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DRY SEASON STUDY OF NECROPHAGOUS INSECTS ASSOCIATED WITH *CAVIA PORCELLUS* (GUINEA PIG) CARCASS IN KADUNA, NIGERIA

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A B S T R A C T

Necrophagous insects associated with decomposing carcass of *Cavia porcellus* were studied during the dry season in Kaduna, Nigeria. The carcass was placed inside a steel cage (81 x 53 x 45 cm) to prevent larger animals and birds from scavenging but allowing insects to have access. The cage was removed to expose the carcass and allow for recording of the progress of decomposition, collection of immature stages, taking of photographs and collection of adult insects. Sampling of adult insects was conducted with sweep nets above and around the carcass to assess species occurrence and abundance. Four decomposition stages were identified comprising fresh, bloat, decay and dry decay stages. The fresh stage lasted only one day beginning soon after the carcass was killed. The bloat stage was observed from day 2 till day 5 post killing. The decay stage commenced on day 6 when the carcass ruptured and lasted till day 9. The bulk of the biomass was removed during the decay stage as a result of the maggot feeding. Dry decay stage began about day 10 when the carcass started showing signs of dryness and continued until day 16 when the experiment was terminated. Three insect orders were encountered namely: Diptera, Coleoptera and Hymenoptera belonging to seven families and twenty one species. The order Coleoptera comprised three families and four species, with Hister beetle being the first to arrive during the bloat stage on day 2 and remained through the decay and dry decay stages of decomposition. No arthropod was recorded during the dry decay stage except one species each of Hister beetle and *Messogalla* ant. Species of *Pheidole* and *Messorgalla* ants (Hymenoptera) were the only species seen during the brief fresh stage but two other species of ants (*Camponotus* sp and *Crematogaster* sp.) were recorded during the bloat stage. On the whole, diptera had the highest prevalence accounting for 75% of the total collection. The Calliphorids were represented by three species, the Sarcophagids by five species and Muscidae by three species. The abundance of the seven families of arthropods occurred in the order:
Muscidae>Sarcophagidae>Calliphoridae>Formicidae>Histeridae> Curculionidae and Caracidae. The insects that emerged from the laboratory - reared immatures were all dipterans from the families Sarcophagidae (*Sarcophaga exuberans and Sarcophaga villa*) and Calliphoridae (*Hemipyrellia fernandica, Phaenicia (L) sericata* and *L. infernalis*).

Keywords: Dry season, Necrophagous insects, decomposition stages, Kaduna, Nigeria.

INTRODUCTION

Succession in forensic entomology refers to the predictable colonization of entomofauna on a cadaver. The faunal organisms which could be insects or other arthropods provide useful information on the diversity of the species, number of each species and their life stages. The composition of the arthropods not only serves as an indicator of the stage of decomposition of the cadaver (Megnin, 1894 and Reed, 1958) but also useful in estimating Post Mortem Interval (PMI), just like the succession patterns of the insects (Keh, 1985). Despite the usefulness of succession of insects on a cadaver in estimation of PMI (Tabor *et al*., 2004) cautioned that not all the insects are useful indicators as some of them are only opportunistic visitors, collected only by chance. Species composition of insects that visit a cadaver vary according to the geographical region and season (Arnaldos *et al*., 2001; Carvalho and Linhares, 2001) and the information obtained from one particular area may not necessarily be useful in determining PMI in another area. The pattern of arthropod succession on a cadaver has been documented for most areas of the temperate regions (Early and Goff, 1986; Amendt *et al*.,

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2000) but there is paucity of such information for African region, particularly Nigeria. Currently, there are no published animal carrion/human corpse arthropod successional studies for Kaduna, Nigeria despite the fact that the area is rich with different insect fauna. It is therefore important to have baseline information on the forensic entomofauna for the area. The environment and location-specific nature of insects of forensic importance (Anderson and VanLaerhoven, 1996) make this study imperative. This study is aimed at identifying the major insect taxa of forensic importance visiting *Cavia porcellus* carcass in Kaduna town, Northern Nigeria and analyzing their succession patterns.

MATERIAL AND METHODS

Study area: The study was conducted within the Zoological garden of Kaduna State University, (10°31`N, 007°26`E) in Kaduna State, northern Nigeria in January 2016 corresponding to the mid dry season. Details of the study area have already been described (Ahmed and Samson, 2016).

Experimental animal: *Cavia porcellus* (Guinea pig) was killed on 9TH January, 2016 by cutting its throat and severing the main blood vessels with a sharp knife and allowed to bleed. The carcass was placed inside a steel cage measuring 81 x 53 x 45 cm to prevent larger animals and birds from scavenging the remains but which allowed insects to enter (Figure 1). The cage and carcass were exposed in full sunlight conditions at ambient conditions and allowed to decompose.

Figure 1. The steel cage to shield carcass from scavengers.

Data Collection: The wire cage was removed daily to expose the carcass and allow for recording of the progress of decomposition, collection of immature stages, taking of photographs and collection of adult insects. Sampling of adult insects was conducted with sweep nets above and around the carcass to assess species occurrence and abundance. The steel cage was placed back over the carcass after daily observations. The collected immature stages of insects were reared on fresh beef meat in the laboratory until eclosion of the adults. Both the insects collected as adult as well as those that emerged from immature stages reared in the laboratory were sorted into morpho-species and sent to the insect museum of Institute for Agricultural Research, Ahmadu Bello University Zaria for identification to species levels using taxonomic keys that described physical characteristics of the insect such as wing vein pattern, stem-vein, hairs on lower calypter, colour of anterior spiracles, surface of genital dilation and postgena focus, antennal segments, leg spurs, and spines, palps and other physical features. From day one until day nine of the study, the carcass was observed twice daily (10.00hrs and 15.00hrs), covering most of the diurnal activity period of insects and thereby increasing chances of finding them. But when decomposition had slowed and insect activities had decreased during the post-decay stage, and only one Coleopteran and one Hymenopteran were recorded, observations were reduced to once daily at 12.00 noon when the temperature is high and activities of most insects is at highest peak.

RESULTS

Decomposition stages: Four decomposition stages were identified comprising fresh, bloated, decay and dry decay stages (Figure 2 a, b, c, d). The fresh stage lasted only one day beginning soon after the carcass was killed. The Bloat stage was observed from day 2 till day 5 post killing. At this time, the carcass began to smell and generate offensive odour and ended when the swollen body deflated. Bloating stage was characterized by production of gases due to metabolic activity of anaerobic bacteria, causing the abdomen to inflate. The decay stage commenced on day 6 when the carcass ruptured and lasted till day 9. During this stage, there skin was broken and the swollen abdomen became deflated. The bulk of the biomass was removed during this stage as a result of the maggot feeding. The end of the decay stage was marked by the dipteran larvae

migrating away from the carcass after feeding to find suitable areas to pupate. Dry decay stage began about day 10 when the carcass started showing signs of dryness and continued until day 16 when the experiment was terminated (Table 1). By this time there was very little physical change in the carcass and insect activity was minimal, with much of the flesh removed and the carcass consisted mostly of dry skin, hairs and bones. Fig. 3 shows the remains of the carcass after three months.

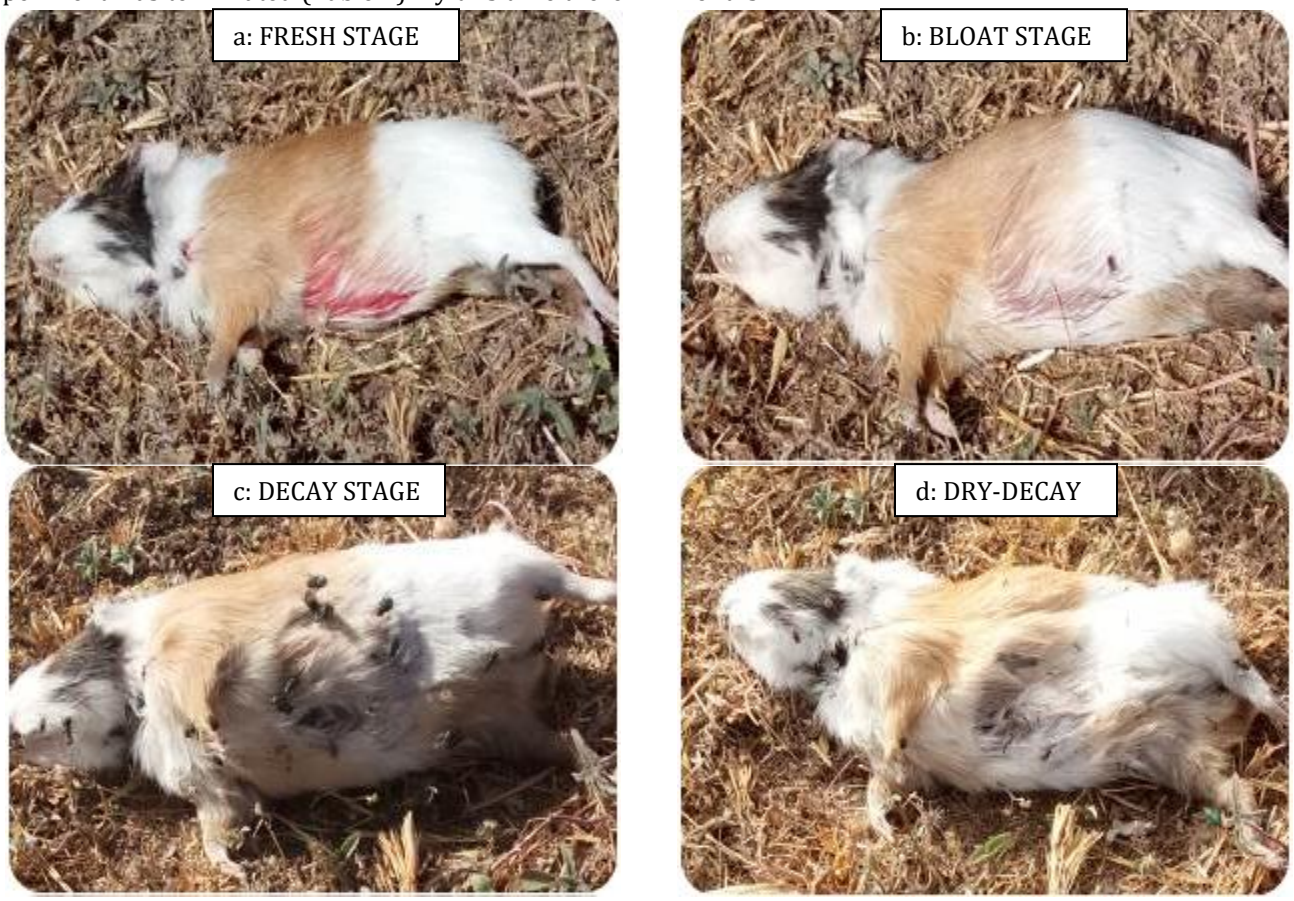

Figure 2. Decomposition stages of *Cavia porcellus* in Kaduna, Nigeria.

Figure 3. The condition of *Cavia porcellus* carcass 3 months later.

Table 1. Decomposition process and insect activity on guinea pig carcass.

Day	Observations
FRESH STAGE (9th January, 2016) DAY 1	i. Caderva still fresh ii. No flies seen iii. Foaming in the mouth iv. Some ants species seen on the foamy site v. Livor mortis
BLOATED STAGE (10th – 13th January, 2016) DAYS 2-5	i. Bloating abdomen with green discoloration ii. Some flies seen on the cut throat, eyes, mouth and nostril iii. Some pungent offensive odour of putrefaction and disintegration of carcasses iv. Livor mortis v. Rigor mortis
DECAY STAGE (14th – 17th January, 2016) DAYS 6-9	i. Broken skin ii. Rupture of abdomen and release of gases iii. Stronger pungent offensive odour of putrefaction and disintegration of carcasses iv. Multiple flies seen v. Extensive maggot activity inside mouth and slit throat vi. Maggots seen under the body vii. Caving of the abdomen viii. Some migrating larvae seen ix. Rigor mortis
DRY DECAY STAGE (18th – 24th January, 2016) DAYS 10-16	i. Few maggots present ii. Diminished putrefaction odour iii. Few beetles seen iv. Most of the flesh removed from carcass

Arthropod collected: Three insect orders encountered during the decomposition process namely Diptera, Coleoptera and Hymenoptera represented by seven families and twenty one species are presented in Table 2. Three families and four species of beetles (Coleoptera) were observed during the entire study. Of the four species, the Hister beetle was the first to arrive during the bloat stage on day 2 and remained through the decay and dry decay stages of decomposition while the other three species were recorded during the decay stage. No arthropod was recorded during the dry decay stage except one species each of Hister beetle and *Messogalla* ant (Table 2). The *Pheidole* and *Messorgalla* sp of ants (Hymenoptera) were the only species seen during the brief fresh stage, with *Pheidole* sp increasing in abundance during the bloat stage. Two other species of ants (*Camponotus* sp. and *Crematogaster* sp.) were recorded during the bloat stage. On the whole, diptera had the highest prevalence accounting for 75% of the total collection: Calliphorids and Muscids had three species each while Sarcophagids had five species. In terms of abundance, seven families of arthropods occurred in order: Muscidae>Sarcophagidae> Calliphoridae>Formicidae>Histeridae> Curculionidae and Caracidae. Insects that emerged from the immature stages reared in the laboratory were all dipterans from the families Sarcophagidae (*Sarcophaga exuberans and Sarcophaga villa*) and Calliphoridae (*Hemipyrelli fernandica, Phaenicia (L) sericata* and *L. infernalis)* (Table 2).

Table 2. Succession and abundance of insects on decomposing guinea pig carcass, 9th – 16th January, 2016.

Order	Family	Genus and species	Fresh 1d	Bloat 2 - 5d	Decay 6 – 9xd	Dry decay 10 -16d	Total
Diptera	Calliphoridae	*Chrysomyia regalis*	0	7	0	0	7
		C. chlorophyga	0	2	0	0	2
		C. albiceps	0	20	4	0	24
		Phaenecia (L) sericata	0	0	1	0	1
		Lucillia infernalis	0	0	1	0	1
	Sarcophagidae	*Sarcophaga exuberans*	0	3	1	0	4
		Sarcophaga villa	0	1	0	0	1
		Sarcophaga cruentata	0	2	0	0	2
		Rhinia apicalis	0	4	0	0	4
		Hemipyrellia fernandica	0	15	0	0	15
	Muscidae	*Musca domestica*	0	36	0	0	36
		M. sorbens	0	1	0	0	1
		Morellia prolectata	0	1	0	0	1
Coleoptera	Histeridae	*Hister* sp.	0	1	1	1	3
	Histeridae	*Hypocacculus buqueti*	0	0	1	0	1
	Curculionidae	*Ischnotrachelus* sp.	0	0	2	0	2
	Caracidae	*Hyparpalus* sp.	0	0	1	0	1
Hymenoptera	Formicidae	*Pheidole* sp.	2	13	0	0	15
		Messorgalla	5	0	0	1	6
		Camponotus sp.	0	1	0	0	1
		Crematogaster sp.	0	4	0	0	4

The number of taxa present during each sampling interval and the abundance of each taxon during each of the study periods are presented in Fig. 4. The trend show a gradual increase in both number of taxon and abundance, with highest peak observed during the bloat stage and decreas es ther eafter.

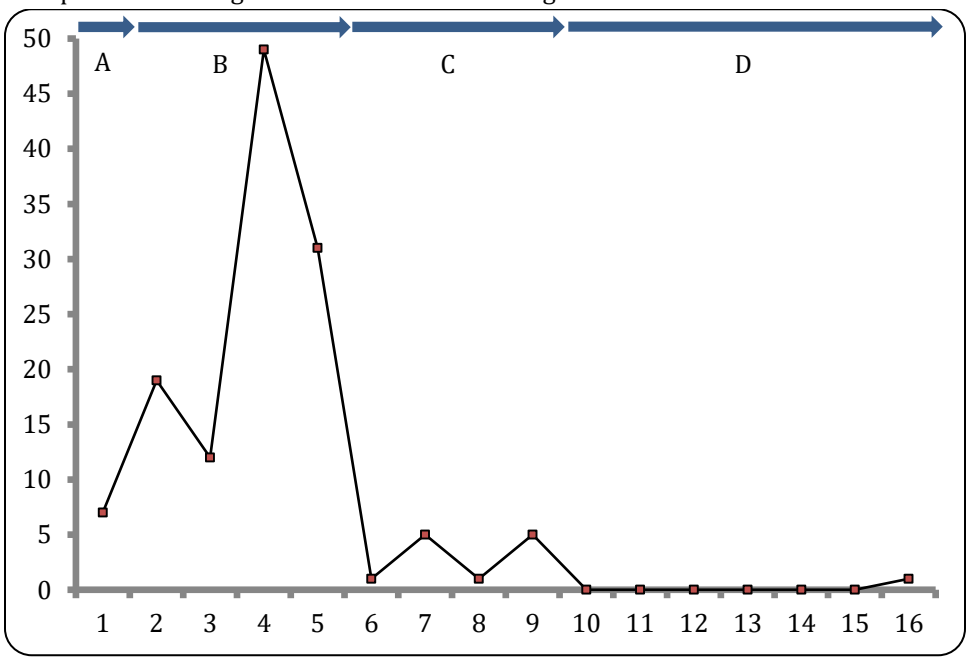

Figure. 4.The number of taxa during each sampling interval during the succession studies. (Decomposition stages are shown above the graph: A=fresh, B=bloat, C=decay, D=dry decay).

DISCUSSION

Although decomposition is a continuous process, it is customary to present results of investigations in series of stages, starting with the point of death and ending when the body has been reduced to bones (Amendt *et al*., 2010). The reported number of carrion decomposition stages varies from one (Cornaby, 1974; Blackith and Blackith, 1990) to as many as nine, depending on the author and geographical region (Megnin, 1894 and Goff, 1993). During the present study, four stages of decomposition were observed, similar to the observations of (Abajue *et al*., 2013) at Okija, Anambra State and (Ndueze *et al*., 2013) in Port Harcourt, southern Nigeria. The arthropods that arrive on a carcass from the beginning of decomposition are the Calliphoridae, Sarcophagidae and Muscidae (Abajue *et al*., 2013; Ndueze *et al*., 2013; Hall, 2001 and Mabika *et al*., 2014). This was confirmed in the present study as eighty-seven percent of the Calliphorids and Sarcophagids were collected during the bloat and decay stages, given the distribution a horseshoe-shaped arch pattern described by Schoenly (Schoenly, 1992) and made possible by the attractiveness of the carcass to a wider range of taxa during these two stages (Hall, 2001; Watson and Carlton, 2003). Both (Ndueze *et al*., 2013 and Mabika *et al*., 2014) considered members of the Sarcophagidae as secondary colonizers during decomposition process, a situation confirmed in the present study. However, our result is not in total agreement with (Shi *et al*., 2009) who described Sarcophagids more as primary colonizers in the warm tropics.

The recorded duration of carcass decomposition of 16 days in this study followed a similar pattern with the observations of (Ndueze *et al.,* 2013) for the giant cane rat, who also recorded much longer decomposition duration lasting more than 50 days with larger animal species. The similarity between our results could possibly be due to the comparative sizes of guinea pig and giant rat (Kuusela and Hanski, 1982; Greenberg, 1991). Several reports have attributed the attractiveness of a carcass to be a function of its size (Nuorteva *et al*., 1959; Davies, 1990 and Erzinclioglu, 1996). This means the speed of decomposition is correlated to the number of feeding maggots on the carcass. No fly was recorded during the dry decay stage of decomposition, except one Hister beetle (Coleoptera) that is usually associated with such dry stages and one ant species. Beetles are generally considered to be common during dry decay stage of decomposition (Mabika *et al*., 2014). Their abundance in the present study, mainly in the bloat and decay stages of decomposition agrees with the findings of Rodriguez and Bass (Rodriguez and Bass, 1983) and (Tabor *et al*., 2004). Their presence in early decomposition stages as observed in this study might have prompted (VanLaerhoven and Anderson, 1999) to conclude that such might be a reflection of peak of their activity rather than the state of decomposition of the carcass. They were recovered from day-3 into decomposition (except the fresh stage), though in very low numbers (Table 2), confirming previous observations (Early and Goff, 1986; Abajue *et al*., 2013 and Mabika *et al*., 2014).

Beetles from the families Silphidae, Trogidae, Dermestidae and Cleridae recorded elsewhere in Nigeria were not seen in Kaduna. It is possible that members of these families exhibit regional diversity and occur less frequently in Kaduna than the other families or their absence could be attributed to the short duration of this study compared to the other reports. Generally, beetles appear to be rare taxa with only one or two individuals taken at a time. Hymenopterans were recorded mainly from the fresh and bloat stages, with one individual taken in the dry decay stage, confirming previous reports that recorded their presence throughout the decomposition process (Abajue *et al*., 2013; Mabika *et al*., 2014 and Chen *et al*., 2014).

The individuals of *Messorgalla* and *Pheidole* spp collected during the fresh decomposition process were feeding on body fluids of the carcass through the eyes and slaughtered area of the neck. Some members of the family were also seen engaged in asymmetrical interguild predation on insect larvae during the decay stage, agreeing with (Morreti *et al*., 2013) that they are important component of the community wherever they occur. (Grassberger *et al*., 2003) observed that interguild predation of immature stages by ants can affect the abundance of each species present, which will in turn affect the course of succession, but (Villet, 2011) noted that such ecological interactions are not common in African carrion communities. (Chen *et al*., 2014) reported that ants are not significant indicators for faunal succession but in forensic entomology, they can act as geographical indicators for different ecological habitats. (Mabika *et al*., 2014) opined that ants do not have any impact on the decomposition process while (Ewuim and Abajue, 2016) consider them as ecosystem engineers that offer services at the decomposition site. The most

abundant dipteran species observed in this study are *M. domestica* that were collected as adults from the carcass, suggesting that they only visited the scene to feed and not to breed. Similar observation was made by (Mabika *et al*., 2014) in Zimbabwe. However two members of Calliphoridae (*P. (L) sericata* and *L. infernalis)* and three members of the Sarcophagidae (*S. exubrans, S. villa* and *H. fernandica*) collected both as adults from the carcass and as immature stages that later emerged in the laboratory, could be important forensic indicators for Kaduna area. The same two species have been collected from this area during a recent area wide entomological survey (Ahmed and Samson, 2016). Review of the literature on catches of blowflies and flesh flies in Nigeria between 2003-2013 (Abajue *et al*., 2013; Ndueze *et al*., 2013; Ekanem and Umoetuk, 2009; Ekrakene and Iloba, 2011; Arimoro, 2013 and Abajue, 2014) suggest that some species like *S. regalis, C. infernalis, S. villa*, *S. cruentata* and *Rhinia apicalis* encountered in the present study appears to have a restricted spatial distribution confined to northern Nigeria. The number of taxa present during each sampling interval and the number of occurrences of each taxon during each of the study periods shows that the attractiveness of the carcass to specific taxa changes during decomposition giving the horseshoe-shaped arch pattern of succession described by Schoenly (Schoenly, 1992). This observation supports earlier reports (Hall, 2001; Watson and Carlton, 2003) that carcasses are more attractive to a wider range of taxa during the bloat and decay stages of decomposition, than in the fresh and dry stages. It is concluded that the succession of arthropods at the family level especially Calliphoridae, Sarcophagidae and the order Coleoptera was similar to insect succession studies in Nigeria and other geographical regions (Ndueze *et al*., 2013; Rodriguez and Bass, 1983; Anderson, 2001). Cognizant of the fact that succession pattern of insect species can differ at different seasons even at the same site, and can also remain unchanged in some cases, further investigation is underway for the wet season survey toward developing a comprehensive data base for Kaduna area in northern Nigeria.

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