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Succession Patterns and Diversity of Arthropods Associated with Decomposing Domestic Rabbit (*Oryctolagus cuniculus* L, 1758) in Different Habitats

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Abstract Succession patterns of arthropods associated with decomposing domestic rabbit (*Oryctolagus cuniculus* Linnaeus, 1758) were investigated in exposed and sheltered habitats, located at 4^{o} 53'41.680 "N, 6^{o} 54'39.127 "E and 4^{o} 54'19.83"N, 6^{o}55'17.36"E respectively, University of Port Harcourt, Nigeria. The decomposition of the six domestic rabbits was observed during the onset of the wet season (1st March – 30th April 2017) to identify forensically important insects attracted to them and determine temperatures and relative humidity influencing carrion decomposition. Five stages of decomposition: Fresh, bloated, active decay, advanced decay and dry remains stages were observed. The sequence of insect succession followed a distinct pattern: dipteran flies first colonized the rabbit carcasses and were succeeded by coleopterans. A total of 33 species of arthropods, in 23 families and 7 orders were collected. The insect families recorded were: Calliphoridae, Muscidae, Sarcophagidae, Histeridae, Piophilidae, Drosophilidae, Bostrichidae, Stratiomyidae, Staphylinidae, Tabanidae, Carabidae, Tenebrionidae, Scarabaedae, Cleridae, Formidae, Sphecidae, Curculionidae and Dermestidae. Three unidentified insect taxa in Lepidoptera, Orthoptera and Odonata were collected in the exposed habitat, while two unidentified species in the class Arachnida; a Macrocheles mite and a non-acarine were collected in both habitats. Based on frequency of occurrence and role of Calliphorids, *Chrysomya chloropyga* and *C.albiceps* were the most forensically significant insects. Temperature apparently accelerated the rate of decomposition although but there was no significant difference (p>5%) between the rates of decomposition of the carcasses in the two habitats.

Keywords Succession Patterns, Rabbit Carcass, Decomposition, Exposed, Sheltered

1. Introduction

Medico-legal forensic entomology is the involvement of certain necrophagous insects for unraveling activities (felonies, murder, suicide and rape) which are criminal components of the legal system (Okiwelu *et al.*,2008). It also seeks to interpret the events preceding various kinds of body injuries and mortalities involving arthropods pre-mortem and post-mortem intervals**.** Other than ecological interest, carrion decomposition and insect succession occurrence on carrion have been utilized and proven to be of utmost importance in forensic entomology (Mullen and Durden, 2009). The decomposition of carrion seeks to provide substantial information on nutrient cycling which is primarily carried out through the activities of bacteria, fungi and insects (Mondor *et al.,* 2012). However, soon after death there is a predictable manner in which insects become the primary colonizers of carrions or corpses that provide a biological clock to precisely determine the time elapsed since death (Resh and Carde, 2009).

Usua (2007) emphasized that forensic entomology in Nigeria is at its infancy, stimulating a call for participation and interest in the field of forensic entomology. Preliminary studies of arthropods associated with mammalian carcasses in Rivers state were conducted by Okiwelu *et al.* (2008) to create awareness on the application of forensic entomology in wildlife conservation to target poachers involved in indiscriminate slaughter of endangered species. Ndueze *et al.* (2015) reported on the period of colonization and succession patterns of arthropods associated with four wildlife carcasses in sheltered and exposed habitats. He provided baseline data for postmortem interval estimates of wildlife species. Ekrakene and Odo (2015), investigated insects associated with exposed rabbit carrions in Warri, Nigeria and found that insect species varied from geographical location to another. Therefore, research is relevant across eco-vegetational zones. The domestic rabbit *(Orytolagus cuniculus)* had been identified as a reliable model in decomposition studies (Ekrakene and Odo, 2015). Ekanem and Dike (2010) stated that forensic entomology is not well practiced in Nigeria due to the paucity of information. Ewuim and Abajue, (2016) reported that forensic science in Nigeria has not gained full recognition and acceptance in the judicial system, especially with respect to cases relating to unnatural deaths**.** There has been trending reports of suspicious deaths of domestic animals and humans around residential areas (Kyerematen *et al.,* 2013). Therefore, Studies were conducted to observe the succession patterns and diversity of arthropods on carcasses of the domestic rabbit *O. cuniculus* in exposed and sheltered habitats at the University of Port Harcourt, Rivers State, Nigeria. The purpose of this study is to provide baseline information on the different forensic insects associated with decomposing rabbit *O. cuniculus* in exposed and sheltered habitats. The findings from this study will be beneficial and can be extrapolated to aid legal investigation in the estimation of postmortem interval in unnatural deaths cases of animals and human in exposed and sheltered habitats.

2. Materials and Methods

3.1. Study Area

Studies on decomposing domestic rabbit (*O. cuniculus* Linnaeus, 1758) were conducted at the University of Port Harcourt, Choba, Port Harcourt, Nigeria in exposed and sheltered habitats at 4^o 53’41.680 "N, 6^o 54’ 39.127" E and 4^{o}53’19.83424 "N , 6^{o}55’ 17.35666 "E, respectively. Choba is in Obio/Akpor Local Government Area, Rivers State, Nigeria (4^o 45’N and 6^o 50’ E), approximately 20 km from the state capital, Port Harcourt. The exposed experimental site was on vegetation dominated by these plant species: *Manihot esculenta* (cassava), *Musa paradesica* (plantain), *Musa sapietum*(banana), *Xanthosomamafaffa* (cocoyam), *Synedrella nodiflora*, *Costus* sp, *Nephrolepis* sp, *Talinum triangulare*, *Commelina erecta*, *Peperomia pallucida*, *Cyathula prostrata*, *Albizia* sp, *Phyllanthus* sp, *Asystasia gangetica*, *Solenostemon monostaehyus*, *Gissus sp*, *Setaria barbata*. The sheltered habitat was a green-roofed house of dimensions; Length, width and Height (12.5) × (7.5) × (12.5m). Sheltered habitat was approximately 2km apart from the exposed habitat.

2.2. Carrion Placement

Six domesticated rabbits (*O. cuniculus* L) each, 1.0-1.8kg, were obtained from the rabbitry of the Faculty of Agriculture, Rivers State University, Port Harcourt, Nigeria. The rabbits were identified, based on the keys of Nagorsen (2002). Each rabbit was euthanized with chloroform for 15 minutes to prevent external bleeding and maintenance of body integrity (Tantawi *et al.*, 1996). The rabbits were placed singly in rectangular cages, 45 × 45 × 60cm and mesh size of 2 x 2cm. The three cages containing rabbit carrions were placed 10 metres apart at each of the site. Daily observations were made using the stages of decomposition criteria: fresh, bloated, active decay, advanced decay and dry remains (Anderson and VanLaerhoven, 1996; Kyerematen *et al.*, 2013).

2.3. Insect Collections/Procedures for Sampling Protocol

Insects were collected, 8:00-10.00 and 14.00-16:00 hours daily, using sweep net, forceps, hand-picking and camel hair brush. Climatic factors (sunlight, rainfall, relative humidity, ambient temperature, internal temperature and maggot mass temperature) that might affect the rate of carrion decomposition were also recorded. Temperature was recorded daily with the aid of a glass thermometer. This was followed by the collection of arthropod specimens on the carrion and its immediate surroundings. The approximate duration of collection of specimens on each carcass was 20 minutes to ensure minimum disturbance at each site; prior to collection, the carrion was photographed.

Examination began from the head region to the genital openings to check for eggs (Byrd and Castner, 2009). Eggs were extracted with the aid of a camel hair brush; half of them were preserved in 70% alcohol before transferring into another vial containing Kahle’s solution. The other half were placed in a container with beef liver to rear to the adult stage for easy identification. Fly larvae were collected from the carrion’s body in batches of 20- 30 per vial using forceps. Larvae collected were reared to adult stage with beef in vials covered with net mesh and adults identified after emergence. The adults were air-dried and put in 10 ml 70% alcohol in a 25 ml capacity capped specimen bottle. They were taken to Ahmadu Bello University Museum for identification. Pupae were also regularly collected from the decomposing rabbit carrion. Adult flies were collected using sweep net, while beetles were handpicked and placed singly in labeled containers. All adults were fixed in Kahle’s solution at the site of collection, taken to the Department of Animal and Environmental Biology laboratory, dried and mounted in the insect box and kept in the Insect Museum of the Department.

3. Results

3.1. Arthropod Identification on Carrions

The arthropods identified were in six insect orders: Diptera, Coleoptera, Hymenoptera, Lepidoptera, Orthoptera and Odonata, while the Arachnids comprised of acarines (mites) and araneids (spiders). A total of 33 species of arthropods, in 23 families and 7 orders were collected, including arachnids were recorded in this study (Table 1).

Table 1. Arthropods on Rabbit Carrions in Sheltered and Exposed Habitats

Order	Family	Species	Sheltered	Exposed
Diptera	Calliphoridae	*Chrysomya chloropyga*	+	+
		Chrysomya albiceps	+	+
		Rhycomyia aenea	+	-
	Sarcophagidae	*Sarcophaga*sp	+	+
	Muscidae	*Musca domestica*	+	+
	Drosophilidae	*Phortica* sp	+	+
	Stratiomyidae	*Hermetia illucens*	+	+
	Piophiidae	*Piophilia casei*	+	+
	Tabanidae	*Thaumastocera sp*	-	+
Coleoptera	Histeridae	*Teritriosoma* sp	+	+
	Staphylinidae	*Bledius incertus*	+	+
		Philonthus sp	+	+
	Scarabaeidae	*Apogonia nitidula*	+	+
		Hetronychus mosambicus	-	+
	Tenebrionidae	*Endustomus senegalensis*	-	+
		Zophosis quadrilineata	-	+
	Carabidae	Dichaetochilus vagans	-	+
		Tachyphanes sp	+	+
	Cleridae	*Necrobia rufipes*	+	+
	Dermestidae	*Dermestes frischii*	+	+
	Bostrichidae	*Rhizopertha dominica*	+	_
	Curculionidae	*Larinus haroldi*	+	-
Hymenoptera	Formicidae	*Dorylus affinis*	+	+
		Pheidole sp	+	+
		Mymicaria striata	+	+
		Camponotus sp	+	+
		Camponotus perrissi	+	+
	Sphecidae	*Larra* sp	-	+
Lepidoptera	Pyralidae	Pyralid moth	+	+
Orthoptera	Gyrillidae	Unidentified cricket	-	+
Odonata		Unidentified dragonfly	-	+
Arachnidae	Acarina	Macrocheles mite	+	+
	Araneidae	Unidentified spider	+	+

Keys: Present (+), Absent (-)

3.2. Abundance of Arthropods on Rabbit Carrions at Exposed and Sheltered Habitats

A total of 983 and 1346 adult arthropods were collected in the sheltered and exposed habitats respectively. A total of 33 species of arthropods, in 23 families and 7 orders were collected; arachnids were also recorded (Table 2). Diptera, Coleoptera and Hymenoptera represented 68%, 7%, 18.8% and 32%, 10%, 43.5% in sheltered and exposed habitats respectively.

The abundance of arthropods in the exposed habitat had the higher diversity of 1.866 when compared to sheltered diversity index of 1.631; the diversity indices were significantly different (p<5%) using Shannon Wiener Index (Past software, version 3.14).

Table 2. Abundance of adult insects associated with rabbit carrions during study period

Order	Family	Sheltered	Exposed
Diptera	Calliphoridae	446	205
	Sarcophagidae	8	27
	Muscidae	198	125
	Drosophilidae	8	7
	Stratiomyiadae	2	10
	Piophilidae	37	57
	Tabanidae	0	1
Coleoptera	Histeridae	25	53
	Staphylinidae	22	42
	Scarabaeidae	4	10
	Tenebrionidae	3	11
	Carabidae	3	10
	Cleridae	2	6
	Dermestidae	3	15
	Bostrichidae	5	-
	Curculionidae	1	-
Hymenoptera	Formicidae	185	585
	Sphecidae	-	1
Lepidoptera	Pyralidae	2	5
Orthoptera	Gyrilidae	-	3
Odonata		-	1
Arachnidae	Acarinae	25	75
	Arachnidae	4	7
Total		**983**	**1346**

3.3. Insect Succession

The patterns of the successions of arthropods in sheltered and exposed habitats are in Tables 3 and 4 respectively.

Table 3. Succession of Arthropods on Rabbit Carrions at Sheltered Habitat

Decomposition Stage	Order	Family	Species	Developmental Stages
Fresh	Diptera	Calliphoridae	*Chrysomya chloropyga* *Chrysomya albiceps*	A ,L,E A,L E
		Sarcophagidae	*Sarcophaga* sp	A,L
		Muscidae	*Musca domestica*	A
		Drosophilidae	*Phortica* sp	A,L,E
	Hymenoptera	Formicidae	*Pheidole* sp	A
			Dorylus affinis	A
Bloated	Diptera	Calliphoridae	*Chrysomyia chloropyga*	A,L,E
			Chrysomyia albiceps	A,L,E
		Muscidae	*Musca domestica*	A,L,E
		Sarcophagidae	*Sarcophaga* sp	A,L
	Coleoptera	Histeridae	*Teretriosoma* sp	A
		Staphylinidae	*Bledius incertus*	A
			Philonthus sp	A

	Hymenoptera	Formicidae	*Pheidole* sp	A
			Myrmicaria striata	A
			Dorylus affinis	A
Active Decay	Diptera	Calliphoridae	*Chrysomyia chloropyga*	A,L,E
			Chrysomyia albiceps	A,L,E
			Rhyncomya aenea	A,L,E
		Sarcophagidae	*Sarcophaga sp*	A,L
		Muscidae	*Musca domestica*	A
		Stratiomyidae	*Hermetia illucens*	A
	Coleoptera	Histeridae	*Teretriosoma* sp	A
			Philonthus sp	A
		Scarabaeidae	*Heteronychus mosambicus*	A
		Curculionidae	*Larinus haroldi*	A
	Hymenoptera	Formicidae	*Pheidole sp*	A
			Myrmicaria striata	A
			Dorylus affinis	A
Advanced Decay	Diptera	Calliphoridae	*Chrysomyia chloropyga*	A,L,E
			Chysomyia albiceps	A,L,E
			Rhyncomya aenea	A,L,E
		Sarcophagidae	*Sarcophaga* sp	A,L
		Stratiomyidae	*Hermetia illucens*	A
		Drosophilidae	*Phortica* sp	A
	Coleoptera	Histeridae	*Teretriosoma* sp	A
		Staphylinidae	*Bledius incertus*	A
			Philonthus sp	A
		Carabidae	*Tachyphanes* sp	A
		Bostrichidae	*Rhizopertha dominica*	A
		Tenebrionidae	*Zophosis quadrilineata*	A
		Scarabaeidae	*Apogonia nitidula*	A
		Dermestidae	*Dermestes frischii*	A,L
	Hymenoptera	Formicidae	*Pheidole* sp	A
			Dorylus affinis	A
			Myrmicaria striata	A
			Camponotus maculatus	A
			Camponotus perrisi	A
Dry Remains	Diptera	Muscidae	*Musca domestica*	A,L
		Piophilidae	*Piophilia casei*	A
	Coleoptera	Histeridae	*Teretriosoma* sp	A
		Staphylinidae	*Bledius incertus*	A
			Philonthus sp	A
		Dermestidae	*Dermestes frischii*	A,L
		Cleridae	*Necrobia rufipes*	A
		Bostrichidae	*Rhizopertha dominica*	A
		Carabidae	*Tachyphanes* sp	A
		Scarabaeidae	*Apogonia nitidula*	A
	Hymenoptera	Formicidae	*Pheidole* sp	A
			Dorylus affinis	A
			Myrmicaria striata	A
			Camponotus maculatus	A
			Camponotus perrisi	A
	Lepidoptera	Pyralidae	Pyralid moth	A
	Acarina	Acarinae	Macrochelus mite	A

Keys: Adult (A), Pupa (P), Larva (L)

Table 4. Succession of Arthropods on Rabbit Carrions at Exposed Habitat

Decomposition Stage	Order	Family	Species	Developmental Stages
Fresh	Diptera	Calliphoridae	*Chrysomyia chloropyga*	A,L,E
			Chrysomyia albiceps	A,L,E
		Sarcophagidae	*Sarcophaga* sp	A,L
		Muscidae	*Musca domestica*	A
		Drosophilidae	*Phortica* sp	A,L,E
	Hymenoptera	Formicidae	*Pheidole* sp	A
			Dorylus affinis	A
			Myrmicaria striata	A
Bloat	Diptera	Calliphoridae	*Chrysomyia chloropyga*	A,L,E
			Chrysomyia albiceps	A,L,E
		Sarcophagidae	*Sarcophaga* sp	A,L
		Muscidae	*Musca domestica*	A
		Drosophilidae	*Phortica* sp	A,L,E
	Coleoptera	Histeridae	*Teritriosoma* sp	A
		Staphylinidae	*Bledius incertus*	A
			Philonthus sp	A
	Hymenoptera	Formicidae	*Pheidole* sp	A
			Dorylus affinis	A
			Myrmicaria striata	A
Active Decay	Diptera	Calliphoridae	*Chrysomyia chloropyga*	A,L,E
			Chrysomyia albiceps	A,L,E
		Sarcophagidae	*Sarcophaga* sp	A,L,E
		Muscidae	*Musca domestica*	A,L,E
		Stratiomyidae	*Hermetia illucens*	A,P
	Coleoptera	Histeridae	*Teretriosoma* sp	A
		Staphylinidae	*Bledius incertus*	A
			Philonthus sp	A
	Hymenoptera		*Pheidole* sp	A
			Dorylus affinis	A
			Myrmicaria striata	A
			Camponotus sp	A
Advanced Decay	Diptera	Calliphoridae	*Chrysomyia chloropyga*	A,P,L
			Chloropyga albiceps	A,P,L
		Muscidae	*Musca domestica*	A,L
		Stratiomyidae	*Hermetia illucens*	A,P
	Coleoptera	Histeridae	*Teretriosoma* sp	A
			Peranus sp	A
		Staphylinidae	*Bledius incertus*	A
			Philonthus sp	A
		Cleridae	*Necrobia rufipies*	A
		Dermestidae	*Dermestes frischii*	A,L
		Tenebrionidae	*Zophosis quadrilineata*	A
			Endustomus senegalensis	A
		Carabidae	*Dichaetochilus vagans*	A
			Tachyphanes sp	A
		Scarabaeidae	*Hetronychus mosambicus*	A
			Apogonia nitidula	A
	Hymenoptera	Formicidae	*Pheidole* sp	A
			Dorylus affinis	A

			Myrmicaria striata	A
			Camponotus sp	A
			Camponotus maculatus	A
			Campnotus perrisi	A
		Sphecidae	*Larra* sp	A
Dry Remains	Diptera	Muscidae	*Musca domestica*	A
		Piophilidae	*Piophilia casei*	A
	Coleoptera	Histeridae	*Teritriosoma* sp	A
		Staphylinidae	*Bledius incertus*	A
			Philonthus sp	A
		Dermestidae	*Dermestes frischii*	A,L
		Cleridae	*Necrobia rufipies*	A
		Carabidae	*Tachyphanes* sp	A
	Hymenoptera	Formicidae	*Pheidole sp*	A
			Dorylus affinis	A
			Myrmicaria striata	A
			Camponotus sp	A
			Camponotus maculatus	A
			Camponotus perrisi	A
	Lepidoptera	Pyralidae	Pyralid moth	A
	Orthoptera	Gyrillidae	Cricket	A
	Odonata		Unidentified dragonfly	A
	Arachnidae	Acarinae	Unidentified spider	A
			Macrocheles mite	A

Keys: Adult (A), Pupa (P) and Larva (L) and Egg (E)

Table 5. Characteristics of decomposition stages, post-mortem interval (Days) and prevailing temperatures in sheltered habitat

Stage	**Characteristics of Stages**	**Post-Mortem Interval (Days)**	**Temperatures (^{o} C)**			
			Ambient temp (range)	Ambient temp (mean)	Internal temp (range)	Internal temp mean
Fresh	No gross morphological changes, odour and sign of decomposition.	0-2	28-31	29.80	30-32	28.95
Bloated	Distention of abdominal wall into a balloon-like appearance, discolouration, maggots developing in body orifices and the release of pungent smell of decomposition.	2-3	30-31	30.3	29-32	30.9
Active Decay	Collapse of the body wall, rapid conversion of carrion and formation of cadaver island and strong odour decay.	4-7	30-32.5	31.4	33-42	36.1
Advanced Decay	Decrease Dipteran dominance, increased Coleopterans activity with moderate odour of decay and remains of dried skin, bones and tissues.	8-12	30-34	31.6	28-33	31.6
Dry Remains	Little or no odour of decay present and characterized by dried hair and bony structures exposed to weathering	13-31	27.5-36	31.67	-	-

Table 6. Characteristics of decomposition stages, post-mortem interval (Days) and prevailing temperatures in exposed habitat

Stage	Characteristics of Stages	Post –Mortem (Days)	Temperatures (^oC)			
			Ambient temp (range)	Ambient temp (mean)	Internal temp (range)	Internal Temp (mean)
Fresh	No gross morphological changes, odour and sign of decomposition.	0-1	27-28	27.66	29-30	29..6
Bloat	Distention of abdominal wall into a balloon-like appearance, discolouration, maggots developing in body orifices and the release of pungent smell of decomposition	2-3	27.2-30	28.5	27-30	28.7
Active Decay	Collapse of the body wall, rapid conversion of carrion biomass and formation of cadaver island and strong odour decay.	4-7	28-33	29.72	30-38	34.0
Advanced Decay	Decrease Dipteran dominance, increased Coleopterans activity with moderate odour of decay and remains of dried skin, bones and tissues.	8-12	28-34.5	31.06	30-34	31.53
Dry Remains	Little or no odour of decay present and characterized by dried hair and bony structures exposed to weathering	13-31	24-37	30.9	-	-

3.4. Characteristics of Decomposition Stages

The characteristics of decomposition stages, prevailing temperatures and post-mortem interval (days) at sheltered and exposed habitats are summarized in Tables 5 and 6.

4. Discussion

There was no significant difference recorded in the abundance of insects attracted to rabbit carrions in sheltered and exposed habitats was similar to the results of Kyerematen *et al.* (2013) who reported no difference in the abundance of insects on pig carcasses in different seasons. The 9 families; Calliphoridae, Muscidae, Sarcophagidae, Piophilidae, Stratiomyidae, Staphylinidae, Dermestidae, Histeridae and Formicidae encountered in this study were not different from those in previous studies on wildlife (Okiwelu *et al.*, 2008 and Ndueze *et al.*, 2015). Five decomposition stages were recorded on decomposing rabbits in sheltered and exposed habitats. This was reported by Silahuddin *et al.* (2015) on decomposing rabbits, Heo *et al.* (2011) on decomposing pigs and Rumiza *et al.* (2010) on decomposing monkeys. However, Bharti *et al.* (2003) and Abouzied (2014) reported four stages on decomposing rabbit carcasses.

There was accessibility by insects to the six carrions placed at sheltered and exposed habitats; thus egg-laying by female insects on carrions was possible. Mann *et al.* (1990) reported that access by insects to carrion is an essential factor influencing the rate of decomposition. Oviposition was not observed until day 2 of exposure when batches of eggs were found on natural orifices, then bloating of the carcasses and strong putrid smell of decomposition attracted flies to the carrion in the two habitats by the end of the day 2. The hatched larvae, probably *Chrysomya* spp. depended on the host for their entire requirement (moisture, warmth, oxygen and food) and was parasitic on other larval species. On day 4, there was massive larval development, in different instar stages on the carcasses. The succession patterns of arthropods associated with exposed habitat were almost similar to those in the sheltered habitat. The higher number of insect taxa in the exposed carrion accelerated the process of drying out carcasses faster, especially during the late stage of decomposition. In the exposed habitat, moisture was a dominant factor that mediated the decomposition process and re-colonization of Muscid larvae during the late stage of decomposition. This accelerated the rate of decomposition, drying up of bones, furs and fibrous skin than in the sheltered habitat. Zeariya *et al.* (2015) and Sukchit *et.al.* (2015) reported that, high relative humidity plays a significant role as well as providing moisture suitable for the development of micro-organisms.

All carcasses in the exposed habitat decayed faster due to the early invasion by Calliphoridae and Sarcophagidae, coupled with optimum temperatures. The bloated stage was delayed for another 24 hours in the rabbit placed in the sheltered habitat due to the prevailing ambient temperatures and low insect colonization. The Calliphorids were the first to colonize the rabbit carrions in both habitats due to the freshness of the carrion. Many authors have also reported that species in this family are usually the first colonizers of decomposing bodies (DeSouza *et. al.*, 2008). The predominant larvae found were those belonging to the family Calliphoridae which were seen on days 2 and 3 at the exposed and sheltered habitats respectively. Larval activities and development continued until the onset of dry remains stage; houseflies *Musca domestica* were subsequently attracted, followed by Sarcophagidae (flesh flies). Ekanem and Dike (2010) made similar observations. Adults of *Musca domestica* were attracted to rabbit carrions in both sheltered and exposed habitats but no

Muscid larvae were found until the 13th day of decomposition which marked the beginning of the dry remains stage. Voss *et al.* (2009) also reported that adult *M. domestica* was regularly attracted to carcasses showing no visible signs of oviposition and only present in rare cases.

Coleopterans dominated the active decay to the dry remains stage. Adult and larval *Dermestes frischii* were most common on the carcasses in the exposed site. Adult Dermestes were most active during the dry remains stage, although Abouzied (2014) reported that, most adults became active during the onset of the bloated stage and the early period of the dry remains stage. Von Hoermann *et al.* (2005) and Abouzied (2014) stated that males of *Dermestes maculatus* at the newly emerged stage became attracted to the odour of decomposing pig at the post bloating stage (day 9 after death) when benzyl butyrate was released, an important odorant cue for beetles. The adult beetles of the families Staphylinidae and Histeridae are known to be actively present on decomposing remains at the exposed habitat from the bloat to the dry remains stage. Findings by Kyerematen *et al.* (2013) and Abouzied (2014) have shown that staphylinid species prey on fly eggs and larvae associated with carrions during the bloat to the dry remains stage. Adult *Necrobia rufipies* were found in the late active decay stage (Abouzied, 2014). The succession patterns of arthropods on decomposing remains occur in predictive sequence and insects in the order Lepidoptera, Orthoptera, Odonata and acarines were essentially incidentals species or parasitic on necrophagous species

5. Conclusions

This research presents the preliminary work on the succession patterns of arthropod fauna attracted to rabbit carcasses in sheltered and exposed habitats. At both sites, the fly species *Chrysomya albiceps* and *Chrysomya chloropyga* were useful forensically significant species which can serve as useful tools for evaluating the postmortem interval in Nigeria, as they were the most significant insects in this study. Habitats do not have effects on the decomposing rabbit carrions as decomposition is a continuous process and is non-functional to location, but only dependent on the bio-geoclimatic factors prevailing in the environment. However, insect succession was significantly greater in exposed habitat than sheltered habitat. The colonization observed in exposed and sheltered habitats was as a result of the number and diversities existing in the open vegetation as compared to enclosed areas. Therefore, postmortem interval (PMI) can be estimated using insects on carrions in exposed and sheltered habitats.

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