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Insect Faunal Succession on Decaying Rabbit Carcasses in Punjab, India*

ABSTRACT: Insect faunal succession on decaying rabbit carcasses was carried out at Punjabi University, Patiala (Punjab), India, from March 1997 to December 1999. Four stages of decomposition were recognized, i.e., fresh, bloated, decay, and dry. A total of 38 insect species belonging to four orders and 13 families were recorded. Diptera, Coleoptera, and Hymenoptera dominated the carrion fauna. Calliphorids were the first to arrive in all the seasons of the year. Five species of Calliphoridae, four of Sarcophagidae, ten of Muscidae, and one each from Anthomyiidae and Otitidae were observed on rabbit carcasses. Representatives of six Coleopteran families, i.e., Staphylinidae, Histeridae, Cleridae, Dermestidae, Tenebrionidae, and Silphidae, were recorded. Eight species belonging to family Formicidae (Hymenoptera) were also collected during the present studies. Only one species of Lepidoptera was observed on carrion.

KEYWORDS: forensic science, forensic entomology, insect fauna, carrion decomposition

Forensically significant conclusions are often drawn through the analysis of successional patterns of insects that sequentially colonize a corpse as decomposition progresses. Also, the rates at which various stages of their progeny develop may provide important data (1–7). However, a detailed knowledge about the carrion fauna with respect to their life history, habits, geographical distribution, taxonomy, morphology of immature stages, and ecological relations is critical for the use of these insects in solving crime. Unfortunately, this type of information is lacking for the insect fauna of carrion in India. To generate the baseline data on carrion insects, studies on insect colonization of decaying rabbit carcasses were carried out at Punjabi University, Patiala (Punjab), India from March 1997 to December 1999. The objectives of these studies included identification of the insect species visiting carcasses, description of decomposition progression, and determination of insect succession patterns through different seasons. This study is the first attempt to study the seasonal insect succession on carrion in India. Though several references are available about studies on arthropod succession in various parts of the world, only a few have described the succession pattern with respect to different seasons (8–10). It is hoped that the present studies will provide a basis for understanding the biology and ecology of the carrion insect community for this region of India, which is a vital prerequisite for application of medico-criminal forensic entomology (11).

Materials and Methods

To study the process of decomposition and related carrion fauna, several sites within the Punjabi University Campus area were selected. Situated at an altitude of about 230 m above mean sea level, the campus area has a loamy type of soil. Site selection was based on the following criteria: it should ensure unhindered accessibility of the carrion to different kinds of insects; it should be within reach to take observations twice or thrice everyday; and there should be no danger of disturbance by humans or other animals, particularly carnivores or scavengers. The domestic rabbit *Oryctolagus cuniculus* L. was selected as the animal model. These animals are small enough for easy handling during the observation and sampling of carrion insects and large enough to support long-term studies as well as a considerable number and diversity of carrion insects. Five seasons are recognized in the state of Punjab (12) (Table 1). These are: summer (mid-April to the end of June), rainy (early July to September), autumn (September to the end of November), winter (early December to the end of February), spring (March to mid-April). Seventeen experiments were conducted to cover all these seasons of Punjab.

Rabbits of approximately the same weight (1 to 1.2 kg) were used for these studies. They were killed by cervical dislocation to minimize bleeding and pain to the animal. A cage was designed to protect the carcasses from vertebrate scavengers. The cage consisted of metal frame measuring 2 by 1.5 by 1 ft covered with welded wire mesh (1 by 1 in.). Wire mesh of about 1 ft in width was extended from the base on all sides to restrict digging under the cage by vertebrates. This kept the scavengers away without interfering with the ingress and egress of the insects. Each carcass was inspected at 3-h intervals during the day (8 a.m. to 6 p.m.), and when it reached dry stage it was examined once daily. At each visit, the physical condition of the carcass and state of decay was noticed.

Flying insects (Calliphorids, Sarcophagids, Muscids, etc.) were captured by the standard aerial sweep net technique. Beetles and immature stages of different species were collected with forceps, while small and fragile insects like ants, etc., were collected by a fine paintbrush moistened with alcohol. The carcass was carefully lifted to examine and sample fauna underneath. Soil beneath the carcass was also examined for post feeding maggots and puparia.

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TABLE 1—*Climatological data (average) recorded during the experimental periods.*

Season	Date	Ambient Temperature (°C)			Relative Humidity, %	Rainfall, mm
		Minimum ± SD	Maximum ± SD	Average		
Summer	23rd April, 98–30th April, 98	21.8 ± 2.0	35.6 ± 0.6	28.7	54.8	Nil
	15th May, 98–22th May, 98	24.2 ± 1.8	36.1 ± 1.78	30.1	60.2	Nil
	12th June, 98–20th June, 98	26.6 ± 1.60	36.6 ± 2.95	31.6	65.7	Nil
Rainy	31st Aug., 97–10th Sept., 97	23.0 ± 0.90	31.5 ± 1.20	27.2	78.7	Nil
	20th Sept., 97–27th Sept., 97	23.3 ± 0.80	32.9 ± 1.25	28.1	76.2	Nil
	14th Sept., 98–24th Sept., 98	23.1 ± 1.67	32.5 ± 1.33	27.8	81.2	3.7
Autumn	20th Oct., 97–30th Oct., 97	16.0 ± 1.80	31.3 ± 1.14	23.6	59.6	Nil
	31st Oct., 97–14th Nov., 97	13.0 ± 1.30	29.5 ± 0.8	21.2	60.5	Nil
	21st Nov., 97–5th Dec., 97	8.9 ± 1.87	24.9 ± 2.5	16.9	61.2	Nil
	4th Oct., 99–20th Oct., 99	18.3 ± 1.2	33.5 ± 1.5	25.9	65.8	Nil
Winter	7th Dec., 97–28th Dec., 97	10.0 ± 1.78	20.4 ± 2.18	15.2	66.8	Nil
	29th Nov., 99–20th Dec., 99	9.4 ± 2.3	24.0 ± 1.79	16.7	78.5	2.2
Spring	11th March, 97–28th March, 97	16.2 ± 1.67	27.3 ± 2.3	18.2	69.5	Nil
	4th March, 98–19th March, 98	14.8 ± 2.04	27.7 ± 1.41	21.2	63.5	Nil
	19th March, 98–5th April, 98	15.5 ± 2.0	27.9 ± 3.13	21.7	62.4	9.5
	10th March, 99–25 March, 99	16.5 ± 1.30	27.6 ± 2.29	22.0	70.0	9.5
	2nd April, 99–12th April, 99	17.2 ± 4.30	33.7 ± 1.43	25.4	42.4	N

TABLE 2—*Total number of fly and beetle specimens collected during the study.*

Order	Family	Name of Species	Total No. of Specimens Collected
Diptera:	Calliphoridae	*Chrysomya megacephala*	327
		Chrysomya rufifacies	317
		Calliphora vicina	80
		Lucilia illustris	40
		Lucilia sericata	24
	Sarcophagidae	*Sarcophaga hirtipes*	110
		Sarcophaga princeps	50
		Sarcophaga albiceps	90
		Sarcophaga misera	75
	Muscidae	*Musca domestica nebulo*	90
		Musca pattoni	45
		Musca ventrosa	37
		Musca sorbens	40
		Hydrotaea capensis	48
		Hydrotaea chalogaster	25
		Hydrotaea occulta	25
		Atherigona orientalis	50
		Atherigona sp. nr. orientalis	16
		Atherigona savia	9
	Otitidae	*Physiophora flavipes*	5
	Anthomyidae	*Adia cinrella*	6
Coleoptera:	Histeridae	*Saprinus* sp.	50
		Euspilotus sp.	40
	Silphidae	*Calosilpha cyniventris*	12
	Staphylinidae	*Philonthus longicornis*	40
	Dermestidae	*Dermestes maculatus*	50
	Cleridae	*Necrobia* sp.	35
	Tenebrionidae	*Gonocephalum* sp.	15
		Scleron reitteri	13

Collection was done within 10-min periods to keep the disturbance of the carcass at its minimum. Adult flies, beetles, moths, etc. were killed by ethyl acetate vapors, while ants and immature stages of different species were placed directly in vials containing Kahle's solution. The number of specimens collected depended upon their abundance. The total number of specimens collected during the study is depicted in Table 2.

Collected specimens were brought to the laboratory for record and identification. Each individual specimen was identified in the laboratory with the help of keys from Senior White et al. (Sarcophagidae, Calliphoridae) (13), Bland and Jacques (Coleoptera) (14), Van Emden (Muscidae) (15). However, for reliable identification and confirmation, the specimens were sent to workers who are authorities in their respective fields, namely, Dr. Hiromu Kurahashi (Diptera, Calliphoridae, Muscidae, Anthomyidae, Otitidae), Dr. Thomas Pape (Diptera, Sarcophagidae), Dr. Vijay Veer (Coleoptera, Dermestidae), Dr. Charles Triplehorn (Coleoptera, Tenebrionidae), Dr. Tae Young Moon (Coleoptera, Silphidae,

Staphlyinidae), Dr. Harjinder Singh Rose (Lepidoptera, Tineidae) and Dr. Himender Bharti (Hymenoptera, Formicidae).

The temperature data on and around the rabbit carcass was recorded with the help of a mercury thermometer. Moreover, climatologically data were also recorded during sampling times from the meteorological station situated within the Punjabi University Campus (200 to 300 m range of experimental sites).

Results and Discussion

Fresh Stage

Though a continuum, the process of rabbit decomposition was divided into four stages for better understanding (8,10). These are fresh, bloated, decay, and dry. The fresh stage begins at the moment of death and continues until bloating is first evident. During this stage the process of autolysis, i.e., the breakdown of complex proteins and carbohydrate molecules to simpler chemical compounds, starts. It is primarily due to the action of digestive enzymes or ferments (33).

Neither gross morphological changes are produced nor odor of decay is detectable at this stage. Carcasses are characterized by their normal intact bodies, pliant skin, movable limbs, and soft fur. Internal temperature of the carcass declines during the fresh stage (10) and may be lower than the ambient air (16) or soil temperature (17). During the present study, the carcass temperature was found to be lower than the ambient air temperature in the fresh stage. The fresh stage lasts for about 22, 18, 117, and 31 h, respectively, during summer, rainy, autumn, winter, and spring seasons.

Bloated Stage

This commences with the onset of carcass swelling and ends when the carcass deflates. Putrefaction, the principal component of decomposition process, begins during this stage. The first visible sign of the bloating stage is slight inflation of the abdomen caused by the buildup of gases in the intestine as a result of anaerobic bacteria. Later, the skin of the abdomen and between the fore and hind limbs begins to tighten, giving the appearance of a taut balloon.

Loss of hair starts and the odor of decay becomes noticeable as fluids begin seeping from natural body openings into the soil. The internal temperature of the carcass begins to rise during this stage as a result of the putrefaction process combined with insect (maggot) activity (17,18). In the present study, the internal temperature was found to be the same as that of the ambient at the beginning of bloating. The rise in temperature was observed only during the end of bloating stage and the start of the decay stage, i.e., when the carcass is about to burst as observed by Reed (8). This could be attributed to the fact that dipteran maggots were not in large enough numbers to increase the carcass temperature above ambient. During the winter months the carcasses did not become as strongly bloated as those observed during warm weather. Another interesting observation regarding carcasses undergoing bloating in warm weather was the lifting of the limbs above the ground level as a result of the swelling process. The bloated stage lasts for about 32, 25, 120, and 98 h, respectively, during summer, rainy, autumn, winter, and spring seasons.

Decay Stage

The beginning of this stage is marked by the release of gases like NH_3, CO_2, NO_2, and H_2S; the carcass deflates and the stage ends when most of the remnants are relatively dry. The skin is usually cracked in one or more places by feeding dipterous larvae, permitting the entrance of air. The latter in turn facilitates the process of aerobic protein decomposition. Hair loss is conspicuous, especially in areas where maggots manifest great activity. The soil under the carcass becomes pulverized by the burrowing activity of maggots. Carrion temperature during the decay stage is considerably higher than the soil temperature (17) and even higher than the surrounding air temperature (19–21). Early and Goff (18) and Tullis and Goff (22) recorded differences of up to 22°C between carcass temperature and ambient air temperature in the Hawaiian Islands. In the present study, carrion temperature was recorded as high as 10°C above ambient during this stage. The odor of decay is strong. Payne (17) observed that fly maggots consumed 90% of the carcass biomass by the end of this stage, and this was observed to be so in the present study as well. The decay stage lasts for about 40, 60, 79, 120, and 126 h, respectively, during summer, rainy, autumn, winter, and spring seasons.

Dry Stage

This is the final stage of decomposition. The carcass consists of only dry skin, fur, cartilage, and bones. Odor is typically of dried animal skin. Internal carcass temperature approximates that of ambient (18). The end of this stage is difficult to define as noted by various other authors due to its long duration and lack of pronounced marking events. However, Reed (8) stated that this stage might last up to a point when no carrion fauna remains.

The duration of each decomposition stage during different seasons is recorded in Table 3. In general, the duration of a particular stage of decomposition is longer than that of its predecessor in the same season (8,9). Carcasses in summer and the rainy season decayed at a much faster rate than those in the winter and spring. In summer, the carcass took only four days (26.6 to 36.6°C) to reach the dry stage as compared to winter, when a period of about 15 days (9.4 to 24.0°C) was required for the same progression to be matched. Daily mean temperature for all the five seasons is shown in Figs. 1 to 5. For this purpose, the daily average of maximum and minimum temperature for replicates in a particular season were calculated (2 for winter, 3 replicates for summer/rainy, 4 replicates for autumn, 5 for spring season). From that, daily mean temperatures for a particular season were deduced.

TABLE 3—*Duration (hours) of decompositional stages of rabbit carcasses in different seasons.*

Stages of Decomposition	Summer	Rainy	Autumn	Winter	Spring
Fresh	0–22	0–18	0–30	0–117	0–31
Bloated	23–54	19–43	31–87	118–237	32–129
Decay	55–94	44–107	88–166	238–357	130–255
Dry*	95 onwards	108 onwards	167 onwards	358 onwards	256 onwards

* No marked end point of this stage, only initial hours recorded.

Insect Succession

As reported in most of the arthropod succession studies on carrion (16,27–32), the three insect orders, i.e., Diptera, Coleoptera, and Hymenoptera, dominated carrion communities in the present study as well, of which Diptera was by far the predominant group.

Twenty-one species of Diptera belonging to five families were recorded, frequenting carcasses out of which immature of seven species were recovered from the carrion. These seven species are: *Calliphora vicina* (Robineau-Desvoidy 1830); *Chrysomya megacephala* (Fabricius 1784); *Chrysomya rufifacies* (Macquart 1842); *Sarcophaga albiceps* (Meigen 1826); *Sarcophaga misera* (Walker 1849); *Sarcophaga princeps* (Wiedemann 1830); and *Sarcophaga hirtipes* (Wiedemann 1830). The succession pattern of the total insect assemblage during different seasons is shown in Figs. 1–5. Members of the families Calliphoridae and Sarcophagidae were found to be responsible for maximum carrion tissue clearing. Combinations of these flies dominated in all the seasons and were found to be the first to reach the carrion.

The blowfly species collected during the present studies did not exhibit any significant population variation. All of them conform to the available descriptions for the Indian populations (13). Most of these species are known to depict some variations among the populations collected from different countries. *Calliphora vicina* prefers cool and moderate temperatures as has also been reported by Greenberg (22). It was observed only during winter and spring seasons, i.e., from December to early April (Figs. 4 and 5). As compared to *Chrysomya* spp., it was available in less numbers. This blowfly was observed on the very first day, and first eclosion was noticed on Day 27 (16°C) and Day 22 (22.7°C) during winter and spring, respectively.

Chrysomya megacephala was observed to colonize throughout the year (Figs. 1 to 5). As the average daily temperature decreased from summer to winter, there was a gradual increase in the time required for the completion of its life cycle. Accordingly, the first eclosion took place on Day 9 (30.6°C), 10 (27.6°C), 11 (21°C), 23 (13.5°C), and 16 (24.5°C) during summer, rainy, autumn, winter, and spring seasons, respectively. The relative abundance of this species is comparable with that of *Chrysomya rufifacies,* and each of them outnumbers the other species of blowflies whenever available.

Chrysomya rufifacies, too, was observed to colonize in all seasons (Figs.1–5). 3rd instars of *Chrysomya rufifacies* are predatory in behavior and feed upon other larvae available on the carcass (23). Gradual decline was observed in the abundance of larvae of other species, and *Chrysomya rufifacies* dominated the scene during later stages of decay. The general pattern of the occurrence of its larvae and pupal eclosion in different seasons is comparable with that of *Chrysomya megacephala.* Adults of *Lucilia sericata* and *Lucilia illustris* were observed during autumn and summer and autumn and spring seasons, respectively. However, these flies were not found to colonize the carrion, probably because they could not compete with the two cardinalate species of *Chrysomya,* which are abundantly available throughout the year. These blowflies were present on the very first day of exposure of carrion and lasted until the decay stage. Three species of blowflies that were found to breed on rabbit carrion were reared in the laboratory at a temperature of 25 ± 1°C to study their life histories and duration of various developmental stages (Table 4).

Four sarcophagid species were associated with rabbit carrion, and all of them co-existed only during spring. The pattern of occurrence of their adults and immature stages in different seasons has been depicted in Figs. 1–5. Flesh flies are known to act as primary invaders of carrion in tropical and subtropical regions (10,17,18). They were found to reach and colonize the carrion during the first two days in all the seasons. *Sarcophaga hirtipes* was found to colonize throughout the year and is the only sarcophagid species available during winter months.

Ten muscid species were collected, though none was found to colonize the carrion. This may be due to the intense competition from members of Calliphoridae and Sarcophagidae. The following species have been collected: *Musca domestica nebulo* (Fabricius 1784); *Musca ventrosa* (Wiedemann 1830); *Musca sorbens* (Wiedemann 1830); *Musca pattoni* (Austen 1910); *Hydrotaea capensis* (Wiedemann 1818); *Hydrotaea chalogaster* (Wiedemann 1818); *Hydrotaea occulta* (Meigen 1825); *Atherigona orientalis* (Malloch 1928); *Atherigona* sp. nr. *orientalis* (Malloch 1928); *Atherigona savia* (Pont and Magpayo 1996). Their occurrence on carrion during different seasons is shown in Figs. 1–5.

The family Anthomyiidae was represented on carrion by *Adia cinerella* (Fallen 1825) and that too only during spring. *Physiophora flavipes* (Karsch 1888), belonging to the family Otitidae was also observed on carcass during spring. This species is known to breed in meat under laboratory conditions (Wells, personal communication).

Beetles belonging to six families, i.e., Staphylinidae, Histeridae, Cleridae, Tenebrionidae, Dermestidae, and Silphidae, were collected during the study. A distinct beetle fauna is available in different seasons during various decomposition stages, and it played an important part in the tissue-clearing process. In general, they are more abundant and important during later stages of decomposition, as has been observed by the earlier workers (10,18,24,25).

Philonthus longicornis (Stephens) is the only staphylinid species collected, and it was available during summer and spring seasons. They were observed preying on dipteran larvae, as has been observed by other workers as well (10,18,25).

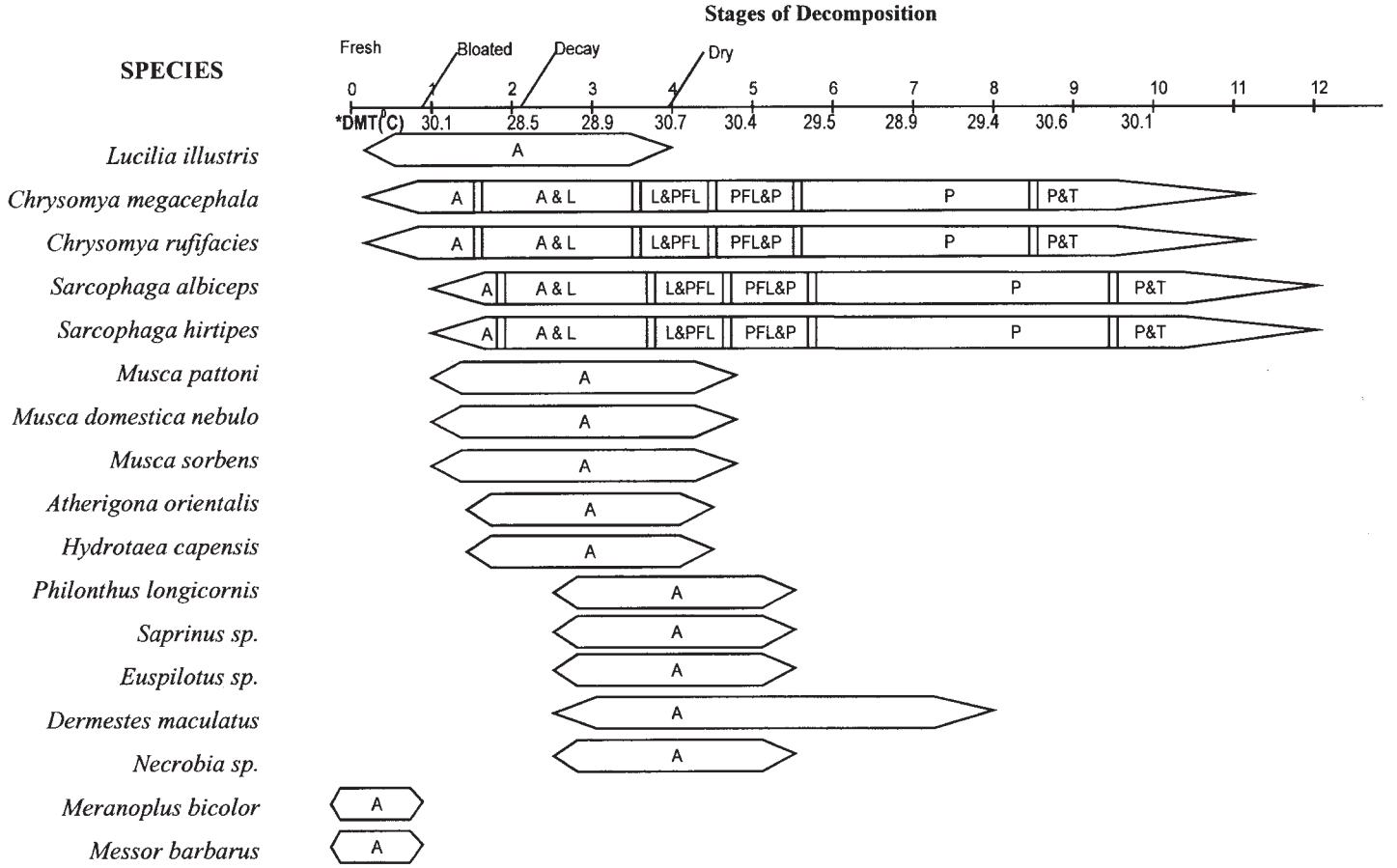
Histeridae was represented by two species belonging one each to genus *Saprinus* and *Euspilotus.* They were found feeding on maggots in all the seasons and may be important in reducing larval numbers significantly (26).

A single clerid species belonging to the genus *Necrobia* was recovered from the carrion. This species was present from spring until the rainy season. Adults were observed to feed on dipteran larvae as well as on carrion. Similar observations have been made by Braack (26).

Tenebrionidae was represented by *Gonocephalum* sp. and *Scleron reitteri.* Both species were observed feeding on carrion during rainy and autumn seasons. No larval feeding has been observed, though such observations have been documented (10). A single dermestid species *Dermestes maculatus* (De geer) was collected. The adults and larvae of this family are well known to feed on dried skin and bones (25). This was observed during summer, autumn, and spring seasons and appeared during the decay stage. In most of the earlier studies, dermestids were confined to the dry stage only.

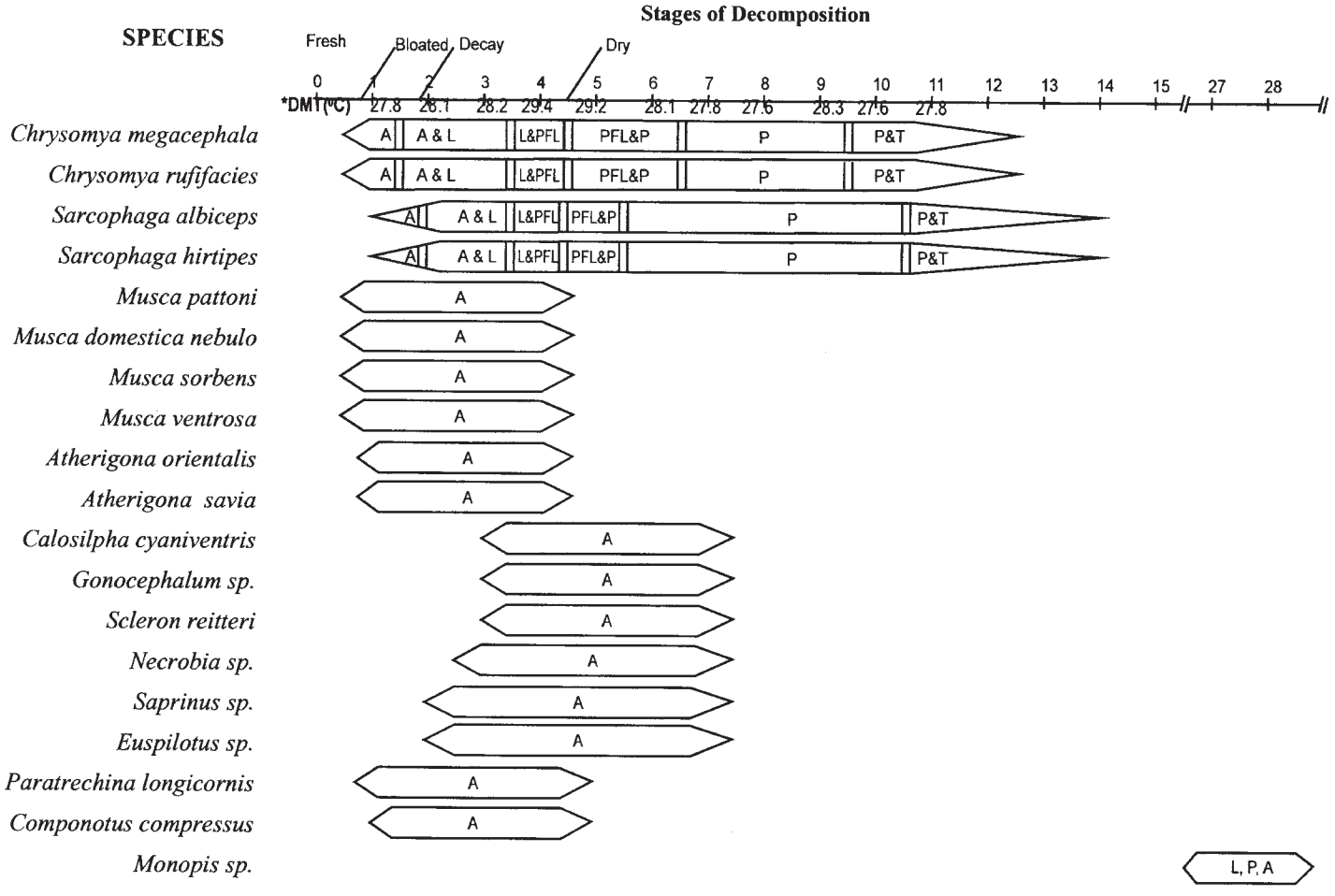
Calosilpha cyaniventris (Motschulsky) was the only silphid species collected and only during the rainy season (Fig. 2). It was observed to feed on dipterous maggots during the decay stage and on carrion during the dry stage.

Five species of ants, i.e., *Meranoplus bicolor* (Guerin-Meneville 1844), *Messor barbarus* (Linnaeus 1767), *Tapinoma melanocephalum* (Fabricius, 1793), *Crematogaster hodgsoni* (Forel 1902), and *Crematogaster contemta* (Mayr 1879) should be considered accidental visitors, while three others may have some role to play in the process of decomposition. *Paratrechina*



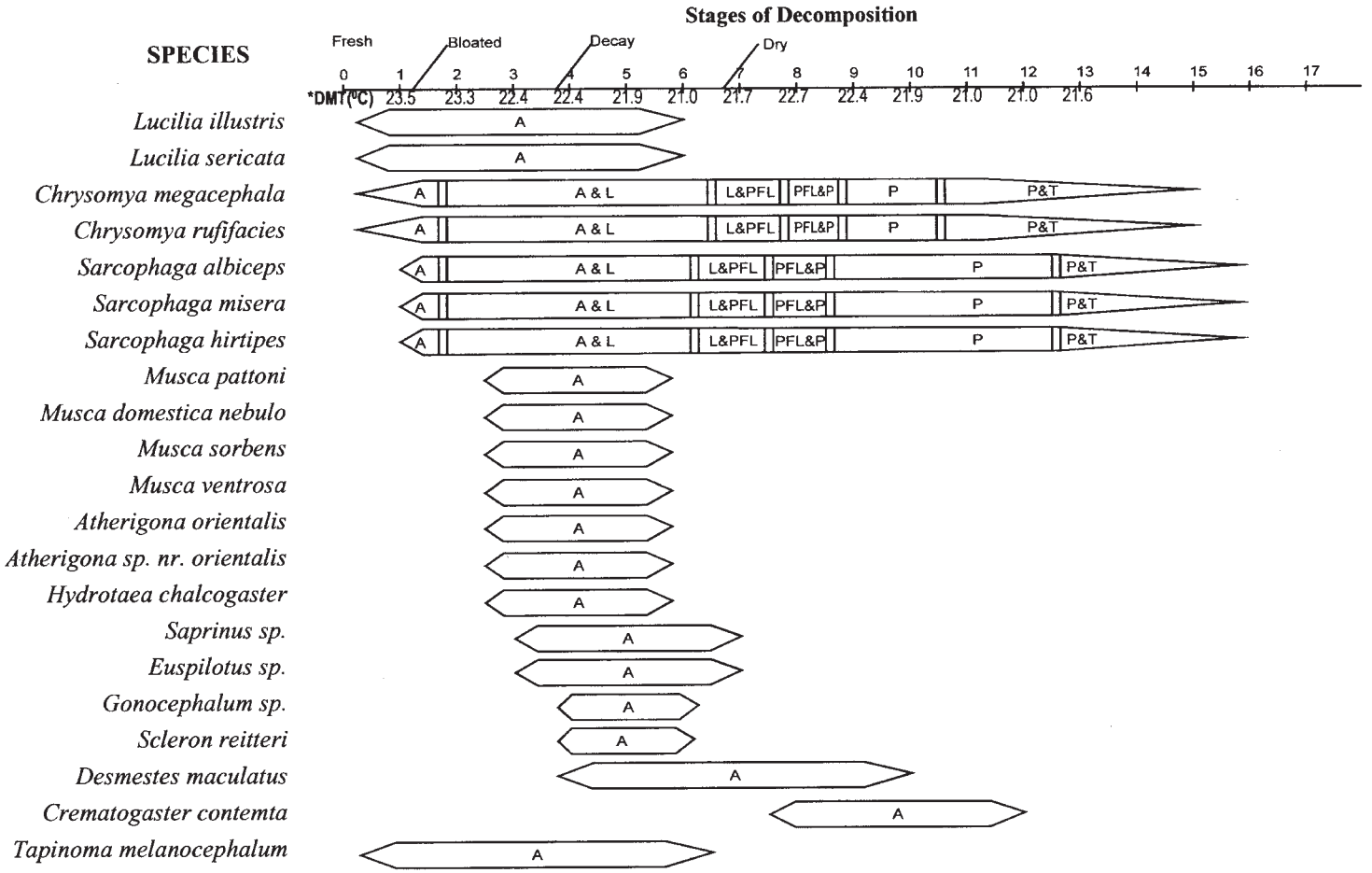
A = Adults ; L = Larvae ; PFL = Post feeding larvae ; P = Pupae ; T = Tenerals; *DMT=Daily mean temperature

FIG. 1—*Insect fauna attracted to rabbit carrion during summer season.*



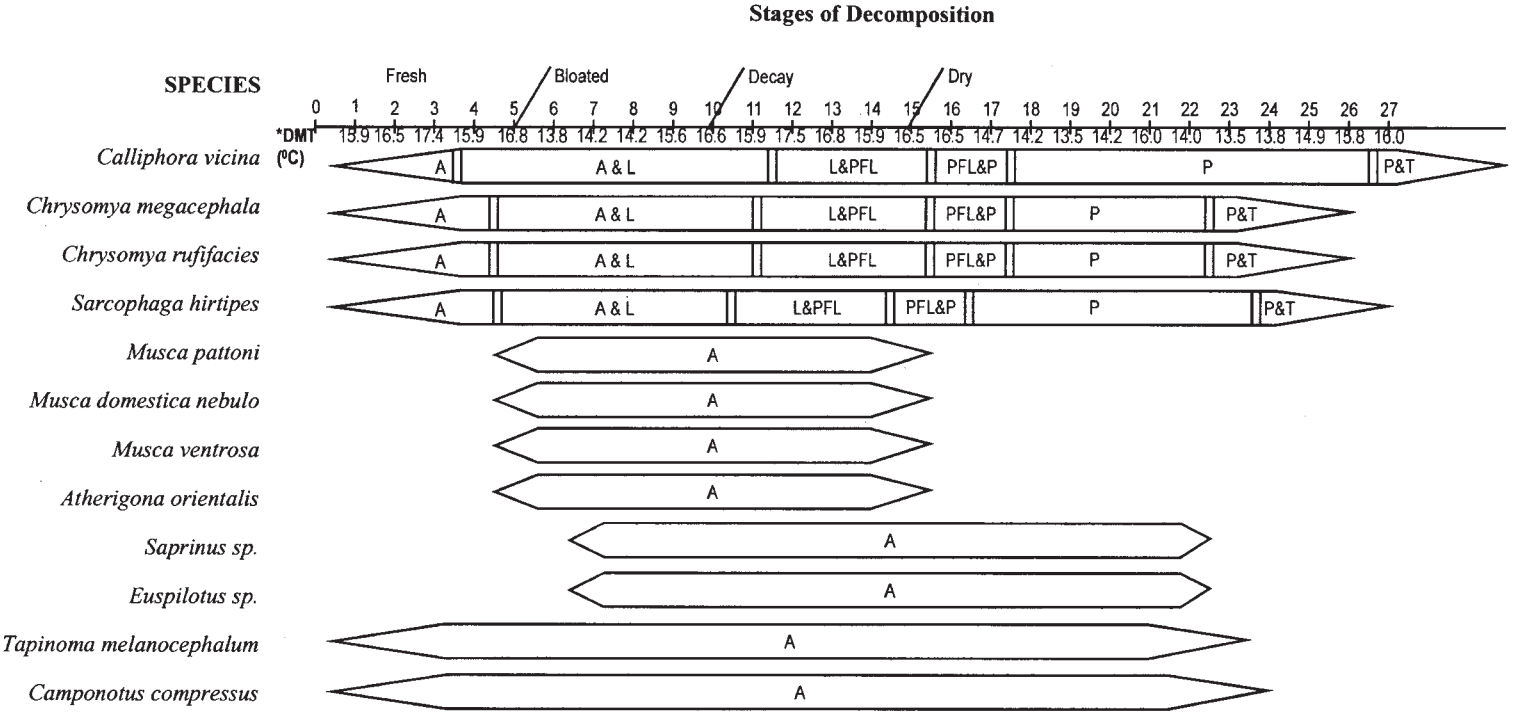
A = Adults ; L = Larvae ; PFL = Post feeding larvae ; P = Pupae ; T = Tenerals; *DMT=Daily mean temperature

FIG. 2—*Insect fauna attracted to rabbit carrion during rainy season.*



A = Adults ; L = Larvae ; PFL = Post feeding larvae ; P = Pupae ; T = Tenerals; *DMT=Daily mean temperature

FIG. 3—*Insect fauna attracted to rabbit carrion during autumn season.*



A = Adults ; L = Larvae ; PFL = Post feeding larvae ; P = Pupae ; T = Tenerals; *DMT=Daily mean temperature

FIG. 4—*Insect fauna attracted to rabbit carrion during winter season.*

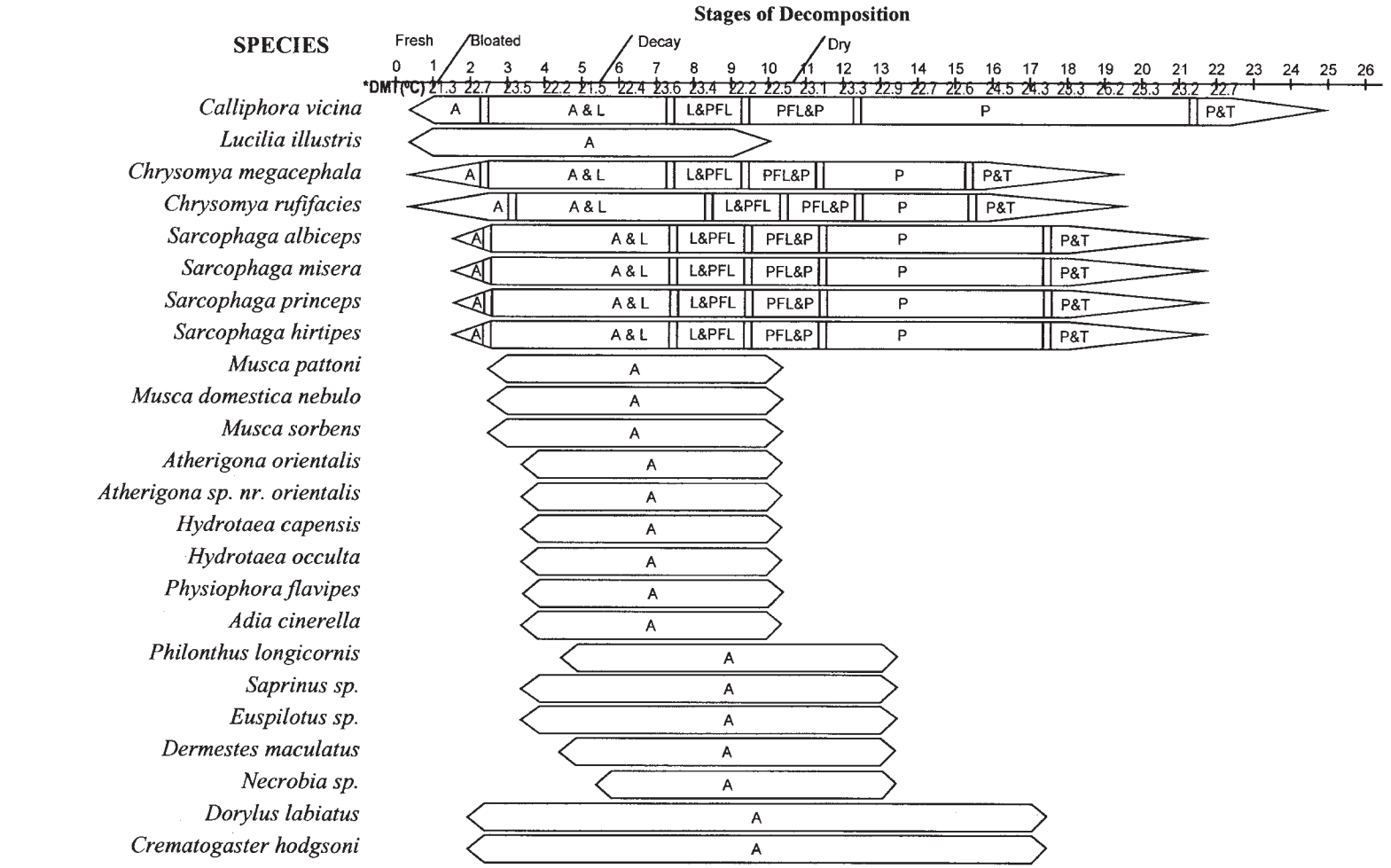


FIG. 5—*Insect fauna attracted to rabbit carrion during spring season.*

TABLE 4—*Summary of the temporal distribution of species collected.*

Insect Fauna		Season				
Order	Family	Summer	Rainy	Autumn	Winter	Spring
Diptera	Calliphoridae	*Lucilia illustris* *Chrysomya megacephala* *Chrysomya rufifacies*	*Chrysomya megacephala* *Chrysomya rufifacies*	*Lucilia illustris* *Lucilia sericata* *Chrysomya megacephala* *Chrysomya rufifacies*	*Calliphora vicina* *Chrysomya megacephala* *Chrysomya rufifacies*	*Calliphora vicina* *Lucilia illustris* *Chrysomya megacelphala* *Chrysomya rufifacies*
	Sarcophagidae	*Sarcophaga albiceps* *Sarcophaga hirtipes*	*Sarcophaga albiceps* *Sarcophaga hirtipes*	*Sarcophaga albiceps* *Sarcophaga misera* *Sarcophaga hirtipes*	*Sarcophaga hirtipes*	*Sarcophaga albiceps* *Sarcophaga misera* *Sarcophaga princeps* *Sarcophaga hirtipes*
	Muscidae	*Musca pattoni* *Musca domestiea nebulo* *Musca sorbens* *Atherigona orientalis* *Hydrotaea capensis*	*Musca pattoni* *Musca domestica nebulo* *Musca sorbens* *Musca ventrosa* *Atherigona orientalis* *Atherigona savia*	*Musca pattoni* *Musca domestica nebulo* *Muscasorbens* *Musca ventrosa* *Atherigona orientalis* *Atherigona sp. nr. orientalis*	*Musca pattoni* *Musca domestica nebulo* *Musca ventrosa* *Atherigona orientalis*	*Musca pattoni* *Musca domestica nebulo* *Musca sorbens* *Atherigona orientalis* *Atherigona sp. nr. orientalis* *Hydrotaea capensis*
	Anthomyidae			*Hydrotaea chalogaster*		*Hydrotaea occulta*
	Otitidae					*Adia cinerella* *Physiophora flavipes*
Coleoptera	Staphylinidae	*Philonthus longicornis*				*Philonthus longicornis*
	Histeridae	*Saprinus sp.* *Euspilotus sp.*	*Saprinus sp.* *Euspilotus sp.*	*Saprinus sp.* *Euspilotus sp.*	*Saprinus sp.* *Euspilotus sp.*	*Saprinus sp.* *Euspilotus sp.*
	Dermestidae	*Dermestes maculatus*		*Dermestes maculatus*		*Dermestes maculatus*
	Cleridae	*Necrobia sp.*	*Necrobia sp.*			*Necrobia sp.*
	Silphidae		*Calosilpha cyaniventris*			
	Tenebrionidae		*Gonocephalum sp.* *Scleron reitteri*	*Gonocephalum sp.* *Scleron reitteri*		
Hymenoptera	Formicidae	*Meranoplus bicolor* *Messor barbarus*	*Paratrechina longicornis* *Camponotus compressus*	*Crematogaster contemta* *Tapinoma melanocephalum*	*Camponotus compressus* *Tapinoma melanocephalum*	*Dorylus labiatus* *Crematogaster hodgsoni*
Lepidoptera	Tineidae		*Monopis sp.*			

longicornis (Latreille 1802) and *Camponotus compressus* (Fabricius 1787) were observed to feed on moist areas around the eyes, nose, mouth, and anal region during the fresh stage and on dead flies, dead larvae, skin of carrion, etc., during the decay stage. *Dorylus labiatus* (Schuckard 1840) is predaceous in nature and was found feeding on dipterous eggs during the early stages of decomposition and on maggots and puparia during the later stages of decay. It may delay the clearing of soft tissue by reducing the dipterous maggots, which are responsible for maximum soft tissue clearing when there are no vertebrate scavengers (18). Wells and Greenberg (23) report a similar role of *Solenopsis invicata* in affecting the occurrence of post-feeding larvae of *Cochliomyia macellaria.*

A species of *Monopis* belonging to the family Tineidae is the only representative from the order Lepidoptera. It was collected in good numbers during the rainy season, colonizing and feeding upon dried fur after all other inhabitants were gone.

Conclusions

A total of 38 insect species belonging to four orders and 13 families were recorded on rabbit carcasses. The maximum number of 24 species was collected from different stages of decay during spring season as compared to only 12 and 17 species during winter and summer months, respectively (Table 4). This is due to the fact that temperature is moderate during spring season, which shares the insect diversity both with late winter and early summer. Succession at high temperature is accompanied by rapid resource depletion and hence lowered faunal diversity. On the other hand, a lesser number of insect species are active during winter months

when the temperature is extremely low. The same explains the high level of diversity during the autumn season.

Diptera, Coleoptera, and Hymenoptera dominated the carrion fauna during these investigations. This is consistent with most of the previous studies on carrion decomposition (8–10,18,22,30,31). Diptera represented 55% of the total number of species, while Coleoptera and Hymenoptera shared 21% each. Lepidoptera was represented only by one species of fur moths. The same pattern of dominance was observed during all seasons. Of all the insect fauna, dipterans belonging to the family Calliphoridae and to a lesser extent Sarcophagidae, along with dermestid beetles, were mainly responsible for soft tissue clearing.

Calliphorids were the first to arrive on carrion (i.e., on the first day of exposure) in all the seasons of the year. In the summer, they arrived on carcasses within a few minutes and females oviposited on carrion within a few hours after carcass placement (Fig. 1). Whereas in winter the flies did arrive on carcass on the first day, but 1st instars were not observed till the 5th day (Fig. 4).

Furthermore, different species of blowflies were found in different seasons, e.g., *Calliphora vicina* was observed only during winter and spring seasons, *Lucilia sericata* during autumn, and *Lucilia illustris* during summer, autumn, and spring seasons. *Chrysomya megacephala* and *Chrysomya rufifacies* were available throughout the year.

Ten species of muscids, 8 species of beetles, and 8 species of ants were also recorded from the rabbit carcasses in different seasons during the present study. A few spiders were also collected during the rainy and autumn seasons although they have not been identified. This study is the first of its kind from India. Thus, the data obtained from this study will provide basic information regarding the carrion fauna of this area. It will also form the basis for similar studies in different geographical and climatological regions of India.

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