on assessing the risk status of the study sites in and around the Sonamukhi forest area with the help of ecological indices and biomonitoring of the study area. Consequently, the presence or absence of the indicator species or indicator community reflects the prevailing environmental conditions.

Keywords: Forensic entomology, Decomposition, Species composition, Biomonitoring, Seasonality

Introduction

Necrophagy is the act of devouring dead or decaying animal flesh. Although scavenger vertebrates, like vultures and jackals, constitute an important part of the detrivore community by devouring animal remains, the role played by the necrophagous arthropods is also of immense significance from ecological perspective (Amendt *et.al.*, 2004; Anderson, 1995). A diverse fauna of necrophagous species that comprise a vital part of the decomposition process belongs to arthropod groups such as Diptera, Coleoptera, Hymenoptera, and Arachnida (Amendt *et al.*, 2000; Amendt *et.al.*, 2004; Gruner *et al.*, 2007).

A wide array of necrophagous insect species occurs on or around a cadaver and, relying on their preference for a given stage of decomposition, a certain chronological sequence of colonization is expected to occur (Byrd and Castner, 2010). Necrophagous flies are the foremost and often the predominant consumers of carrion and thereby not only play

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a crucial ecological role in the decomposition process but also represent an important tool in criminal investigations (Catts and Goff, 1992).

Detrivores affect the decomposition of detrital resources in virtually all natural systems, with severe consequences for community structure and ecosystem function (Seastedt and Crossley, 1984; Moore *et al.*, 2004). Detrivores not only accelerate microbial decomposition by shredding, consuming, and transforming organic detritus but also help in nutrient cycling (Edwards *et al.*, 1970; Kitchell *et al.*, 1979; Vossbrinck *et al.*, 1979; Lussenhop, 1992). Thus, the importance of necrophagous flies, an important section of the detrivore community is not only in the ingestion of carrion but also in making the carrion available to microorganisms (Galante and Marcos-Garcia, 2008).

In India, necrophagous flies colonizing corpses are mostly the calliphorids, sarcophagids, and muscids, visiting carcasses at fresh and decay stages whereas flies from families like Fannidae, Stratiomyidae, Phoridae, Sepsidae, Piophiliidae, Neriidae, Anthomyiidae, Ulidiidae have also been reported (Joseph and Parui, 1980; Bharti and Singh, 2003; Majumdar *et al.*, 2007; Sinha, 2009; Bharti, 2012; Chakraborty *et al.*, 2015; Archana *et al.*, 2016; Khullar *et al.*, 2016; Singh *et al.*, 2016, Hore and Banerjee, 2017; Hore, 2021, Kar *et al.*, 2022).

Diptera or true flies are potentially useful bio-indicators for assessing the impact of environmental changes and monitoring forest recuperation. Moreover, Diptera also occupies a wide array of ecological niches and several different trophic levels (Majer, 1987). Analysis of dipteran community composition can be crucial in determining indicator faunae for detecting even subtle changes in the environment (Sousa *et al.*, 2014; Odat *et al.*, 2015).

The necrophagous flies colonizing carrion form a successional sequence of families and species that relies on the size of the carrion, and also on the climatic and edaphic conditions of the region where they are located. Indeed, very few species are widespread worldwide, and each geographical area and ecosystem has its specialist species devouring carrion (Galante and Marcos-Garcia 2008).

The habitat of the protected forest of Sonamukhi, Bankura, West Bengal is characterized by climatic extremities with temperature ranges between 39° to 42° C during summer and 7° to 14° C during winter. Sonamukhi protected forest area signifies unique topographical features for its location as an ecotone. The present study is the first comprehensive study of necrophagous dipteran fauna from the Protected Forest Area of Sonamukhi, Bankura. The main objectives of the study lie mainly in assessing the seasonal variation in the diversity and abundance of necrophagous dipteran species obtained from various meat bait traps located in typical three types of ecosystems, namely, forest vegetation, agricultural fields, and human-inhabited village areas nearby. The importance of the study lies in generating a clear idea about the species richness status of necrophagous dipteran fauna in different ecosystems and its correlation with seasonal patterns and anthropogenic disturbances. This present work carries immense significance from both ecological as well as forensic entomological perspectives.

Materials and Methodology

1) **Study site:** Three study sites, each representing an ecosystem type, were selected for the present study. The first study site was the Sonamukhi protected forest area, Bankura, West Bengal. The agricultural fields and human-inhabited village regions nearby were considered as the two other ecosystem types in the study. Sonamukhi is located at 23°18 N 87°25 E, with an average elevation of 66 m (217 ft).
2) **Duration of the study conducted:** The study was conducted for a duration of three years (2017-2019), during three seasons, namely, pre-monsoon (PRM), monsoon (MON), and post-monsoon (PST). This was done to monitor the seasonal variation in necrophagous species composition in the three ecosystem types.
3) **Collection, identification, and preservation:**
    i) **Placing meat bait for collection of necrophagous species-** Goat meat and liver were used as baits for collecting the necrophagous fly species. A total of twelve (four traps each for three ecosystems) such traps were kept in open areas close to herbage each in the forest, agricultural fields, and human-inhabited village regions of Sonamukhi, Bankura. The same procedure was repeated for each year of study during pre-monsoon, monsoon, and post-monsoon.
    ii) **Collection and preservation of specimens-** A modified version of the Malaise trap was utilized for the collection of adult specimens. Adult flies were collected and sacrificed by placing them in a killing jar containing cotton soaked with benzene as the killing agent. Flies were sorted and kept in insect

envelopes; then kept in a relaxing chamber for about 24 hours; then the specimens were pinned using entomological pins, dried in a drying chamber for 3-4 days, and finally stored in the insect cabinet after labeling.

iii) **Morphological identification of the fly specimens collected**- Senior-White (1940), Nandi (2002), and Oriental Catalog (1977) were utilized for taxonomic and morphological identification of specimens. The morphology of adult flies was photo-documented with the help of LEICA M205A coupled with LEICA DFC 500 camera as shown in the figures below.

4) **Statistical analysis:** All statistical analyses were conducted in Microsoft Office Excel 2019. The biodiversity indices considered for the present study are as follows- Species diversity, Species richness, Relative abundance, Index of dominance, and Shannon's diversity (SH) index (Hubalek, 2000).

Results

A. Taxonomic studies:

The present research, the first of its kind from this region showed a diverse necrophagous species composition, consisting of 24 species under 12 genera from 6 families. Notably, out of the 24 species recorded in the present study, a total of 4 species (Plate 1 A-D) were recorded for the first time from this state to date, marked with double asterisks.

List of Dipteran species

Family	Species
Stratiomyidae	*Hermetia illucens* Linnaeus, 1758
Phoridae	*Megaselia (Megaselia) scalaris* (Loew, 1866)
Sepsidae	*Australosepsis niveipennis* (Becker, 1903)
Sepsidae	*Sepsis indica* (Wiedemann, 1824)
Sepsidae	*Sepsis nitens* (Wiedemann, 1824)
Sepsidae	*Sepsis (Sepsis) cynipsea* (Linnaeus, 1758)
Muscidae	*Musca (Musca) domestica* (Linnaeus, 1758)
Muscidae	*Orthellia viridis* (Wiedemann, 1824)
Muscidae	*Atherigona orientalis* (Schiner, 1868)
Sarcophagidae	*Sarcophaga (Liopygia) ruficornis* (Fabricius, 1794)
Sarcophagidae	*Sarcophaga (Liosarcophaga) dux* (Thomson, 1869)
Sarcophagidae	*Sarcophaga (Liosarcophaga) brevicornis* (Ho, 1934) **
Sarcophagidae	*Sarcophaga (Parasarcophaga) albiceps* (Meigen, 1826)
Sarcophagidae	*Sarcophaga (Parasarcophaga) taenionota* (Wiedemann, 1819)
Sarcophagidae	*Sarcophaga (Iranihindia) martellatoides* (Baranov, 1931)
Calliphoridae	*Hemipyrellia ligurriens* (Wiedemann, 1830)
Calliphoridae	*Hemipyrellia pulchra* (Wiedemann, 1830) **
Calliphoridae	*Lucilia cuprina* (Wiedemann, 1830)
Calliphoridae	*Lucilia porphyrina* (Walker, 1856)
Calliphoridae	*Lucilia sericata* (Meigen, 1826) **
Calliphoridae	*Chrysomya bezziana* (Villeneuve, 1914) **
Calliphoridae	*Chrysomya megacephala* (Fabricius, 1794)
Calliphoridae	*Chrysomya nigripes* (Aubertin, 1932)
Calliphoridae	*Chrysomya rufifacies* (Macquart, 1842)

B. Diversity and abundance studies (Results of Statistical analyses):

The current experiment spanned from 2017 to 2019. The total number of specimens captured was 1,995. In the forest ecosystem, during the pre-monsoon season, a total of 268 specimens of 24 different species were recovered from the malaise traps. In the monsoon season, a total of 196 specimens of 20 different species were recorded from the malaise traps. In the post-monsoon season, a total of 200 specimens of 20 different species were recorded from the malaise traps. In the agricultural field during, the pre-monsoon season, a total of 278 specimens of 21 different species were recovered from the malaise traps. In the monsoon season, a total of 229 specimens of 22 different species were recorded from the malaise traps. In the post-monsoon season, a total of 181 specimens of 21 different species were recorded from the malaise traps. In human habitation, during the pre-monsoon season, a total of 272 specimens of 24 different species were recovered from the malaise traps. In the monsoon season, a total of 208 specimens of 21 different species were recorded from the malaise traps. In the post-monsoon season, a total of 163 specimens of 20 different species were recorded from the malaise traps.

Statistical analyses

Species composition

Overall, the most frequent were *Sarcophaga (Liosarcophaga) dux* (SLD) (n = 484) & *Sarcophaga (Liosarcophaga) ruficornis* (SLR) (n = 232), and the least occurring species were *Hemipyrellia ligurriens* (HL) & *Lucilia porphyrina* (LP) (n = 8). In the forest ecosystem, the most frequent were SLD (n= 163) & SLR (n = 82) and the least occurring species were *Chrysomya rufifacies* (CR) (n = 2). In agricultural fields, the most frequent were SLD (n = 161) & SLR, and *Megaselia scalaris* (MS) (n = 77) and the least occurring species were HL & *Chrysomya nigripes* (CN) (n = 2). In human habitation, the most frequently occurring species were SLD (n= 160) & SLR, and MS (n = 73).

Diversity

The number of taxa and Shannon index (H) of all species increased near the Agricultural fields (transition of forest ecosystem and human inhabitation zone) and declined towards human habitation. While dominance decreased in the human inhabitation zone. These values are affected by the number of individuals and taxa in the community. Diversity value was highest in the Agricultural fields>forest ecosystem> human inhabitation (2.604 > 2.516 > 2.405) respectively. The number of the most frequently occurring SLD (H) varied as (0.341 > 0.337 > 0.330). A high value of H was recorded in the pre-monsoon > monsoon > post-monsoon (2.6 > 2.5 > 2.4).

Seasonal species richness

Seasonal species richness was highest in the pre-monsoon > monsoon > post-monsoon for all the sites. The only difference is the number of specimens being captured and the site localities prevailing climatic conditions. The highest seasons species richness was of pre-monsoon of Agricultural fields > forest ecosystem > human inhabitation (278 > 272 > 268) respectively.

Relative abundance

The cumulative abundance value for the forest ecosystem seasonally was pre-monsoon = monsoon > post-monsoon (99.88 = 99.88 > 96). The cumulative abundance value for agricultural fields seasonally was pre-monsoon > monsoon > post-monsoon (99.88 > 99.86 > 97.97). The cumulative abundance value for human habitation was post-monsoon > pre-monsoon > monsoon (99.68 > 96.16 > 92.09). (Figure 3). Overall, comparatively agricultural field > forest ecosystem > human habitation (Table 1).

Index of dominance

The cumulative dominance value for the forest ecosystem seasonally was monsoon > post-monsoon > pre-monsoon (0.12 > 0.10 > 0.09). The cumulative dominance value for agricultural fields seasonally was pre-monsoon > post-monsoon > monsoon (0.60 > 0.10 > 0.09). The cumulative dominance value for human habitation was pre-monsoon > post-monsoon > monsoon (0.11 > 0.09 > 0.08) (Figure 3) (Table 2).

SH index

The cumulative SH for the forest ecosystem seasonally was post-monsoon > pre-monsoon > monsoon (2.6 > 2.25 > 0.4). The cumulative dominance value for agricultural fields seasonally was post-monsoon > monsoon > pre-monsoon (2.4 > 2.02 > 1.29). The cumulative dominance value for human habitation was post-monsoon > pre-monsoon > monsoon (2.51 > 2.44 > 2.23) (Figure 3) (Table 3).

Discussion

Taxa richness tends to decline as environmental quality, favourable climatic conditions decline. This seemed to happen seasonally, with the pre-monsoon season being the most favoured for most of the species. Regarding species composition SLD & SLR are clearly, the most frequently occurring in all three sites annually, therefore acting as opportunistic species. Relative abundance gave an idea of species under stress, their resource utilization, and uniformity.

During the study, it was observed that overall SLD best utilized this ecosystem resources and was more evenly distributed than any other flies. SLD had an RA of Agricultural fields>forest ecosystem>human inhabitation (26.10 > 23.74 > 22.38) respectively. Therefore, acting as an opportunistic species. A high abundance of such groups indicates the availability of resources and their utilization over time.

The index of dominance was used to determine the domination by a few species or families indicates stress or conditions which preferentially support particular taxa such as nutrient enrichment and toxic contaminants or in other words it reflects the degree of the unfavourable environment on each species. The current study shows that the season-wise pre-monsoon > monsoon > post-monsoon is favourable for necrophagous community growth and development.

SH index reflects the dispersion of species in this necrophagous community, the more the value of the H, the more dispersion is shown by the species, but this is inversely proportional to the decrease in the number of species or uniformity. The current study shows that the season-wise pre-monsoon > monsoon > post-monsoon is favourable for necrophagous community growth and development.

Biomonitoring is a valuable assessment tool that is receiving increased usage. The presence or absence of the indicator or of an indicator species or indicator community reflects environmental conditions. Taxa richness tends to decline as environmental quality, favourable climatic conditions decline. This seemed to happen seasonally, with the pre-monsoon season being the most favoured for most of the species. During the study, it was observed that overall SLD best utilized this ecosystem resources and were more evenly distributed than any other flies. SLD had an RA of Agricultural fields > forest ecosystem > human inhabitation (26.10 > 23.74 > 22.38) respectively. Therefore, acting as an opportunistic species. A high abundance of such groups indicates the availability of resources and their utilization over time. The current study shows that the season-wise pre-monsoon > monsoon > post-monsoon is favourable for necrophagous community growth and development. The current study shows that the season-wise pre-monsoon > monsoon > post-monsoon is favourable for necrophagous community growth and development.

Tables and Figures

Table 1- The relative abundance is plotted for three seasons of three years graphically; this can be uniform or not uniform. The environment is unfavourable for growth and development. Only the tough species survive, in our case those are SLD and SRL.

	2017	**2018**	**2019**
PRM	Moderately Stressed	Severely Stressed	Moderately Stressed
MON	Severely Stressed	Severely Stressed	Severely Stressed
PST	Stressed	Severely Stressed	Moderately Stressed

Table 2- Index of dominance are plotted for three seasons of three years in graphically, reflects the degree of unfavorable environment on each species. If this value increases, then the community is under stress.

	2017	**2018**	**2019**
PRM	Moderately unfavourable	Severely unfavourable	Moderately unfavourable
MON	Severely unfavourable	Severely unfavourable	Severely unfavourable
PST	Unfavourable	Severely unfavourable	Moderately unfavourable

Table 3- SH index reflects the dispersion of species in this necrophagous community, the more the value of H, the more dispersion is shown by the species, but this is inversely proportional to decrease in the number of species or uniformity.

	2017	2018	2019
PRM	Evenly dispersed	Moderately dispersed	Evenly dispersed
MON	Unevenly dispersed	Evenly dispersed	Evenly dispersed
PST	Evenly dispersed	Evenly dispersed	Evenly dispersed

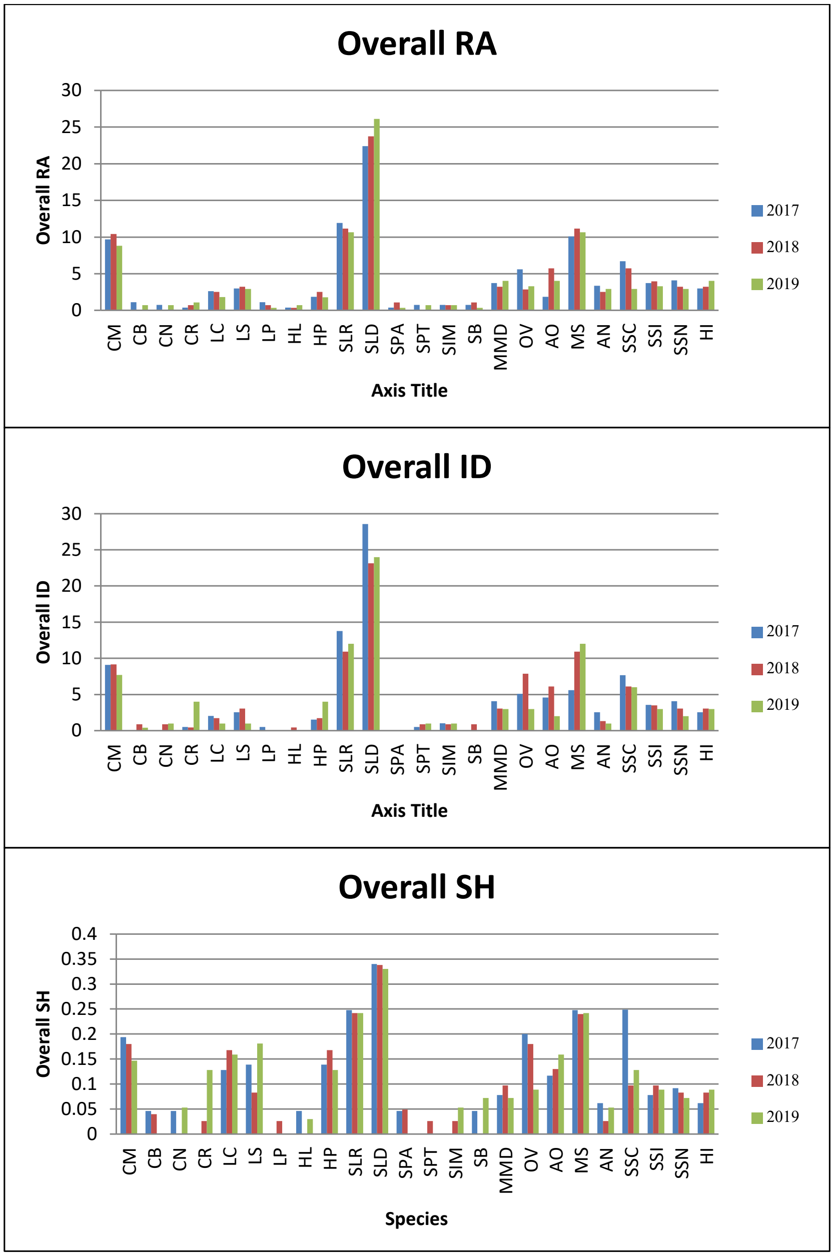

Figure 3: Comparison of the three relative abundance (RA), index of dominance (ID), and SH index (SH) parameters for three years.

Taxonomic plates:

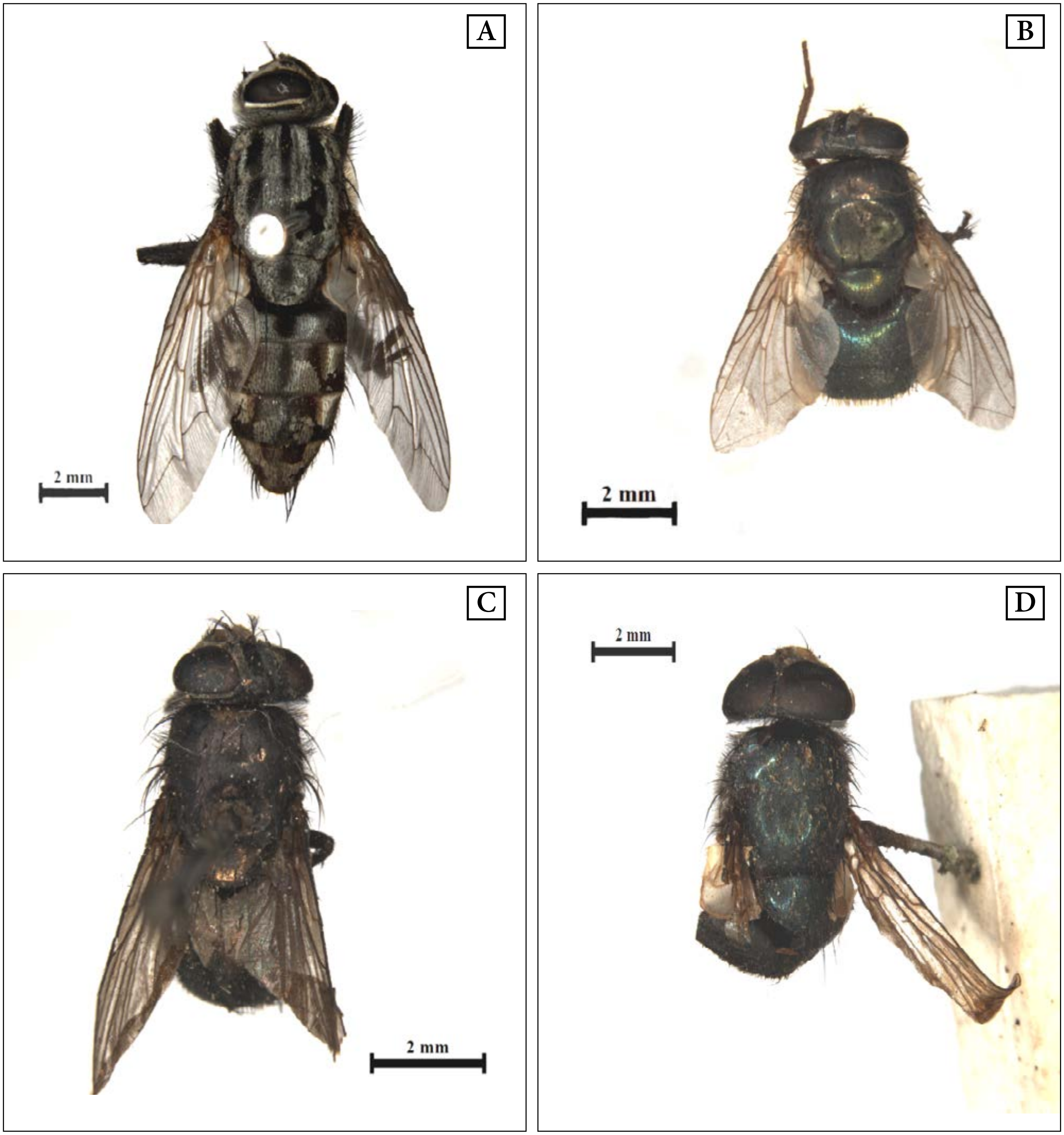

Plate 1 A-D: Habitus of four newly recorded necrophagous flies from Sonamukhi Protected Forest area of West Bengal. A: Dorsal view of *Sarcophaga (Liosarcophaga) brevicornis* (Ho, 1934) (Male); B: Dorsal view of *Hemipyrellia pulchra* (Wiedemann, 1830) (Female); C: Dorsal view of *Lucilia sericata* (Female) (Meigen, 1826); D: Dorsal view of *Chrysomya bezziana* (Villeneuve, 1914) (Male).

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References

Amendt, J., Krettek, R., Niess, C., Zehner, R. and Bratzke, H. 2000. Forensic entomology in Germany. Forensic Science International, 113(1-3):309-314.

Amendt, J., Krettek, R. and Zehner, R. 2004. Forensic entomology. Naturwissenschaften, 91:51-65.

Anderson, G.S. 1995. The use of insects in death investigations: an analysis of forensic entomology cases in British Columbia over a five year period. Canadian Society of Forensic Science Journal,28: 277-292.

Archana, M., D'Souza, P.E., Ojha, R. and Jalali, S.K. 2016. DNA barcoding of flies commonly prevalent in poultry farms of Bengaluru District. Journal of Entomology and Zoology Studies,4(4): 228-233.

Arnaldos Sanabria, M.I., Torres Tomás, B. and García García, M.D. 2013. First data on the development of the life cycle of Sarcophaga cultellata Pandellé, 1896 (Diptera: Sarcophagidae). Cuadernos de Medicina Forense.,19(1-2): 6-12.

Bharti, M. and Singh, D. 2003. Insect faunal succession on decaying rabbit carcasses in Punjab, India. Journal of Forensic Sciences, 48(5): 1133-1143.

Bharti, M. 2012. Altitudinal Diversity of Forensically Important Blowflies Collected from Decaying Carcasses in Himalaya. The Open Forensic Science Journal,5: 1-3.

Byrd, J.H. and Castner, J.L. 2009. Insects of Forensic Importance. In Forensic Entomology: The Utility of Arthropods in Legal Investigations,2: 39-126. (Published by CRC Press).

Catts, E.P. and Goff, M.L. 1992.Forensic entomology in criminal investigations. Annual Review of Entomology, 37: 253–272.

Carvalho, C.J.B. and Mello-Patiu, C.A. 2008. Key to the adults of the most common forensic species of Diptera in South America. Revista Brasileira de Entomologia, 52(3): 390-406.

Chakraborty, A., Ghosh, S., Ansar, W. and Banerjee, D. 2015. Developmental analysis of immature stages of Sarcophaga (Parasarcophaga) albiceps Meigen,1826 (Diptera: Sarcophagidae) on *Gallus gallus* carcass: Their applications as forensic indicators. IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS), 8(8): 79-89, e-ISSN: 2319-2380, p-ISSN: 2319-2372.

Edwards, C.A., Reichle, D.E. and Crossley, D. 1973. The role of soil invertebrates in turnover of organic matter and nutrients. Analysis of temperate forest ecosystems, 147-172.

Galante, E. and Marcos-Garcia, M.A. 2008. Decomposer insects. Encyclopedia of Entomology. 665-674.

Gruner, S.V., Slone, D.H. and Capinera, J.L. 2007. Forensically important Calliphoridae (Diptera) associated with pig carrion in rural north-central Florida. Journal of Medical Entomology, 44(3), 509-515.

Hardy, D.E. 1977. Family Tephritidae. In'A Catalogue of the Diptera of the Oriental Region, Vol. 111, Suborder Cyclorrhapha (excluding Aschiza)'. (Eds MD Delfinado and D. E. Hardy.) 44-134.

Hore, G. and Banerjee, D. 2017. Necrophagous flies (Insecta: Diptera) and their role in maintaining ecosystem balance. ENVIS Centre Faunal Diver, 23, 2-6.

Hore, G. 2021. Studies On Necrophagous Flies (Insecta: Diptera) Of Forensic Importance In Urban And Semi-Urban Areas Of Kolkata And Adjoining Areas. Ph.D. Thesis, University of Calcutta, Kolkata, India.

Hubalek Z. 2000. Measures of species diversity in ecology: an evaluation. *Folia Zoologica-Praha*, 49(4): 241-260.

Kar, O., Naskar, A., Pramanik, D., Mukherjee, K., Sarkar, S., Mukherjee, A., Ghosh, D., Sengupta, J. And Banerjee, D. 2022. AN INVENTORY OF NECROPHAGOUS FLIES FROM INDIA. UTTAR PRADESH JOURNAL OF ZOOLOGY, 79-108.

Joseph, A.N.T. and Parui, P. 1980. Filth inhabiting flies (Diptera) of Calcutta City. Bulletin of the Zoological Survey of India, 3(1/2), 1-12.

Khullar, N., Singh, D. and Jha, C.K. 2016. Short COI marker: A valuable tool for identification and phylogenetic analysis of 6 forensically important blow fly species from India. Journal of Entomology and Zoology Studies, 4(3), 27-31.

Kitchell, J.F., O'Neill, R.V., Webb, D., Gallepp, G.W., Bartell, S.M., Koonce, J.F. and Ausmus, B.S. 1979. Consumer regulation of nutrient cycling. BioScience, 29(1), 28-34.

Letana, S.D. 2011. Taxonomy of black scavenger flies (Diptera: Sepsidae) from Luzon, Philippines.

Lussenhop, J. 1992. Mechanisms of microarthropod microbial interactions in soil. Advances in ecological research, 23: 1–33.

Majer, J.D. 1987. Invertebrates as indicators for management. DA Saunders, GW Arnold, AA Burbidge, and AJM Hopkins, 353-354.

Majumdar, S.K., Jana, I. and Misra, K.K. 2007. Synanthropy of Carrion Flies in Three Districts of Southern West Bengal, India. International Journal of Ecology and Environmental Sciences, 33(1): 29-39.

Nandi, B.C. 2002. The fauna of India and the adjacent countries. Diptera: Volume X, Sarcophagidae. Zoological Survey of India.

Odat, N., Hasan, H.S., Obeidat, M. and Aladaileh, S. 2015. Relationships between species diversity and evenness of necrophagous Diptera and environmental conditions in three habitats of Jordan. Journal of Entomology and Zoology Studies, 3, 89-94.

Roskov, Y, Kunze, T, Paglinawan, L, Orrell, T., Nicolson, D., Culham, A., Bailly, N., Kirk, P., Bourgoin, T., Baillargeon, G., Hernandez, F. and De Wever, A. 2017. Species 2000 & ITIS Catalogue of Life

Seastedt, T.R. and Crossley Jr, D.A. 1984. The influence of arthropods on ecosystems. Bioscience, 34(3), 157-161.

Senior-White, R. 1940. The Fauna of British India, including Remainder of the Oriental region. Diptera VI. Family Calliphoridae.

Singh, N., Kumari, V. and Singh, N.P. 2016. An analysis of the ecological succession pattern of Diptera on the carcass of laboratory bred rats. International Journal of Agriculture Innovations and Research, 4(5), 2319-1473.

Sinha, S.K. 2009. Sarcophagidae, Calliphoridae and Muscidae (Diptera) of the Sundarbans Biosphere Reserve, West Bengal, India. Occasional Paper-Records of the Zoological Survey of India, (308).

Sousa, J.R.P.D., Esposito, M.C., Carvalho Filho, F.D.S. and Juen, L. 2014. The potential uses of Sarcosaprophagous flesh flies and blowflies for the evaluation of the regeneration and conservation of forest clearings: a case study in the Amazon Forest. Journal of Insect Science, 14(1).

Vossbrinck, C.R., Coleman, D.C. and Woolley, T.A. 1979. Abiotic and biotic factors in litter decomposition in a serm iarid grassland. Ecology, 60(2), 265-271.