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Altitudinal Diversity of Forensic Blowflies (Diptera: Calliphoridae) of Western Ghats (Maharashtra)

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Abstract

Western Ghats is one of the 18 hot spots of the world for biodiversity conservation and protection. Increasing human activities and tourism in forestry and changing life style of humans lead more difficult to solve criminal cases. Blow flies (Diptera: Calliphoridae) are important components of decomposition process of wild and human bodies in forest ecosystems. Biotic and abiotic factors of environment have direct impact on population dynamics of flora and fauna of forensic importance. The blow flies use carrion as a resource for propagation of their own progeny. Therefore, altitudinal diversity of forensic blow flies in Western Ghats has been reported. A total of 19 species of blow flies belonging to the genera *Chrysomya*, *Lucilia* and *Calliphora* have been reported. The genus *Lucilia* and *Chrysomya* were abundant at low altitude than higher altitudes of Western Ghats. In general, blow fly diversity decreased with increase of altitudes and qualitative faunal diversity of blow flies were different at different study spots. The outcome of faunal turn over analysis clearly indicated that assemblage at 545 m and 585 m share almost 71.42% of their fauna in common. Also elevation of 900 m shares 70.70% of its assemblage with 585 m. Similarly, assemblage at 42 m and 22 m share about 40% of their fauna in common. The life cycle under laboratory ($27 \pm 1^\circ\text{C}$, 70-80%, 12 hours photo period) ranged from 9-11 days in the species, *C. erythrocephala* and *L. sericata*.

Keywords: Altitudinal diversity; forensic blowflies; Developmental time; Western Ghats Maharashtra; India

Introduction

Blow flies (Diptera: Calliphoridae) are commonly called green bottles and blue bottles. The blue bottles *Calliphora* occur commonly around houses in search of breeding material and food and attracted to meat, carrion, fecal matter and dead animals for egg laying and to cheese for food. The genus *Chrysomya* includes green bottles of large size and metallic green colour and cause myiasis in human and other animals in India. This genus is reported from India, Africa, Philippines, Celebes and New Guinea. *Lucilia* species are also known as green bottles and are metallic, shining green but smaller and less bristly than *Calliphora*. The larvae of *Lucilia* infect wounds and body cavities in man and some attacks sheep in India. Western Ghats is one of 18 hot spots of the world for conservation and protection of biodiversity. Biotic and abiotic factor have direct impact on population dynamics of flora and fauna. Extension tourism in forestry and changing life style of humans lead criminal cases. Therefore, altitudinal diversity of blow flies in Western Ghats will add great relevance in protecting wild and human life and the data will be helpful to forensic science. Review of literature indicates that forensic insects have been studied with respect to diversity, biology, development and utility in forensic science by Senior-white [1], James [2], Smith [3], Greenberg [4], Kurahashi and Thapa [5], Smith and Wall [6], Anderson [7], Dadour et al. [8], Kurahashi [9], Tachibana and Numata [10], Bharti and Singh [11], Grassberger et al. [12], Pitts and Wall [13], Clark et al. [14] Bharti [15,16] Bharti and Kurahashi [17], Higley and Haskel [18], Shiravi et al. [19], Sathe and Jadhav [20,21], Sathe et al., [22] Vasconcelos et al. [23], Ghodake et al. [24] etc.

Materials and Methods

Collection of blow flies were made during the years 2012-13 from Kolhapur city, Radhanagari, Gaganbawada, Vaibhavwadi, Kankawali and Sindhudurg covering most of the altitudinal and road side spots. The blow flies were collected with the help of sweeping net from the carcasses. The carcasses of dogs, cats and cows were used

in the present study. Collections were made weekly. After recording morphological features and identification, the blow flies were released in the environment from which they were collected. A fresh piece of goat meat 4×4 cm was placed in mesh cage 25×25×25 cm and cages were kept road sides at each study spot in the areas where there was no interference of scavengers and carnivores and collection of blow flies was made after 30 minutes of placement of cage in the field and diversity was recorded (Table 1). Geographical and climatic data of study spots have been noted in the Table 3. Developmental studies were conducted at laboratory conditions ($27 \pm 1^\circ\text{C}$, 70-80%, 12 hr photo period) in 10 groups of plastic bottles. The bottles were ventilated with numerous holes. Life cycles of *C. erythrocephala* and *L. sericata* were determined by recording the average time in days, for different stages for each species. Recording the time required for egg hatching, larval stage developments and pupation and total time for egg to imago was performed every six hr intervals. The rate of development was measured for each life stage.

Results

Results are recorded in the Tables 1-3 and Figures 1-4. In all, 19 species of blow flies have been reported from the selected spots of Western Ghats (Maharashtra) (Table 1) belonging to the genera *Chrysomya*, *Lucilia* and *Calliphora*. The genus *Chrysomya* was represented by 6 species namely *Chrysomya megacephala*, *C.indica*,

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Sr. No.	Place	Species recorded
1.	Kolhapur	<i>Chrysomyamegacephala</i> (Fab.) <i>Chrysomyarufifacies</i> (Macquart) <i>Chrysomyaindica</i> <i>Luciliaampullacea</i> Villeneuve <i>Luciliapapuensis</i> Macquart <i>Luciliaporphyria</i> (Walker) <i>Calliphoraerythrocephala</i> (Meigen)
2.	Radhanagari	<i>Chrysomyamegacephala</i> (Fab.) <i>Chrysomyarufifacies</i> (Macquart) <i>Chrysomyanigripes</i> (Wied.) <i>Luciliaampullacea</i> Villeneuve <i>Luciliapapuensis</i> Macquart <i>Luciliasericata</i> (Meigen) <i>Calliphoraerythrocephala</i> (Meigen)
3.	Gaganbawda	<i>Chrysomyamegacephala</i> (Fab.) <i>Chrysomyarufifacies</i> (Macquart) <i>Chrysomyanigripes</i> (Wied.) <i>Luciliaampullacea</i> Villeneuve <i>Luciliaillustris</i> (Meigen) <i>Calliphorapattoni</i> Aubertin
4.	Vaibhavwadi	<i>Chrysomyamegacephala</i> (Fab.) <i>Chrysomyanigripes</i> (Wied.) <i>Chrysomyamarginalis</i> (Meigen) <i>Luciliacuprina</i> (Wiedmann) <i>Luciliaampullacea</i> Villeneuve <i>Calliphorapattoni</i> Aubertin <i>Calliphorabazini</i>
5.	Kankawali	<i>Chrysomyamegacephala</i> (Fab.) <i>Chrysomyanigripes</i> (Wied.) <i>Chrysomyamarginalis</i> (Meigen) <i>Luciliacuprina</i> (Wiedmann) <i>Luciliaillustris</i> (Meigen) <i>Calliphorapattoni</i> Aubertin <i>Calliphorabazini</i>
6.	Sindhudurg	<i>Chrysomyamegacephala</i> (Fab.) <i>Chrysomyanigripes</i> (Wied.) <i>Chrysomyamarginalis</i> (Wied.) <i>Chrysomyarufifacies</i> (Macquart) <i>Chrysomyabazziana</i> Villeneuve <i>Luciliaporphyria</i> (Walker) <i>Luciliaampullacea</i> Villeneuve <i>Luciliasericata</i> (Meigen) <i>Luciliapapuensis</i> Macquart <i>Luciliacuprina</i> (Wiedmann) <i>Luciliaandrewsi</i> Senior-white et al. <i>Calliphoravomitona</i> (Linn.) <i>Calliphoraerythrocephala</i> (Meigen)

Table 1: Calliphorids recorded from Western Ghats (Maharashtra).

Place	Dog	Cat	Cow	Goat meat
Kolhapur	442	172	521	20
Radhanagari	220	142	410	18
Gaganbawda	115	75	147	12
Vaibhavwadi	190	111	350	15
Kankawali	222	113	371	18
Sindhudurg	510	214	559	24

Table 2: Blow flies collected on different carcasses in Western Ghats.

C.bazziana, *C.rufifacies*, *C.nigripes* and *C. marginalis* and the genus *Lucilia* by nine species, *Lucilia sericata*, *L. cuprina*, *L. vicina*, *L. papuensis*, *L. ampullacea*, *L. illustris*, *L. porphyria*, *L. andrewsi* and *L. bazini* while, the genus *Calliphora* represented by only four species viz, *Calliphora vicina*, *C.erythrocephala*, *C.vomitona* and *C. bazini*. In Kolhapur city, the genera *Lucilia*, *Chrysomya* and *calliphora* were common with a total of seven species. Gaganbawda, the highest altitude spot showed *Calliphora*, *Chrysomya* and *Lucilia* genera with 1, 3 and 2 species respectively. While the Sindhudurg, altitudinally lowest spot showed 13 species of blow flies belonging to the genera *Chrysomya*,

Lucilia and *Calliphora* with 5, 6 and 2 species respectively (Table 1). The results indicated that the blow flies population was increased during the monsoon season than the winter and summer season and diversity of blow flies was found decreased with increase in altitude in the Western Ghats. It was noted that in almost every spot blowflies gathered on meat piece within half an hour expect *Chrysomya* which appeared 3 hours. The number of attracted blowflies was decreased with increase of altitude (Table 2). The blowflies were also found increased in number on goat meat after 30 minutes of exposure. In general, qualitative and quantitative diversity of blowflies were more in monsoon than winter and summer. The outcome of faunal turn over analysis clearly indicated that assemblage at 545 m and 585 m share almost 71.42% of their fauna in common. Also elevation of 900 m shares 70.70% of its assemblage with 585 m. Similarly, assemblage at 42 m and 22 m share about 40% of their fauna in common.

Life cycle duration of *C. erythrocephala* and *L. sericata* from egg to adult indicated that they completed their life cycle on different carcasses (dog, cat, cow) within the range of 9 days to 11 days at $27 \pm 1^\circ\text{C}$, 70-80% and 12 hr photoperiod in the laboratory. There was not much difference in developmental life stages duration in both the species even on different carcasses (Table 4).

The life cycle of blow flies included four distinct stages viz, egg,

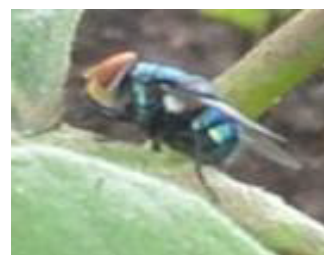


Figure 1: *Calliphora* sp.



Figure 2: *Calliphora* sp.

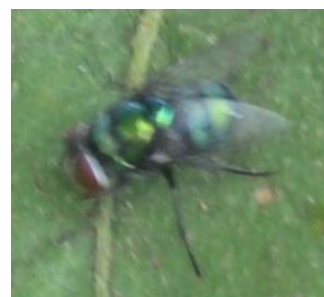


Figure 3: *Chrysomya* sp.

Sr No.	Place	Altitude (m)	Latitude (°N)	Longitude (°E)	Temperature (°C)	Humidity (%)	Rainfall (mm)
1.	Kolhapur	545.6	16.42	74.16	10 - 40	65-87	1000-1025
2.	Radhanagari	585.0	16.41	73.99	10 - 38	67-90	2500
3.	Gaganbawda	900	16.545	73.83	10 - 32	64-94	5000-6000
4.	Vaibhavwadi	80	16.496	73.745	10 - 28	64-97	3240
5.	Kankawali	42	16.285	73.684	17- 29	59 - 92	3200
6.	Sindhudurg	22	16.04	73.46	16.3 - 33.7	65-95	3300

Table 3: Geographical and climatic conditions of study spots.

Sr. No	Carcass	Developmental duration in days	
		<i>C. erythrocephala</i>	<i>L. sericata</i>
1	Dog	9.00	9.5
2	Cat	10.00	11.00
3	Cow	9.5	10.00

Table 4: Development of blow flies on different carcasses.

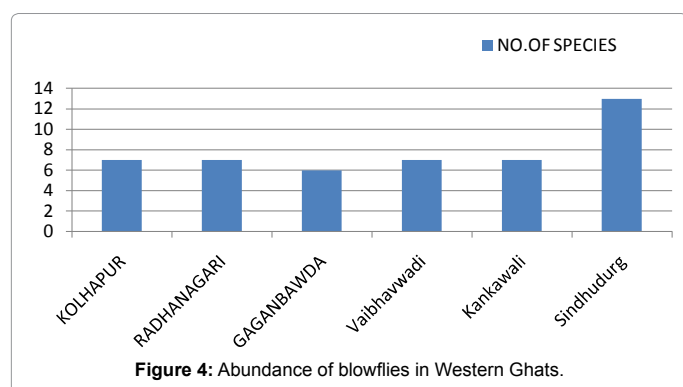


Figure 4: Abundance of blowflies in Western Ghats.

larva, pupa and imago. In the maggot stage 3 instars were noted. The flies deposited their eggs directly on carcasses. The eggs were elongated, the larvae were whitish opaque, legless and tapered towards anterior side and broader towards posterior side and were further characterized by number of respiratory slits at posterior end. The third instar was lasted longer than others on carcasses and found feeding on host tissues. The pupal duration was about half the length of the total development.

Discussion

According to Stevens and Walls [7,25-27] different species of Calliphorids have adapted to different feeding habits over the years for their survival and broadly divided as saprophages, facultative parasites like *Chrysomya megacephala* and *Lucilia sericata* and obligate parasites causing myiasis in man and other animals like *Chrysomya bezziana*. They were also adapted to various ecological niches. Bharati [4] studied altitudinal diversity of forensically important blow flies from Himalaya on decaying carcasses. A total of 14 species belonging to the genera *Calliphora*, *Chrysomya* and *Lucilia* have been reported. Out of 14 species, 6 were from the genus *Chrysomya*, 2 from the genus *Calliphora* while 6 were from the genus *Lucilia*. Bharti [4] further reported that at an elevation of 350 m (Shivalik range of Himalaya), a total of five species namely *Chrysomya megacephala*, *Chrysomya rufifacies*, *Lucilia porphyria*, *Lucilia papuensis* and *Lucilia ampullacea* were present on the carcass. *C. megacephala* and *L. papuensis* were the most abundant species at this elevation. At 970 m also 5 species have been recorded (*C. megacephala*, *C. rufifacies*, *C. nigripes*, *L. illustris* and *L. ampullacea*). These species were found feeding and egg laying on the carcass. At this elevation, the fresh and bloating stages of decomposition of carcass were dominated by all 3 species of *Chrysomya* while, during the decay stage *C. nigripes* was most abundant. She reported maximum diversity

of blow flies at an elevation of 2057 m. A total of 8 species of blow flies were collected from cow carcass. Here *C. megacephala* and *L. sericata* were most abundant. Additional species occurred at this elevation were *C. albiceps*, *C. pinguis*, *C. villeneuvei*, *L. sericata* and *L. cuprina* and also *Calliphora vicina*. However, at an elevation of 2511 m only 3 species namely, *C. villeneuvei* and *Calliphora vicina* and *Calliphora vomitoria* were present. With increase in altitude there was a marked decrease in faunal diversity. In the present study, in Western Ghats (Maharashtra), maximum 13 species of blow flies were recorded from altitudinally lowest spot, Sindhudurg while, only six species have been reported from altitudinally highest spot, Gaganbawda. However, qualitative faunal diversity was different at different spots. The reason for maximum diversity of blow flies at Sindhudurg may be due to availability of more diverse host carcasses since it is a sea coastal spot.

Vasconcellos et al. [23] provided first check-list of forensically important dipteran species in a rainforest environment in North eastern Brazil, a region exposed to high rates of homicides. They used a decomposing pig, *Sus scrofa* L. (Artiodactyla : Suidae), carcass as a model and adult flies were collected immediately after death and in the early stages of carcass decomposition. To confirm actual colonization of the carcass, insects that completed their larval development on the resource were also collected and reared until adult stage. They noted 28 species of seven families of order Diptera with necrophagus habits within few minutes after death. Out of 28 species, 11 have completed their larval development on carcass. The majority of individuals emerged from larvae collected at the dry stage of decomposition. *Hemilucilia segmentaria* Fab. (Calliphoridae), *H. semidiaphana* (Rondani) and *Ophyra chalcoguster* (Wied.) (Muscidae) were the dominant species among the colonizers. In the present study, carcasses of dog, cat and cow and goat meat were used. The dominant species found in the western Ghats was *Chrysomya megacephala*. However, the genus *Lucilia* represented maximum 6 species in the region with altitudinal specificity. At an elevation of 22 m Sindhudurg represented 6 species of *Lucilia* and 5 species of *Chrysomya*.

Vasconcelos et al. [23] reported in total, 153 insects from 14 families in the first 3 hours after the death. This included species of Phoridae 24.2%, Sarcophagidae 18.3%, Piophilidae 10.5%, Calliphoridae 10.5%, Fanniidae 8.5%, Chloropidae 6.5%, Muscidae 4.6% and Dixidae 4.6% while other families were in smaller proportions. The present study was pinpointed for the single family Calliphoridae. However, reporting other families from this region will be of great interest in future.

Determination of post mortem interval (PMI) or the time between death and the discovery of the corpse is the most important application of forensic entomology. Flies belong to the families Calliphoridae (blow flies) and Sarcophagidae (flesh flies) are often the first insects to arrive on a corpse where their larvae feed and breed effectively [2,18]. Developmental rates of flies are frequently used to estimate PMI in homicide investigations in the first few weeks after death. The development of immature insects is climate or temperature dependent. Therefore, PMI is normally calculated by the accumulated degree day/ hour model.

According to Shiravi et al. [19] the developmental rates in *C. albiceps* and *L. sericata* were highly different in terms of accumulation of degree days required than that of the flesh fly *Sarcophaga* sp. They reported that the speed of development in the flesh fly was slower than blowflies. At 28°C the total developmental time from egg to adult was 13-19 days in *Sarcophaga* sp. While, in the present study the development was completed within the range of 9 to 11 days in both the species *C. erythrocephala* and *L. sericata*.

According to Hall and Doisy [26] the amount of time after death affected the structure of the assemblage of insects attracted to a carcass; a feature that will have direct implications on the accuracy of the biological information available to the forensic entomologist. Forest ecosystems are characterized by predator prey relations, parasitism, mutualism, symbiotism, etc. Therefore, forensic insects are supposed to be the indicators of ecologically varying regions and types of forests. The present work will add great relevance.

The speed of development in the flesh fly was also reported slower than blow flies [22]. Therefore, temperature requirements of some common forensically important blow and flesh flies (Diptera) under laboratory conditions have been studied by several workers [1,12,19]. They reported that rates of development decreased step by step as the flies grew from egg to larvae and then to adult stage. However, this rate was bigger for blow flies *C. albiceps* and *L. sericata* in comparison with the fleshy fly *Sarcophaga* sp. According to Gallagher et al. [27] the development of fly larvae is temperature dependant and in higher temperature, the rate of development increases and duration of development becomes shortened. The variation of developmental times between different populations emphasizes on specific characterization of regional developmental times and survival in the region. The present work was carried out at various altitude and climatic conditions. Therefore, the present data will be very useful for ecologists, environmentalist and in forensic science.

The development of blow flies is related with natural and synthetic diet, humidity and competition between larvae [14]. It has been noted that beef liver that are often used in laboratory rearing of flies produce offensive odours and contamination. The presence of toxins in decomposing tissues from natural diets has also been demonstrated affecting the developmental rate of blow flies [14]. On the liver of pigs and cows, the larvae of flies develop very fastly with larger adult size than tissues. An artificial diet, powdered milk caused a lower duration of larval stages in comparison with the animal liver [10]. Similarly, overcrowding of larvae also decreased the growth rate of blow flies leading to wrong conclusions [6]. Therefore, biology fecundity, intrinsic rate of increase of blow flies plays an important role in forensic cases. The present work will add great relevance in forensic science and environmental science for wild life protection and conservation.

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