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Arthropod succession on buried carrion of the African giant rat *(Crycetomys gambianus)*

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ABSTRACT: The arthropod succession on buried carrion and decomposition rates of the African rat (*Crycertomy gambianus*) in both raining and dry seasons were determined. Three sets of the experiment were conducted from December 2002 to October 2003. For each experiment, ten African giant rats with a mean weight of 1.85kg were used.

Carcass in the December/March experiment representing the dry season decayed at a faster rate than those in the August/October which, represented the raining season. Observation further revealed four orders of arthropods ranking in a decreasing order of abundance: Diptera, Coleoptera, Hymenoptera and Araneae occurred out of the study period. Families of Calliphotidae and Sarcophagidae of the Dipteran order and Desmestidae and Cleridae of the Coleoptean order were consider of potential forensic importance as they were responsible for carrion degradation.

Key Words: Arthropod succession; African giant rat (*Crycertomy gambianus*); Carrion sites; Forensic entomology.

Introduction

The study of arthropod succession on a carrion or corpse is a very critical area of concern because of the role of these arthropods after the death of an organism. Hundreds of arthropod species are attracted to Carrion site primarily flies (Diptera), beetles (Coleoptera). Others include mites, isopods, opiliones, nematodes, micro-organism which included fungi and bacteria which may be involved in their decomposition process.

Forensic entomology is the name given to any aspect of the study of insecta and their arthropod counterparts that interact with legal matters. Lord and Sevenson (1986) divided Forensic entomology into three components, *Urban Entomology* (legal proceedings involving insects and related animals that affect man structures and other aspects of the human environment); *Stored Products Entomology* (proceedings involving insects infesting stored commodities such as cereals and other kitchen quarantine procedures on stored imported grating products, and *Medicolegal Entomology* sometimes referred to as forensic medical entomology.

Arthropods are important in medicolegal forensic entomology and they are important carrion feeders that eat dead vertebrate including man. Thus they perform a valuable recycling of organic matter in our ecosystem and experiments have shown that human corpses share the same fauna with animal corpses. Medical Entomology deals mainly with inferences made after examination and identification of arthropods collected from or near a corpse or corpses. The area relates primarily to determination of time (post mortem interval or PMI) or site of human, death, cases involving possible sudden death, traffic accidents (Leclarcq, 1969). Forensic entomology is inextricably linked with the broader scientific fields of medical, taxonomy and forensic pathology.

Fauna composition in terms of species and numbers may also be affected by certain environmental factors which include seasonal period, that is time of year, soil type or composition, rainfall, altitude, relative humidity and most importantly temperature (Mann *et al*., Shean *et al*., 1993).

According to Greenberg (1991), insects of forensic importance are cold-blooded animals and their rate of development is more or less dependent on ambient temperature. Work by Galloway *et al* (1989), Mann *et al*. (1990), So and Dudgeon (1990), Shean *et al* (1993), have revealed that certain factors which include temperature, humidity, rainfall, composition fauna affect carrion decomposition and arthropod succession. Edward (1900) in the experimental observation of flies on cat, fox, mole and calf cadavers confirmed that human corpses share the same fauna with animal corpses, both vertebrate and the invertebrates.

Smith (1986) and Zumpt (1965), recorded that in the old world, blow flies of the genera *Calliphora, Lucilia* and *Chrysomya* are considered the most important carrion species and in Africa, *Chrysomya albicep* (Wiedemanna) *Chrysomya marginalis* (Widemanna) have been regarded as the determinant species in carcass decomposition process.

Smith (1986) and Catts and Goff (1992) classified the arthropod fauna found in or on carrion into several ecological categories such as nacrophages, parasites, predators of the necrophagous species, ominivores, incidentals or adventurers.

Claude and Morley, (1907) classified carrion beetles into carnivorous beetles and beetles that act as final dissoluters to the ancient carcase.

Hall, (1948) considered *Phormia regina (Meigen), Cochliomya macelleria* (Farbricus) and several species of *Phaemicia* and *Calliphora* as important carrion breeders in the world. The introduction and dispersal of four species of Chrysomya namely: *C. albiegs, C. putoria,* (Wiedemann), *C. magacephata,* (Farbricus) and *C. rufifacies* (Wiedeman) into tropical and sub-tropical regions of the New World may be affected by carrion insect community in areas whereby carrion insect community in areas where they have become established (Guimaraes *et al*., (1978); Lawrence (1981-1986).

Tantawi *et al*., (1996) after an experimental research on carrion revealed four different successive decomposition stages of a carrion; fresh, bloated, decay and the stages which lead to a series of activities and corresponding changes in the carries state.

Payne, (1965), Payne and King (1970) and Greenberg (1991), considered Diptera and Coleoptera to be of prime importance comprising about 65% of the fauna, and the Dipteran families; Calliphoridae Eacrophasidae and Muscidae are considered the most important decomposers. Nourteva (1997) and Smith (1986) recorded that the Coleoptera families, Dermestidae, Silphidae and Cleridae strongly followed the Dipterans.

The objectives of the present study include:

(a) Collection and identification of the arthropod species involve in the degradation of carcass of the buried carrion.

(b) Determining and establishing arthropod successional pattern and their larval development stages on carcass of the African giant rate.

(c) Comparing the arthropod fauna and the degradation pattern during the raining and dry seasons.

Materials and Methods

Field studies of the African giant rate (*Crycertomys gambianus*) buried carrion decomposition and its associated fauna were conducted from December 2002 to October, 2003.

The experimental site measured approximately $16m^2$ squares by $16m^2$ square. Daily ambient temperatures were recorded with a minimum and maximum thermometer. The mean temperature during the dry season was 30.5°C while during the raining season was 26.5°C.

The experiment was conducted thrice the first experiment was from December 2003 to March 2003. The second experiment was from May 2003 to July 2003. The third experiment was August 2003 to October, 2003.

For each experiment, ten African giant rats (*Crycertomys gambianus*) weighing a mean of 1.85kg were used. The rats were killed by gassing with chloroform to avoid external bleeding and to maintain their bodies intact immediately after killing, they were buried in holes of 30m deep and placed on their left side.

Three carrion were exhumed each week and the state of decay during each process of exhuming well environmental temperature. Excavations of the soil above and beneath the carcass were made with a small trowel to search for post feeding larvae and puparia of flies including other soil arthropods.

Egg rafts were collected and some place in 70% ethyl alcohol while others were placed into a well ventilated mesh net cage box and buried at the same depth with part of the carcass and the temperature monitored and they were allowed to proceed to adult stage for proper identification.

Soil samples were taken and processed with a Berlese-Tullgreen funnel to extract the soil dwelling arthropods. Minimal numbers of the arthropod species were collected.

Emergent flies, beetles, ants and other arthropods were collected and killed ethylacetate and preserved for identification.

The data collected were analysed using the two way analysis of variance and the Kolmogrov Smirnov one sample test.

Results

During the course of the experiment, a total of 12 adult individual arthropods were collected (Table 1).

The process of exhumation began simultaneously with collection on day 2, 24hrs after killing and burial (Table 2). It was observed that the Dipterans were the first family to visit the carrion, laying their eggs in rafts. By the second exhumation, which was carried out on day 7, larvae were observed and collected. Their measurements ranged from between 8.5mm-10.5mm, and were discovered to be second instar larvae.

The third exhumation was carried out on the 14^{th} day and the pre-pupae stage was observed with an average measurement of 12mm while few 3^{rd} instar larvae were also collected measuring 17mm in length.

Amongst the larvae of Cyclorrhaphous flies cultured in the laboratory species (*Chrysomia bezzina* (50.3%) were the most numerous followed by *Lucilia serricata* (33.0%) while *Fannia* sp was the least (1.7%).

Adult Cyclorrhaphous flies were observed on the carrion during the first exhumation, which was the second day. *Chrysomyia bezziana* which was the most abundant persisted from day 2 to the 7^{th} day.

Lucilia serricata larvae was the second most abundant observed and during the process of exhumation the adult flies were observed visiting the exposed carrion. They were present during the first and second process of exhumation, which occurred on the 2^{nd} and 7^{th} days respectively.

Musca domestica was observed around the exhumed carrion from day 2 to 28, 4^{th} exhumation, and the frequency decreased as the process of decay progressed (table 3).

Sacophaga carnaria was observed on the 7^{th} day only that during the 2^{nd} exhumation.

Fannia sp was observed only during the second exhumation i.e. day 7.

Pheidole magacephala (Hymenoptera:Formidae) was observed during the 7^{th} day after exhumation but it persisted to the 42^{nd}.

Rhizopertha was observed during the 3^{rd} exhumation (Day 14) and it persisted to the end of the experiment.

Table 1: Adult arthropod collected visiting the carrionsite on exhumed *Crycertommys gambianus.*

ORDER	FAMILY	%	SPECIES	TOTAL	MEAN
Coleoptera	Dermestide		*Dermestes*	10	3.0
			maculatus		
	Cleridae		*Necrobia rufipes*	12	4.0
	Silphidae	40.56	*Necrophorus sp*	2	0.7
	Trogidae		*Trox sceber*	2	1.0
	Bostrychidae		*Rhizopertha dominica*	6	2.0
Diptera	Calliphoridae		*Chrysomyia sp*	6	2.0
			Lucillia sericata	6	2.0
			Calliphora sp	11	3.7
	Sarcophagidae	35.8	*Sarocophaga canaria*	7	2.3
			Musca domestica		
	Muscidae		*Fannia cannicularis*	12	4
				3	1
Hymenoptera	Formicidae	21.3	*Phelidole megacephale*	26	8.7
Araneae		2.4		3	1

Table 2: Mean weekly frequency of adult arthropod on dead *Crycertomys gambianus*

Adult arthropod	**DAILY MEAN (days)**							
	2	7	14	21	28	35	42	49
Chrysomyia sp.	0.7	3.7						
Lucilia sp.	2.3	3.0						
Musca sp.	2.0	4.0	30	2.70	1.7			
Hydrotaea sp.		3.0	40	1.5				
Sarcophaga sp.		2.5						
Fannia sp.		0.3						
Phaidole sp.		1.7	2.0	4.0	3.7	3.0	3.7	1.7
Necrobia sp.		1.0	1.7	2.3	3.7	4.3	3.3	1.5
Rhizopertha sp.			1.5	.7	1.7	1.3	0.7	
Dermestes sp.			0.7	1.5	2.0	4.0	4.0	0.3
Necrophorus sp.					2.3			
Araneae					1.0			
Trogidae				1.0	1.6	2.7	0.7	0.7

Necrobia rufipes (Order:Coleoptera and family: Cleridae) was actually the 1st identified coleopteran and present also from Day 7 to the end of the experiment.

Hydrotaea (carrion fly) was observed on the 7th dat after the end exhumation.

Dermestes maculates was observed on the 14th day after exhumation and it was still present after exhumation on the 49th day, although with the least frequency.

Trox sceber was the last Coleopteran observed on the carrion, which was already dried up by this time. It occurred on the 35th day that the 6th process of exhumation.

The Coleopterans had the highest percentage species composition observed adults and larvae bred in the culture medium (40.65%), closely followed by the Dipteran (35.8%) (Table 1). Hymenoptera (21.13%) while Aranea had (2.4%) which had the least percentage (Table 1).

A total of 604 larvae and perpupae of cyclorrhaphous flies were collected from various body parts of the carrion of *Crycertomys gambianus* with the highest numbers recorded in the experiment (December-March) when average temperature was 34.5°C and least frequency during the (August-October) experiment with average temperature of 24.5°C (Table 3).

Table 3: Mean number of pre-adult cyclorrhaphous flies from various body parts of dead *Crycertomys gambianus* in 14 day period during the dry season.

Day	Stage	Head	Abdomen	Limbs	Tails	Total
2	Egg	14.3(50)	22.7(18)	7.2(15)	1.3(6)	45.706
7	L_3 Larvae	11.7(32)	14.595	8.35	3.06	37.713
14	Pre-pupae	8.3(52)	12.7(57)	6.436	2.7(15)	30.262

A total of 367 adult Cyclorraphous flies were reared successfully in the laboratory (Table 3).

Eggs rafts were collected from different body parts, but it was observed that the highest frequency of oviposition was noticed in the eyes, nostrils and mouth, which are natural body openings.

The larvae stages were also collected from the body parts of the carrion head, limbs, tail and abdomen. Subscribing to the two-way analysis of variance (ANOVA), it was observed that at $F = 0.01$, the larvae collected from the different parts of the carrion, there was a significant different in the number of larvae collected from the abdominal region. Using the Kolmogorov Simirnov one-way sample test, there was significant difference between the calculated value and the tabulated value ($0.336>0.136$, $P<0.05$), thus from the available statistical data, we conclude that more larvae is normally found in the abdominal region of carrion in the absence of external injuring.

Discussion

Species of *Calliphora* and *Lucilia* of the family of Calliphoridae and order Diptera were observed to be primary colonizers of the carrion of *Crycertomys gambianus* since they were the first to visit the carrion. *Calliphora* sp development is favoured more by shady condition, lower temperature Zumpt (1965). Species of *Chrysomyia* the family Sarcophaidae and Muscidae followed next in the secondary phase hence are termed secondary species or colonizers. Primary species i.e. *Calliphora* also predating on other larvae. The family Formicidae and Demestidae are amongst the tertiary species.

The presence of fluid in the abdominal region was responsible for the highest frequency of the dipterous larvae, corroborating the works of Hall (1948); Zumpt (1965).

Table 4: Percentage emergence of pre-adult *Cyclorrhaphous* flies recorded in the laboratory.

Month	**Survival**	**Confined**	***Chrysmoyia***	***sp***	***Lucilia***	***sp***	***Sarco***	***phagae***	***Calli***	***phora***	***Musca***	***sp***	**Fannia**	**sp**
	No	No	No	%	No	%	No	%	No	%	No	%	No	%
Dec/Mar	147	205	74	50.4	49	33.3	12	8.6	4	2.4	6	4.1	2	1.2
May/Jul	131	201	64	48.9	42	32.2	12	9.2	3	2.3	7	5.2	3	2.3
Aug/Oct.	89	198	45	51.7	30	33.7	8	9.0	2	2.2	3	3.4	0	1
Total	367	604	184	50.3	121	33.0	30	8.9	9	2.3	16	4.2	5	1.7

The presence of *Phidole megacephala* naturally in the environment and the act that they fed actively on all stages of carrion decomposition. Tantawi *et al* (1996), justify their numerical dominance as the arthropod species on the carcass.

As putrefaction developed, more groups of arthropods arrived on the carrion, with most presence just before the carcass dry out because of the seepage of fluid.

Necrobia rufipes was observed during the 2nd process of exhumation and it was the first coleopteran species observed. Blackburn (1990) observed that aecrophagous beetles thrives in environments that the favourable hence the reason for a low frequency. Some necrophagous are predaceous but this still very controversial. Baraack (1987).

Dermestes maculatus was observed at the later part of the experiment during the 4th exhumation the (21st day) when the carcass proceeded to the dry stage according to Fuller (1934), Payne (1965), the reason is that beetles specialize on bones and therefore must wait until the bones are exposed, hence their delay in arrival, particularly, in the (August to October experiment with temperature of 24.5°C when the decay process was slowest. Some predatory rove beetles or parasites that feed on maggots will have to wait until the blow flies arrive and lay their eggs hence their delay in arrival, this observation was however corroborated by Tantawi *et al*., (1996).

The larvae of *Dermestes maculatus* feed on bones of dry animal, Hinton (1945), hence justifying the reason for the observation of only the larva form of this beetles.

Necrophorous species were observed only during the 4th exhumation (i.e. the 21st day), very few of them were observed. Easton (1968) reports that *Necrophorus* species are well known for their habit of undertaking small carcasses and have a good sense of smell, hence the reason for their invasion of the carcass.

Trox scaber was the last observed coleopteran. It was observed on the 28th and 35th day in the first two experiments and on the 35th and 42nd day after exhumation on the 3rd experiment, which was observed to have the highest frequency.

The decay process was faster in the first two experiments, which had an average temperature of 32.5°C at depth of burial and also with the lowest growth of bacterial in the cultures of carrion. The reason is that immediately after death, succession of micro-organism are favoured by higher temperature and until this happens, certain arthropod species cannot act on the carrion hence being responsible for the process of faster decay recorded in the first two experiments. Hence the possibility of identification of carrion after a particular time is greater in the raining season than in the dry season when a daily temperature is at its peak.

Conclusion

In conclusion, it has been observed that the feature with arthropods that are not important in medicolegal forensic entomology is that they are important carrion feeders, thus performing a valuable recycling of organic matter in our ecosystem. Medicolegal forensic entomology includes arthropod involvement in events such as murder, rape, contraband and trafficking is indispensable in establishing proofs in such event and therefore cannot be over-emphasized. Succession data can be incorporated in a data bank and when the forensic entomologist investigates a case, he can use the taxa found on the body as input and get an estimate of the time of death.

This present study has further established and verified the carrion fauna characteristic in the tropical rain forest, successional pattern and larval development stages of carrion fauna and micro-organism counts in both raining and dry season in our tropical environment.

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