NJE Vol. 40(2): 62-79, 2024
Nigerian Journal of Entomology
Published by the Entomological Soc. of Nig.
www.esnjournal.com.ng
DOI.10.36108/NJE/4202/04.0250

Insect Diversity on Decomposing Domestic Piglets (*Sus domesticus* ERXLEBEN) Carcasses at Umudike, Southeast Nigeria

***EHISIANYA, C. N. AND OZUM, E. K.**

Department of Zoology and Environmental Biology, College of Natural Sciences, Michael Okpara University of Agriculture, Umudike, Abia State

Abstract

Outdoor experiments were carried out to identify arthropods colonizing ground-placed and hung piglets (*Sus domesticus*) carcasses, their species diversity, and decomposition pattern. The trial was carried out in two seasons: July to September, 2019 (wet), and January to March, 2020 (dry) at Michael Okpara University of Agriculture, Umudike Abia State, Nigeria. A total of four healthy piglets with average weight of 3.73 kg were sacrificed for the trial. The piglets died by dislocating their cervical vertebrate (to mimic natural death); two were placed on the ground in metal cage whereas the other two were hung on a tree. Data on carcasses arthropod populations, temperature, weights and decomposition stages and rates were collected. Results showed that the total arthropod taxa of seventeen genera, ten families in four orders were recorded from the carcasses. A total of 29,629 individual insects were counted, belonging mainly to; Calliphoridae, Muscidae, Sarcophagidae, Dermestidae, Staphylinodea, Pyrrhocoridae and Formidae. Their species abundance was; *Musca* spp. (37.09 %), *Chrysomya* spp. (12.97 %), *Pheidole* spp. (12.09), *Componotus* spp. (9.69 %), *Monomorium* spp. (6.04 %), respectively. Higher number of insects were collected from ground-placed piglets (34.08%) than hung piglets (28.06%) carcasses. More insects were recorded during the dry (55.28%) than wet (44.11%) season. Higher insect diversity was also recorded amongst insect species on ground-placed (0.80) than hung (0.72) carcasses. Data also showed that five stages (fresh, bloat, active decay, advanced decay and skeletonization) of decomposition were observed over a duration of 10 days. This study provided base-line data on the local insect fauna associated with the stages of decomposition with emphases on their arrival time, and it is crucial for estimating the post-mortem interval during forensic investigations in south eastern Nigeria.

Keywords: Arthropod, Decomposition, Carcass, Colonizing, Piglets.

*Correspondence email:
ehisianya.collins@mouau.edu.ng
ORCID: 0000-0001-9243-8373

INTRODUCTION

Forensic entomology is a specialty in forensic science which applies information about insects' and/or related arthropods' life cycle and behaviour to help interpret evidence in a legal context relating to both human and wildlife (Gennard, 2012; Ramos-Pastrana *et al*., 2018), and creating associations between a suspect, a victim, and a crime scene (Li *et al.,* 2016). Recent research has focused on analyzing insect gut contents to determine the species on which fly larvae had fed (Campobasso *et al.*, 2005; Li *et al.,* 2016). In the case of human death, carrion insects are used to assist in crime scene reconstruction (Paola *et al*., 2019). The diversity of and natural history of local flies are vital elements for post-mortem interval (PMI) estimation

(Catts and Haskel, 1990; Pujol-Luz *et al*., 2006; Ramos-Pasrana *et al*., 2018).

It is also clear according to Ramos-Pasrana *et al*. (2018) that the time between decomposition stages, the arthropod composition, the pioneer species and the colonization times differed depending on the location of the corpse. Many death cases have been recorded, some as suicide, murder or from natural causes. Some of the human remains are often discovered in certain stages of decomposition. Therefore, the ability to correctly estimate the PMI is critical, particularly in a case involving suspicious deaths and this has been a challenge faced by security agencies and medico-legal especially in Nigeria where criminal forensic studies are yet to be fully adopted and practiced.

Monitoring of insects associated with carcass decomposition has been reported in countries like Australia, USA, Canada, Argentina, Brazil (Centeno *et al.*, 2002; Cruz and Vasconcelos, 2006; Hobischak *et al*., 2006; Dekeirsschieter, *et al*., 2013), and more recently in Nigeria by Ndueze *et al*. (2013) in Rivers State; Ojianwuna *et al.* (2019) in Delta State; Abajue and Ewuim (2020) in Awka, Anambra State, and Onyishi *et al*. (2020) in Enugu State. Evidently, no studies on forensic entomology have been documented in Abia State. Forensic entomology could provide useful data for the minimum postmortem interval (PMI_{min}) estimation and other relevant information such as causes and circumstance of death (Ren *et al*., 2018).

Hanging is known to be one of the commonest ways of committing suicide globally (Thomas and Gunnel, 2010). Although many researchers have worked on forensic entomology globally but there is need to generate a baseline entomological data in Nigeria for the detection of crime, death and its cause. It is noteworthy that pigs present a suitable analogue for studying human decomposition (Catt, 1992; Schoenly, 2006; Goff, 2009) because of their similarities to the human skin structure, thickness, pigmentation, hair follicle content, collagen and lipid composition (Summerfield *et al.*, 2015; Uhm et al., 2023), and also yielded highly similar insect community composition (Watson and Carlton, 2003; 2005).

Presently, there is paucity of data on the diversity of insects and their succession wave on carcasses especially in southeastern Nigeria. Information of the insect pest complex colonizing carcasses is crucial for obtaining an accurate PMI estimate. This could be applied to identification of the human remains and possibly discover the cause of death. Data from this study will also serve as a part of baseline data pool for PMI determination in this region of Nigeria. This study was conducted to ascertain the insect diversity, species successions, and decomposition in piglets (*S. domesticus*) at Umudike.

MATERIALS AND METHODS

Arthropod species colonizing *S. domesticus*, and their decomposition pattern was evaluated at Michael Okpara University of Agriculture, Umudike (MOUAU), Abia State, south-eastern Nigeria (Figure 1), located in the tropical rainforest zone on Latitude $05^{0}26^{'}$ to $5^{0}25^{'}$N and Longitude $07^{0}34^{'}$ to $7^{0}36^{'}$E.

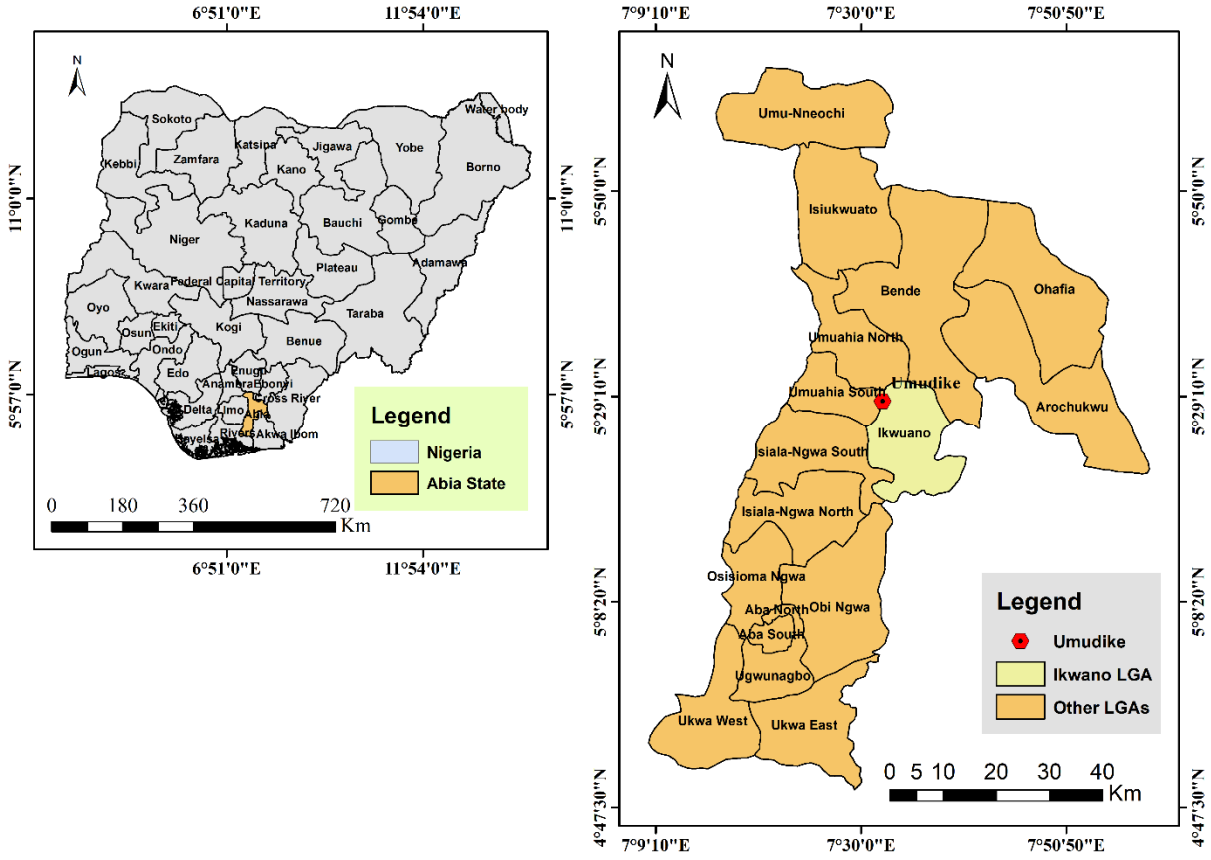

Figure 3.1: Study area at Umudike in Ikwuano LGA, Abia State, Nigeria

.

Four domestic piglets were procured from the piggery farm of Animal Production Department, MOUAU. Four metal cages, weighing scales, vials, trays, hand gloves, brushes, hand lens, microscopes, twines, formaldehyde, ethyl-acetate, ethanol, and thermometers were obtained from laboratory equipment store in Umuahia.

Permission was obtained from the Ethical Committee of College of Natural Sciences, MOUAU before the commencement of the field research. Protective clothing was worn to protect the data collectors from pathogens, pollutants or contaminants.

For this research, *Sus domesticus* was chosen as a good analogue for studying the decomposition of human cadavers (Matuszewski *et al*., (2020), due to the similarities in the progression of decomposition (Micozzi 1991; Campobasso *et al.,* 2001). A total of four healthy domestic piglets with average weight of 3.73 kg were used.

A suitable site was selected; located behind the Departmental animal house by the College of Physical Sciences, MOUAU. The site was characterized of grasses and trees.
The metal cages (120 cm x 120 cm) were covered with wire (2 cm x 2 cm meshing size), to allow access to the carcass by insects while preventing scavenger vertebrate and placed in

an open location (Wolff *et al.,* 2001). A sign-post warning passersby about the experiment was tagged at the site to avoid disturbance or removal.

The piglets were transported alive to the study site and sacrificed by severing their cervical (to mimic natural death). Care was taken to prevent external bleeding that might alter the attractiveness of the carcass to flies or provide alternate sites for oviposition or larviposition. After death, the carcasses were immediately placed into the mesh cages to prevent large vertebrate scavengers' access. Two of them were hung on a tree (shaded), whereas, the other two were placed on the ground (surface), and they were exposed to natural conditions. The weights of the carcasses were taken daily using a spring scale.

The experiments were conducted in two seasons, wet (July to September, 2019) and dry (January to March, 2020) seasons. Data collection was twice daily (between 6:30am and 5pm) for two weeks, subsequently, data were collected once a day; either in the morning (6:30am) or in the evening (5pm) until the end of the experiment. During sampling, the sites were approached slowly to minimize the disturbance of flying adult insects.

The environmental conditions serve as one of the factors leading to insect colonization and decomposition. The temperature was taken using a calibrated mercury thermometer. Internal temperature was taken through the anus. The weights of the carcasses were taken daily using a spring scale.

Insects were collected from openings on the decomposing carcass such as mouth, anus, ears and eyes. These openings were thoroughly examined for presence of arthropod species and/or their remains. Flying insects were sampled using entomological nets, while creeping insects and other arthropods were handpicked or using forceps or aspirated, and put in glass vails containing ethyl-acetate. Arthropods collected were carefully handled to avoid denature and for easy identification. Eggs and larvae present under and around the carcasses were also collected using tweezers and fine tip brushes and divided into two. One part was reared to the adult stage for identification of species, and the other part was transferred to vials containing 70% ethanol for preservation. Arthropod identification was made by using taxonomic keys (Klimaszewski and Watt, 1997; Choate, 2003; Scudder and Cannings, 2006; Whitworth, 2006; Carvalho and Mello-Patiu, 2008; Vairo *et al.,* 2011; Szpila and Villet, 2011) and picture chat. All insects were identified to the generic level.

Data Analyses

Species richness was measured as the number of species per carcass; species abundance as the total number of specimens per carcass; alpha diversity was estimated using Shannon diversity and dominance was measured using Simpson dominance index (Alvarez *et al*., 2006). Descriptive statistics was done on Microsoft Excel 2013, while diversity indices were performed using Paleontological Statistics (PAST) version 4.03

RESULTS

Insect Abundance and Succession Patterns on Piglet Carcasses

During the wet season, a total of 8315 individual insects with highest population (41.35%) collected in the advanced decay stage from ground-placed piglet carcass, and were sorted into twelve genera representing three orders and seven families (Tables 1). For hung carcasses, a total of 4934 individuals of insects were collected with highest population of (53.93%) collected during the active decay stage sorted into orders (3), families (5), and

genera (7) (Table 2). In the dry season, the ground-placed carcasses had a total of 10099 insect individuals were collected with highest population (34.30%) collected in the advanced decay stage in genera (10), families (7) and order (3) (Table 3), while the hung carcasses during the dry season, a total of 6281 insects individuals were collected with highest population (39.66%) collected in the advanced decay stage, sorted and identified to 12 genera and eight families (Tables 4).

Table 1: Insect Succession on ground-placed piglet carcasses during the rainy season, 2019

Order	Family	Species	Decomposition Stages (days)					Total
			Fresh (day 0 - 1)	Bloated (day 1 - 3)	Active decay (day 3 - 5)	Advanced decay (day 5 - 7)	Dry (day 7 - 10)	
Diptera	Calliphoridae	*Calliphora vomitoria*	0	0	0	79	0	79 (0.95)
		Crysomya sp	83	0	0	0	0	83 (1.00)
		Crysomya sp *(*larva*)*	0	52	1357	316	0	1725 (20.75)
	Muscidae	*Fannia sp*	0	43	16	0	0	59 (0.71)
		*Musca domestica (*Adult*)*	0	161	223	184	61	629 (7.56)
		Musca domestica (larva)	0	14	1776	537	0	2327 (27.99)
	Sarcophagidae	*Sarcophaga sp*	0	76	18	0	0	94 (1.13)
		Sarcophaga sp larva	0	0	6	0	0	6 (0.07)
	Piophilidae	*Piophila casei*	0	4	1	0	0	5 (0.06)
Coleoptera	Dermestidae	*Dermestes maculatus*	0	0	1	1	3	5 (0.06)
	Staphylinoidea	*Philonthus* sp.	0	0	1	1	4	6 (0.07)
Hymenoptera	Formicidae	*Camponotus* sp	0	0	0	76	18	94 (1.13)
		Cheliomyrmex andicola	0	0	0	619	133	752 (9.04)
		Monomorium sp.	0	0	0	284	79	363 (4.37)
		Pheidole sp.	0	0	0	1341	747	2088 (25.11)
Total			**83 (1.00)**	**350 (4.21)**	**3399 (40.88)**	**3438 (41.35)**	**1045 (12.57)**	**8315**

Table 2: Insect Succession on hung piglet carcasses during the rainy season, 2020

Order	Family	Species	Decomposition Stages (days)					Total
			Fresh (day 0 - 1)	**Bloated (day 1 - 3)**	**Active decay (day 3 - 5)**	**Advanced decay (day 5 - 7)**	**Dry (day 7 - 10)**	
Diptera	Calliphoridae	*Calliphora vomitoria*	0	0	0	46	0	46 (0.93)
		Crysomya sp	61	7	0	0	0	68 (1.38)
		Crysomya sp *(*larva*)*	0	122	1011	631	0	1643 (33.30)
	Muscidae	*Musca domestica (Adult)*	0	93	219	199	49	560 (11.35)
		Musca domestica larva	0	127	1431	373	0	1931 (39.14)
		Musca domestica pupa	0	0	0	16	11	27 (0.55)
Coleoptera	Dermestidae	*Dermestes maculatus*	0	0	0	16	37	53 (1.07)
		Dermestes maculates larva	0	0	0	0	146	146 (2.96)
	Chrysomelidae	*Altica sp*	0	0	0	41	16	57 (1.16)
Hymenoptera	Formicidae	*Monomorium* sp.	0	0	0	71	191	262 (5.31)
		Solenopsis sp	0	0	0	43	98	141 (2.86)
Total			**61 (1.24)**	**349 (7.07)**	**2661 (53.93)**	**1436 (29.10)**	**548 (11.11)**	**4934**

Table 3: Insect Succession on ground-placed Piglet Carcass during Dry Season, 2019

Order	Family	Species	Decomposition Stages (days)					Total
			Fresh (day 0 - 1)	Bloated (day 1 - 3)	Active decay (day 3 - 5)	Advanced decay (day 5 - 7)	Dry (day 7 - 10)	
Diptera	Calliphoridae	*Calliphora larva*	0	0	0	21	0	21 (0.21)
		Calliphora vomitoria	0	0	81	11	0	92 (0.91)
		Crysomya megacephala	0	3	24	0	0	27 (0.27)
		Crysomya sp	156	31	14	0	0	221 (2.19)
		Crysomya sp *(*larva*)*	0	0	117	51	0	168 (1.66)
	Muscidae	*Musca domestica (*Adult*)*	0	223	517	86	62	888 (8.79)
		Musca domestica (larva)	0	0	2037	1104	62	3203 (31.72)
	Sarcophagidae	*Sarcophaga sp*	0	0	22	0	0	22 (0.22)
Coleoptera	Dermestidae	*Dermestes maculatus*	0	0	0	41	18	59 (0.58)
		Dermestes maculates larva	0	0	0	0	21	21 (0.21)
	Chrysomelidae	*Altica sp*	0	0	0	19	213	232 (2.30)
	Tenebrionidae	*Cynaeus sp.*	0	0	0	11	3	14 (0.14)
Hymenoptera	Formicidae	*Camponotus* sp	0	0	0	277	2501	2778 (27.51)
		Monomorium sp.	0	0	0	432	188	620 (6.14)
		Pheidole sp.	0	0	0	1411	322	1733 (17.16)
Total			**156 (1.54)**	**257 (2.54)**	**2812 (27.84)**	**3464 (34.30)**	**3390 (33.57)**	**10099**

Table 4: Insect Succession on Hung Piglet Carcass during Dry Season, 2020

Order	Family	Species	Decomposition Stages (days)					Total
			Fresh (day 0 - 1)	Bloated (day 1 - 3)	Active decay (day 3 - 5)	Advanced decay (day 5 - 7)	Dry (day 7 - 10)	
Diptera	Calliphoridae	*Calliphora vomitoria*	0	0	41	0	0	41 (0.65)
		Crysomya megacephala	0	0	0	0	0	0 (0.00)
		Crysomya sp	101	18	6	0	0	125 (1.99)
		Crysomya sp *(*larva*)*	0	0	221	86	0	307 (4.89)
	Muscidae	*Musca domestica (*Adult*)*	0	197	309	17	9	542 (8.63)
		Musca domestica (larva)	0	0	1506	2021	0	3527 (56.15)
	Sarcophagidae	*Sarcophaga sp*	0	0	52	10	0	62 (0.99)
Coleoptera	Dermestidae	*Dermestes maculatus*	0	0	4	7	2	13 (0.21)
		Dermestes maculates larva	0	0	0	0	21	21 (0.33)
	Chrysomelidae	*Altica sp*	0	0	6	11	49	66 (1.05)
		Asphaera sp.	0	0	6	6	41	53 (0.84)
	Tenebrionidae	*Cynaeus sp.*	0	0	0	4	4	8 (0.13)
Hemiptera	Pyrrhocoridae	*Dysdercus sp.*	0	0	0	0	4	4 (0.06)
Hymenoptera	Formicidae	*Camponotus* sp	0	0	0	0	0	0 (0.00)
		Monomorium sp.	0	0	0	133	412	545 (8.68)
		Solenopsis sp	0	0	0	196	771	967 (15.40)
Total			**101 (1.61)**	**215 (3.42)**	**2151 (34.25)**	**2491 (39.66)**	**1313 (20.90)**	**6281**

Table 5: Arthropod Distribution on Domestic Piglets (*Sus domestica*) Carcasses during Rainy and Dry Season at Umudike, 2021

Order	Family	Species	Wet Season		Dry Season		Total (%)
			Gound-P Piglet (%)	Hung Piglet (%)	Ground-P Piglet (%)	Hung Piglet (%)	
Diptera	Calliphoridae	*Calliphora spp*	79 (0.95)	0	21 (0.21)	0	100 (0.34)
		Calliphora vomitoria	0	46 (0.93)	92 (0.91)	41 (0.65)	179 (0.60)
		Crysomya megacephala	0	0	27 (0.27)	0	27 (0.09)
		Crysomya spp	83 (1.00)	68 (1.38)	221 (2.19)	125 (1.99)	497 (1.68)
		Crysomya sp *(*larvae*)*	1725 (20.75)	1643 (33.30)	168 (1.66)	307 (4.89)	3843 (12.97)
	Muscidae	*Fannia spp*	59 (0.71)	0	0	0	59 (0.20)
		*Musca domestica (*Adult*)*	629 (7.56)	560 (11.35)	888 (8.79)	542 (8.63)	2619 (8.84)
		Musca domestica (larvae)	2327 (27.99)	1931 (39.14)	3203 (31.72)	3527 (56.15)	10988 (37.09)
		Musca domestica pupa	0	27 (0.55)	0	0	27 (0.09)
	Sarcophagidae	*Sarcophaga spp*	94 (1.13)	0	22 (0.22)	62 (0.99)	178 (0.60)
		Sarcophaga sp larvae	6 (0.07)	0	0	0	6 (0.02)
	Piophilidae	*Piophila casei*	5 (0.06)	0	0	0	5 (0.02)
Coleoptera	Dermestidae	*Dermestes maculatus* adult	5 (0.06)	53 (1.07)	59 (0.58)	13 (0.21)	130 (0.44)
		Dermestes maculates larva	-	146 (2.96)	21 (0.21)	21 (0.33)	188 (0.64)
	Staphylinoidea	*Philonthus* spp	6 (0.07)	-	-	-	6 (0.02)
	Chrysomelidae	*Altica sp*	-	57 (1.16)	232 (2.30)	66 (1.05)	355 (1.20)
		Asphaera sp.	-	-	-	53 (0.84)	53 (0.18)
	Tenebrionidae	*Cynaeus sp.*	-	-	-	8 (0.13)	8 (0.03)
Hemiptera	Pyrrhocoridae	*Dysdercus sp.*	-	-	-	4 (0.06)	4 (0.01)
Hymenoptera	Formicidae	*Camponotus* spp	94 (1.13)	-	2778 (27.51)	-	2872 (9.69)
		Cheliomyrmex andicola	752 (9.04)	-	-	-	752 (2.54)
		Cynaeus sp.	-	-	14 (0.14)	-	14 (0.05)
		Monomorium spp	363 (4.37)	262 (5.31)	620 (6.14)	545 (8.68)	1790 (6.04)
		Pheidole spp	2088 (25.11)	-	1733 (17.16)	-	3821 (12.90)
		Solenopsis sp	-	141 (2.86)	-	967 (15.40)	1108 (3.74)
Total			**8315 (28.06)**	**4934 (16.65)**	**10099 (34.08)**	**6281 (21.20)**	**29629**

Table 6: Diversity Indices of Insect Species Collected from Surface-placed and Hung Piglets during Wet and Dry Seasons

Piglet Placement (Season)	No. of species	Dominance (D)	Simpson index diversity (1-D)	Shannon (H)	Evenness
Ground-placed (Wet Season)	8315	0.20	0.80	1.83	0.41
Hung (Wet Season)	4934	0.28	0.72	1.57	0.44
Ground-placed (Dry Season)	10099	0.22	0.78	1.78	0.40
Hung (Dry Season)	6281	0.36	0.64	1.47	0.31

Table 7: Stages and rate of decomposition (Day) of ground-place and hung piglet at Umudike

Stage	Rate of Decomposition (Day)										
	0	1	2	3	4	5	6	7	8	9	10
Fresh											
Bloat											
Active decay											
Advanced decay											
Skeletonization											

In both rainy and dry seasons, *Crysomya* spp. (larva) represented the earliest insects arriving during the fresh decay stage of both carcasses (Tables 1, 2, 3 and 4) irrespective of placement methods. *Calliphora vomitoria* and *Musca domestica* flies were present on both placed and hung piglets' carcasses throughout the seasons. *Altica* spp. was observed on the ground-placed carcass in the advanced decay and dry decay stages. Also, on the hung carcasses in the active decay, advanced decay and dry decay stages in the dry season (Tables 1, 2, 3 and 4).

In this study, a total of 29629 individual insects were collected belonging to four orders, ten families, and eighteen genera. Calliphoridae (*Calliphora* spp. and *Crysomya* spp.), Muscidae (*Fannia* spp. *Musca domestica*), Sarcophagidae (*Sarcophaga* spp.), Piophilidae (*Piophila casei*), Dermestidae (*Dermestes maculatus*), Staphylinodea (*Philonthus* spp.), Crysomelidae (*Altica* sp., *Cynaeus* sp.), Pyrrhocoridae (*Dysdercus* spp.) and Formicidae (*Camponotus* spp., *Cheliomyrmex andicola*, *Cynaeus* spp., *Monomorium* spp., *Pheidole* spp. and *Solenopsis* spp) (Table 5).

Larvae of *M. domestica* were the most abundant insect species (37.09 %), followed by *Chrysomya* spp. (12.97 %), *Pheidole* spp. (12.90 %), *Componotus* spp. (9.69 %). Others were adult *M. domestica* (8.81 %), *Monomorium* spp. (6.04%), *Solenopsis* spp (3.74%), *Cheliomyrmax andicola* (2.54%), and *Altica* spp. (1.20%). The remaining species were less than 1.0 % (Table 5).

Based on piglets' placement, ground-placed carcasses had higher arthropod colonization than hung carcasses; population of arthropods on ground-placed carcasses in dry (10099) and wet (8315) seasons, while the population on hung piglets in dry (21.80%) and wet (16.65%) seasons (Table 5). Arthropod abundance was higher in the dry season (55.28 %) than in the wet season (44.11 %)

Table 6 presents the diversity indices of arthropod species collected from *S. domesticus* carcasses at Umudike in the wet and dry seasons. Higher Simpson indices were recorded on the ground-placed (0.80 and 0.78) than the hung (0.72 and 0.64) carcasses in the wet and dry seasons, respectively. Similarly, the Shannon indices followed same trend for ground-placed carcasses in wet (1.83) and dry (1.78) seasons, respectively, and in hung carcasses during the wet (1.57) and dry (1.47) seasons, respectively (Table 6).

A total of five stages of decomposition (fresh, bloat, active decay, advanced decay, and skeletonization) was observed in this experiment. The average of decomposition rate was as follows: skeletonization was longest (over 3 day), followed by active decay (3 days), and the shortest was fresh stage (1 day). The pig carcasses completely dried/skeletonized by 10 days during the wet and dry seasons (Table 7).

DISCUSSIONS

Insect activity was observed immediately after placement of the piglet carcasses. The first (2-6 hours after placement) arthropod colonizers to arrive during the fresh stage of carcass decomposition were the *Chrysomya* spp. Similar conclusions by Tembe and Mukaratirwa, (2021) and Ramos-Pastrana *et al.* (2014) in South Africa and Columbian, respectively reported that *Chrysomya* spp. are the first arrival and colonizer of carcasses. Taleb *et al.* (2019) also reported *Chrysomya albiceps* amongst the dominant initial colonizers of cadavers. In a similar trend, *Chrysomya megacephala* was reported to be a preponderant blowfly species of forensic importance in many parts of the world namely: Asia by Adrus and Abdulrahim (2018) from Sarawak, Malaysia Borneo and

from India by Bala and Sharma, (2016); Sontigun *et al*., (2018), and from Malaysia (Kumara *et al*., 2012). In Nsukka, Nigeria, Onyishi *et al.* (2020) also reported the presence of *Chrysomya albiceps* as the most abundant insects occurring on exposed and shaded mammalian carcasses. In other climes, Studies by Adrus and Abdulrahim (2018) on insect succession and decomposition patterns of carcasses in Sarawak, Malaysian Borneo also reported the presence of *Chrysomya* species.

In their study, Onyishi *et al.* (2020) also reported the presence of other dipterans including members of the family Muscidae, Fannidae, Dermestidae, and Staphylinidae, which is similar species of insects found in this current study. Although, members of the Muscidae were the most populous species, the *Chrysomya* species were among the highest insects that colonizes the carcasses of pigs in their study. In Uyo, Akwa-Ibom State, Ekanem and Dike (2010) studied the arthropod succession on pig carcasses, and reported that the calliphorids, phorid and sarcophagids were initial colonizers of pig cadavers. Mabika *et al.* (2014) reported the presence of *Chrysomya albiceps*, *Musca domestica*, *Sarcophaga* sp., *Dermestes* sp. and *Pheidole* sp. from the sun-exposed carcass of rabbits in Harare, Zimbabwe. Also, studies by Ahmed *et al.* (2016) in guinea pig in Kaduna revealed the presence of *Pheidole* spp. and *Camponotus* spp. Other studies by Ullah *et al.* (2019) in Pakistan, Ndueze *et al.* (2013) and Izuma and Noutcha (2019) both in Rivers State, Nigeria reported similar species colonization on carcasses.

Carcass internal temperature increase was recorded as maggot masses developed starting from the bloated stage. This stage was characterized by colour changes as well as onset of marbling and bloating or swelling.

Increase in the diversity indices of ground-placed carcasses indicate increase in the insect orders in the community when compared with the hung piglet carcasses in wet and dry seasons. According to Onyishi *et al*., (2020), decomposition rate of carcass is affected by environmental factors such as temperature, relative humidity, precipitation and insect abundance.

The Shannon diversity indexes of the arthropod species for the both surface-placed piglets and hung piglet were high, 20 species of arthropods were observed on the carcasses. Similar observation was reported by a study in Southern eastern Brazil by Moretti *et al.* (2008), where over 53 species were found. Also, the species were evenly found in the different carcasses. Other factors might have favoured this high diversity such as the longer decay period due to lower temperatures and humidity which permit the arrival of a wider range of arthropods. Onyishi *et al*. (2020) investigated arthropod succession on mammalian carcasses in Nsukka, Nigeria using ten wistar rats. The study concluded that higher number of arthropods were found on the exposed carcass than the shaded one.

Findings from this study also revealed that higher insect species diversity was recorded on the ground-placed than on the hung carcasses. This could be attributed to displacement of necrophagous maggot mass on the hanging carcasses. A similar observation was reported by Lynch-Aird *et al.* (2015). Unless a hanging carcass is partially in contact with the ground, crawling insects would not likely return to the carcass if they fall into the drip zone (Shalaby *et al.,* 2000). Also, hung carcasses are more likely to be physically disturbed as buttressed by Cross and Simmons (2010); Adlam and Simmons, (2007) in their studies concluded that physical disturbance of carcasses has also been reported to have a significant effect on the rate of mass loss during decomposition The relationship between the mean weights and insects' abundance for ground-placed piglet

carcasses in the rainy season showed a negative and significant correlation. However, their mean internal temperatures and mean weights were also negative but not significant.

Insect activity was observed immediately after the placements of piglet carcasses. *Chrysomya spp.* were the earliest to colonize both the hung and surface-placed carcasses. Higher numbers of arthropods colonized ground-placed than hung carcasses. The study also revealed five stages of decomposition namely: fresh, bloat, decay, active decay and dry. Overall, the duration of their decomposition stages in the wet season was similar to that of the dry season. The high insect diversity was recorded on the pig carcasses, with higher populations in the dry season than in the wet season.

.

CONCLUSION

Musca spp. constituted about 37.09 % of insects recorded, and the most abundant insect species on the carcasses. Higher insect diversity was recorded on ground-placed compared to hung piglet carcasses. Insect abundance was highest during the advanced decay stages. Irrespective of placement method or season, five stages of piglet decomposition were recorded over a ten-day period

.

REFERENCES

Abajue, M. C. and Ewuim, S. C. (2020). Evaluation of activities of dipteran maggots on a poised pig cadaver at Nnamdi Azikiwe University Awka, Nigeria. *Egyptian Journal of Forensic Sciences.* 10 (33): 1 - 8.

Adlam, R. E. and Simmons, T. (2007). The effect of repeated physical disturbance on soft tissue decomposition – are taphonomic studies an accurate reflection of decomposition? *Journal of Forensic Sciences,* 52(5): 1007 - 1014.

Adrus, M. and Abdulrahim, N.A. (2018). Insect succession and decomposition patterns of carcasses in Sarawak, Malaysian Borneo. *Journal of Sustainability Science and Management*, 13(2): 71 - 84.

Ahmed, A. B., Joseph, S. G. and Naman, K. (2016). Dry season study of necrophagous insects associated with *Cavia porcellus* (Guinea pig) carcass in Kaduna, Nigeria. *International Journal of Entomological Research*, 4(3): 99 - 106.

Bala, M. and Sharma, A. (2016). Postmortem interval estimation of mummified body using accumulated degree hours (ADH) method: A case study from Punjab (India). *Journal of Forensic Science and Criminal Investigation*, 1(1): 552.

Benbow, M. E., Lewis, A. J., Tomberlin, J. K., Pechal, J. L. (2013). Seasonal Necrophagous Insect Community Assembly During Vertebrate Carrion Decomposition. *Journal of Medical Entomology* 50: 440–450.

Bourel, B., Hedouin, V. Martin-Bouyer, L., Becart, A., Tournel, G., Deveaux, M, and Gosset, D. (1999). Effects of morphine in decomposing bodies on the development of *Lucilia sericata* (Diptera: Calliphoridae). *Journal of Forensic Science:* 44(2):354-358.

Bygarski, K. and LeBlanc, H. N. (2013). Decomposition and arthropod succession in Whitehorse, Yukon Territory, Canada. *Journal of Forensic Sciences*, 58(2): 413 - 418.

Byrd, J. H. and Allen, J. C. (2001). The development of the black blow fly, *Phormia regina* (Meigen). *Forensic Science International*, 120(1-2): 79 -

88. doi: 10.1016/s0379-0738(01)00431-5.

Byrd, J. H. and Butler, J. F. (1996). Effects of temperature on *Cochliomyia macellaria* (Diptera: Calliphoridae) development. *Journal of Medical Entomology*. doi: 10.1093/jmedent/33.6.901. 33(6): 901 - 905.

Byrne, D. G., Byrne, A. E. and Reinhart, M. I. (1995). Personality, stress and the decision to commence cigarette smoking in adolescence. *Journal of Psychosomorphology Resources.* 39(1): 53–62.

Campobasso, C. P., Linville, J. G., Wells, J. D. and Introna, F. (2005). Forensic genetic analysis of insect gut content. *The American Journal of Forensic Medicine and Pathology*, 26(2): 161 - 165. Doi: 10.1097/01.paf.0000163832.05939.59.

Campobasso, C. P., Vella, G. D. and Introna, F. (2001). Factors affecting decomposition and Diptera Colonization. *Forensic Science International*, 120(1-2): 18 - 27. https://doi.org/10.1016/S0379-0738(01)00411-X

Carvalho, C.J. and Mello-Patiu, C.A. (2008). Key to the adults of the most common forensic species of Diptera in South America. *Revista de Entonologia*, 52(3): 390-406.

Catts, E. P. and Haskel, N. H. (1990). Entomology and Death: *A Procedural Guide*. Joyce's Print Shop, South Carolina (1st ed), 182pp.

Catts, E. P. (1992). Forensic entomology in criminal investigations. *Annual Review of Entomology,* 37: 253 - 272.

Catts, E. P. and Goff, M. L. (1992). Forensic entomology in criminal investigations. *Annual Revised Entomology.* 37: 253 - 272. Doi: 10.1146/annurev.en.37.010192.001345.

Centeno, N. D., Maldonado, M. and Olivia, A. (2002). Seasonal Patterns occurring on Sheltered and Unsheltered Pig Carcasses in Buenos Aires Province (Argentina). *Forensic Science International*, 126(1): 63-70.

Choate, P. M. (2003). Introduction to the identification of beetles (Coleoptera). Dichotomous keys to some families of Florida Coleoptera. https://entnemdept.ufl.edu/choate/beetles1a.pdf. Accessed 5th August, 2021.

Cross, P. and Simmons, T. (2010). The influence of penetrative trauma on the rate of decomposition. *Journal of Forensic Sciences*, 55(2): 295–301.

Cruz, T. M. and Vasconcelos, S. D. (2006). Soil entomofauna associated with swine carcass decomposition in an Atlantic Forest fragment from Pernambuco, Brazil. *Biosciences*, 14(2): 193-201.

Dekeirsschieter, J., Frederick, C., Verheggen, F. J. Boxho, P. and Hubrecht, E. (2013). Forensic entomology investigations from Doctor Marcel Leclercq (1924 - 2008): a review of cases from 1969 to 2005. *Journal of Medical Entomology*, 50(5): 935 – 954.

Ekanem, M. S. and Dike, M. C. (2010). Arthropod succession on pig carcasses in Southeastern Nigeria. *Zoology Loose Papers*, 50(35): 561-570.

Gennard, D. (2012). *Forensic Entomology: An Introduction*, 2nd edition, John Wiley & Sons, Ltd., Publication. 290pp.

Goff, M. L. (2009). Early postmortem changes and stages of decomposition. In: Amendt, J., Goff, M. L.

Campobasso, C., Grassberger, M editors. *Current Concepts in Forensic Entomology*. Dordrecht: Springer; 2010. pp. 1–24.

Hosbischak, N. R., Vanlaerhoven, S. L., and Anderson, G. S. (2006). Successional pattern of diversity in insect fauna on carrion in sun and shades in the boreal forest region of Canada, near Endonton, Alberta. *Canadian Entomology*, 138: 376-683.

Hunt, T. J., Bergsten, J. and Levkanicova, Z. (2007). "A comprehensive phylogeny of beetles reveals the evolutionary origins of a super-radiation," *Science*, 318(5858) 1913–1916.

Izuma, I., and Noutcha, M. A. E. (2019). Succession patterns and diversity of arthropods associated with decomposing domestic rabbit (*Oryctolagus cuniculus* L., 1758) in different habitats. *Environment and Ecology Research*, 7(6): 303-312.

Klimaszewski, J. and Watt, J. C. (1997). Coleoptera: family-group review and keys to identification. *Fauna of New Zealand*. 37, 199pp. doi.org/10.7931/J2/FNZ.37.

Kumara, D.S.; Prasad, R. M. V., Kishore, K. R., Rao, E. R., (2012). Effect of Azolla (*Azolla pinnata*) based concentrate mixture on nutrient utilization in buffalo bulls. *Indian Journal of Animal Research*, 46 (3): 268-271.

Li, C., Wang, Q., Zhang, Y., Lin, H., Zhang, J., Huang, P., and Wang, Z. (2016). Research progress in the estimation of the postmortem interval by Chinese forensic scholars. *Forensic Sciences Research*, 1(1): 3-13.

Lynch-Aird, J., Moffatt, C. and Simmons, T. (2015). Decomposition Rate and Pattern in Hanging Pigs. *Journal of Forensic Sciences*, 60(5): 1155–1163.

Mabika, N., Masendu, R. and Gilbert, M. (2014). An initial study of insect succession on decomposing rabbit carrions in Harare, Zimbabwe. *Asian Pacific Journal of Tropical Biomedicine*, 4(7): 561-565.

Matuszewski, S., Hall, M. J., Moreau, G. Schoenly, K., Tarone, A. M and Villet, M. H. (2020). Pigs vs. people: the use of pigs as analogues for humans in forensic entomology and taphonomy research. *International Journal Legal Medicine,* 134(2): 793 - 810. Doi: 10.1007/s00414-019-02074-5.

Micozzi, M. S. (1991). Postmortem change in human and animal remains: A systematic approach. Springfield, Illinois: CC Thomas Publishers. Xii + 124pp. https://doi.org/10.1002/ajhb.1310040519

Moretti, T.C., Ribeiro, O.B., Thyssen, P.J. and Solis, D.R. (2008). Insects on decomposing carcasses of small rodents in a secondary forest in Southeastern Brazil. *European Journal Entomology*, 105: 691-696.

Ndueze, O.U., Noutcha, M.A.E, Umeozor, O.C, and Okiwelu, S.N. (2013). Arthropods associated with wildlife carcasses in Lowland Rainforest, Rivers State, Nigeria. *European Journal of Experimental Biology*, 3(5): 111- 114.

Ojianwuna, C. C., Odibo, O. E. Akpan, A. U. and Egwaoje, K. I. (2019). Succession pattern of insects in relation to killing methods of Rattus norvegicus at Delta State University, Abraka, Nigeria. *Journal of Applied Sciences and Environmental Management*, 23(3): 483 - 487.

https://doi.org/10.4314/JASEM.V2313.18

Onyishi, G.C., Osuala, F., Aguzie, I.O., Okwuonu, E.S. and Orakwelu, C.H. (2020). Arthropod succession on exposed and shaded mammalian carcasses in Nsukka, Nigeria. *Animal Research International*, 17(3): 3869 - 3877.

Paola, A., Magni, J., David, N., Melle, Z. and Ian, R.D. (2019). Insect Succession Pattern on Decomposing Pig Carcasses in Tasmania: A Summer Study. *Papers and Proceedings of the Royal Society of Tasmania,* 153: 31 - 38.

Pujol-Luz, J.R., Marques, H., Urrahy-Rodrigues, A., Rafael, J.A., Santana, F.H.A., Arantes, L.C. and Constantini, R. (2006). A Forensic Entomology Case from the Amazon Rain Forest of Brazil. *Journal of Forensic Science*, 51: 1151 - 1153.

Ramos-Pastrana, Y., Velasquez-Valencia, A., and Wolff, M. (2014). Preliminary study of insects associated to indoor body decay in Colombia. *Revista Brasileira de Entomologia*, 58: 326 – 332.

Ramos-Pastrana, Y., Virgueze-Diaz, Y and Wolff, M. (2018). Insects of Forensic Importance Associated to Cadaver Decomposition in a Rural area of the Andean Amazon, Caqueta, Colombia. *Acta Amazonica*, 48: 126 - 136.

Ren, J., Friedmann, D., Xiong, J., Liu, C. D., Ferguson, R., Weerakkody, T., DeLoach, K. E., Ran, C., Pun A., Sun, Y., Weissbourd, B., Neve, R. L., Huguenard, J., Horowitz, M. A. and Luo, L. (2018). Anatomically Defined and Functionally Distinct Dorsal Raphe Serotonin Sub-systems. *Cell*. 175(2): 472-487.

Schoenly, K. G., Haskell, N. H., Mills, D. K., Bieme-Ndi, C., Larsen, K. and Lee, Y. (2006). Recreating death's acre in the school yard: using pig carcasses as model corpses to teach concepts of forensic entomology & ecological succession. *American Biology Teacher,* 68(7): 402–410.

Scudder, G.G. E. and Cannings, R. A. (2006). The Diptera family of British Columbia. Columbia University: 1-163.

Sontigun, N., Sanit, S., Wannasan, A., Sukontason, K., Amendt, J., Yasanga, T. and Sukontason, K. L. (2018). Ultrastructure of male genitalia of blow flies (Diptera: Calliphoridae) of forensic importance. *Acta Tropica*, 179: 61-80.

Summerfield, A., Meurens, F. and Ricklin, M. E. (2015). The immunology of the porcine skin and its value as a model for animal skin. Molecular immunology, 6691): 14 – 21.

Szpila, K, Madra, A, Jarmusz, M. and Matuszewski, S. (2015). Flesh flies (Diptera: Sarcophagidae) colonizing large carcasses in central Europe. *Parasitological Research*, 114: 2341 - 2348.

Taleb, M, Tail, G., Nihal, Acikgoz, H. N., Djedouani, B. and Toumi, M. (2019). Ecological roles of cadaveric fauna in relation with decomposition stages. *Congress of Ecology and Environmental with International Participation.*

Tembe, D. and Mukaratirwa, S. (2021). Insect succession and decomposition pattern on pig carrion during warm and cold seasons in Kwazulu-Natal Province of South Africa. *Journal of medical Entomology*, 58 (6): 2047 – 2057.

Thomas K. and Gunnell, D. (2010). Suicide in England and Wales 1861–2007: a time-trends analysis. *International Journal of Epidemiology*, 39(6): 1464 - 75.

Uhm, C., Jeong, h., Lee, S.H., Hwang, J. S., Lim, K. and Nam, K. T. (2023). Comparison of structural characteristics and molecular markers of rabbit skin, pig skin, and reconstructed human epidermis for an *ex vivo* human skin model. *Toxicological Research*, 39: 477 – 484.

Ullah, R. Naveed, R., Ghulam, N., hamid, U., Shen, Y. Yu-Dong, Z. and Junfen, F. (2019). Role of nutrition in the pathogenesis and prevention of non-alcoholic fatty liver disease: recent updates. *International Journal Biological Science*. 15(2): 265 - 276.

Vairo, K.P. Mello-Patiu, C.A de Carvalho, C. J. B. (2011). Pictorial identification key for species of Sarcophagidae (Diptera) of potential forensic importance in south Brazil. *Revista Brasileira de Entomologia*, 53: 333 - 347.

Watson, E. J. and Carlton, C. E. (2003). Spring succession of necrophilous insects on wildlife carcasses in Louisiana. *Journal of Medical Entomology,* 40(3):338–347.

Watson, E. J. and Carlton, C. E. (2005). Insect succession and decomposition of wildlife carcasses during fall and winter in Louisiana. *Journal of Medical Entomology,* 42(2):193–203.

Whitworth, T. L (2006). Keys to genera and species of blow flies (Diptera: Calliphoridae) of America north of Mexico. *Proceedings of the Entomological Society of Washington*, 108(30): 689 - 725.

NJE Vol. 40(2): 62-79, 2024
Nigerian Journal of Entomology
Published by the Entomological Soc. of Nig.
www.esnjournal.com.ng
DOI.10.36108/NJE/4202/04.0250