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Dry Season Study of Arthropods' Succession on Pig Carrions in Edjeba, Nigeria

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***Abstract*-** Arthropods' succession on putrefying pigs were monitored at the Edjeba community in Southern Nigeria, from 10th June to 10th August 2018. The arthropods were collected with the aid of sweep nets while the bodies of the carrions and the soil below the carrions were combed with brushes for the presence of the arthropods two times for the first week and one time for the remaining weeks, insects' maggots found were grown till adults. Multiple bar charts were applied to illustrate the regularities of the flies in every phase of decay, pie charts were used similarly to indicate phases of putrefaction, Component bar charts were applied to demonstrate succession of the different orders of insects, while Principle Component Analysis (PCA) was used to show the spreading of insects in the different decay phases. Whereas PCA indicates that constituent 1 stood for 47.9% of the disparity in the dataset, constituent 2 stood for 30.8% making a total of 78.7%. The Simpson index was high (0.94) in the active decay phase but low (0.87) in the fresh phase. The dominance index was high (0.13) in fresh phase but low (0.06) in active decay phase, Shannon–Wiener index (H) was high (2.96) in the active decay phase but low (2.19) in the fresh phase. The evenness index (E) was high (0.92) in active decay phase but low (0.75) in dry decay phase and Margalef (R) was high (3.32) in advanced decay phase but low (1.88) in fresh phase. The equitability index was high (0.97) in active decay phase but low (0.89) in dry decay phase. The total number of insects collected were 1495, 244 were at fresh phase of decay, 273 at bloated phase, 437 at active decay phase and 346 at advance decay phase and 195 at dry decay phase of decay as 1090 of these insects were Diptera, Coleoptera were 285 and only 110 were Hymenoptera. More studies on carrion ecology should be carried out in the Edjeba community and its environs in order to generate trustworthy data base of arthropods of forensic importance in the city.

Keywords— *Forensic entomology, Arthropods, Insects, phases of decay, succession.*

I. INTRODUCTION

Forensic entomology is an area of science which is concerned with the information on the arthropods and their usage in drawing conclusion when investigating legal issues connected with wildlife and human beings. Insects could be applied in the enquiry of cases in both the aquatic and terrestrial habitats [1, 2, 3, 4, 5]. The arthropods Class that is of immense significant ant in forensic entomology is the Hexapod especially the orders Diptera, Coleoptera and sometimes the Hymenoptera while the families include the Cleridae, Stratiomyiidae, Calliphoridae, Formicidae, Sarcophagidae, Muscidae, Cheese skippers, Histeridae, Dermestidae, Staphylinidaee, among others.

Man has for a lengthy period conquered the bionetwork and adapted the natural course of the earth by force. According to [6], the environment has its own system and a finest significance is the nutritional-chain which stands a sequence of consuming and being consumed also. It was affirmed positively that the method is always very big to the extent that the deceased carrions of other faunas as well as humans are equally corroded by other creatures and insects on phase of predominant task.

For eras, till in the latest times, in urbanized domain, worms found on the original vents and wounds or dead bodies were well thought-out repulsive part of the rot immediately bodies remained positioned on the desk for examination. The worms were often sweep away devoid of without minding hidden details of investigation attached to them. As stated by [7], whereas the shot gun scrutiny surface-to-air, bite-marks, gun ash remainder understanding, blood spray enquiry and added fundamentals of crime related information were investigated and recorded, the insects allied with the bereavement section were principally disregarded.

For the quest for advancement in forensic entomological studies, researchers on the carrion ecology from different parts of the world have carried out scientific research works on the influence of various variables in resolving of the time after dead. Various methods of establishing the PMI from the insects that invade the decaying carrions exist.

They include arthropod succession phases [8], age dependent change in the intestinal content [9], on the phase of invasion [10], developmental pattern [11],

Isomegalen/isomorphen diagrams [12, 13], the eggs of the flies [14], insects' gut content [15], from cuticular hydrocarbons [16], from accumulated degree days/hours [17], aging Calliphoridae fly eggs through the gene expression [18], the influence of the body and the speed of crawling [19], the ontogenetic study [20], the larval dispersal [21], estimation of age through the 3D micro computed tomography [22], volatile organic compound release by the pupae and larvae [23], Pupae [24] and the internal morphological analysis of the pupae [25] but the commonly used method is the successive wave of insects on the carrion.

This study was aimed at the sequential collection of the Arthropods of assembled from the decaying pig cadaver at the Edjeba town, during the dry seasons with regard to the phases of decay and its respective insects' groups and their usefulness in the establishment of the time after death occurred.

In this paper, Section I contains the Introduction, Section II comprises the interrelated work as Section III covers Methodology and Section IV encompasses the experimental Results, Section V holds Discussion and Section VI has the Conclusion while VII comprises the Acknowledgement.

II. Related Work

Arthropods are popularly used in the detection of latent facts of crime for a long period and several researchers have explained the history of forensic entomology both internationally and locally [26, 27, 28, 29, 30, 31]. The forensic entomology can give an estimation of the conceivable time of death depending on phases of life cycle of the specific insect groups collected on the decaying animal carrion or from the sequence of the arthropods groups found on the decaying bodies.

III. Methodology

The Area of Study

This work was carried out at Departmental Farm of Biology Science of the State College of Education, Edjeba, Warri, South Nigeria is located between Latitude 5°33′27.5634″N and 5°44′27.8459″N and Longitude 5°32′33.4565″E and 5°44′40.0027E.

Three pigs were being used in this study, each pig was knifed in the chest, beneath the forelimb with a high-pitched switchblade to fake and conventional assassination wound at 6.00 pm the day earlier than beginning of this work.

Those pig dead bodies stayed set down, protected from foragers with wire that allowed entry of insects but sheltered the experimental pigs from the higher animals. The wire was used to form cages that were always removed on each sampling instances with least 40m inter carrions distances to decrease disturbance of insects from neighbouring bodies.

Insects specimens were twice daily by 10.00 am as well as 02 pm (Nigerian Time) during first seven days while daily for the remaining days. The collected Insects were assembled by hand by the use of sweep-nets for aerial species. The aerial species were assembled through fifteen sweeps in every regime. The animal bodies were combed with comb so as to gather the insects recorded as hand picking were also used to gather the insects, pitfall traps were used to gather the creeping insects as soil just under each carrion were searched with forceps to assemble phases found around.

Larvae of the second instars were assembled on the pig carrions, bred in the translucent vessels with depth of 15cm and 11.5cm of depth and width diameter at $25.^0$C each as muslin material lid and rubber bands that tolerated exposure to air and prevented the escape of the insects. The rearing dishes contained powder wooden material with pigs' remains for the feeding the juvenile.

Data Analysis

Data Analysis was done through Microsoft Excel, graphs were used to demonstrate relationship between the period of phase of decay and the length of each phase, the numbers of insects' orders encountered at each phase of decay and also the diversity index at each phase of decay respectively as Principle Component Analysis (PCA) was applied to compare the spreading of the frequency of occurrence of species at the different phases of decay of the pig carrions

Identification of the insects

keys for identifying of arthropods were used through this study: Diverse groups of insects were identified through [32, 33]. Diptera: [34, 35, 36, 37, 38, 39], Lepidoptera: [40]. Coleoptera: [41, 42, 43, 44]. For Hymenoptera: [45, 46, 47].

IV. Results and Discussion

Succession of the dipteran species

Out of the 18 species of Diptera implicated in this station, *M. domestica* was 24 at the fresh phase of decay, increased to 25 and 31 at the bloated and active decay phases, but decreased to 25 and 6 at the advanced decay phase and dry decay phase respectively. The *H. minuta* was just 9 at the fresh and bloated s phases respectively but increased to 21 at the active decay phase and 17 at the advanced decay phase but was not recorded at the dry decay phase of decay.

A. occidentalis was only observed at the fresh phase of decay where its frequency was only 4 and was not observed at the other phases of decay but the *Sarcophaga sp* was 12 at the fresh phase of decay but increased to 17 and 22 at the bloated and active decay phases of decay

respectively and reduced to 12 at the advanced decay phase as it was not encountered at the dry decay phase of decay.

S. tibalis was 9 at the fresh phase of decay, absent at the bloated phase but increased to 15 and 19 at the active and advanced decay phases respectively but was equally not recorded at the dry decay phase of decay but the *S. inzi* was 2 at the fresh phase of decay, increased to 20 and 26 at the bloated and active decay phases of decay and reduced to 2 at the dry decay phase as its presence was not recorded at the advanced decay phase of decay. The *Lucilia sericata*, the frequency was 31 at the fresh phase of decay, but increased to 27 and 33 at the bloated and active decay phases of decay respectively and reduced to 15 and 6 at the advanced and dry decay phases respectively.

However, the *C. albiceps*, 47 at the fresh phase of decay, but 31, 38 and 16 at the bloated, active and advanced decay phases respectively but decreased in frequency to 5 at the dry decay phase of decay. *C. megacephala* was highest at the fresh phase just like the *C. albiceps*; its frequency was 27 and was not recorded at the bloated phase but 12 and 4 respectively as it was not equally recorded at the dry decay phase of decay (Figure 1).

Meanwhile *C. vomitoria* was 16 at the fresh phase of decay but decreased to 13 and 6 at the active and advanced decay phases respectively as they were absent at the bloated and dry decay phases of decay n respectively but the *C. chloropyga* was 24 and 21 at the bloated and active decay phases as they were not recorded at the fresh, advance and the dry decay phases respectively. *Fannia sp*. was 25 and 19 at the bloated and active decay phases of decay but was not recorded at vthe other phases of decay respectively. The *S. exubreans*, was 5 at the bloated phase but increased to 11 and 9 at the active and advanced decay phases respectively but reduced to 5 at the dry decay phase as it was absent at the fresh phase of decay.

Drosophilia sp. was only recorded at the active decay phase of decay where its frequency was 32. *Hydrotae sinigera* was 31 at the active decay phase but it's was not recorded in the other phases of decay but *F. canicularis* was equally only recorded at the active decay phase of decay as they were absent at the others phases of decay. *Hermetia illucens* was 32 at the active decay phase, 65 at the advance decay phase but decreased to 48 at the dry decay phase while the *C. rufifacies* was 2 and 4 at the advance and dry decay phases respectively and was not recorded at the other phases of decay (Figure 1).

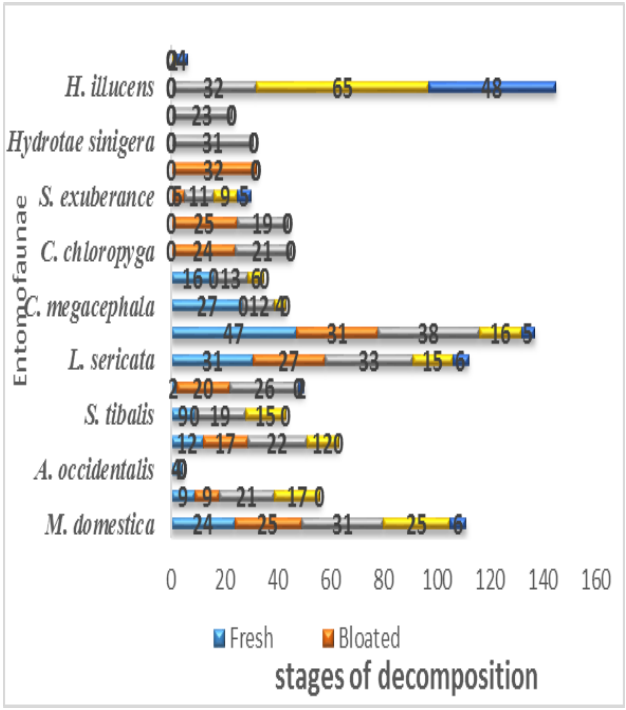

Figure 1 Succession of Dipteran species on the pig carrions

Succession of the Coleopteran species

There were 9 species of Coleoptera while *S.violaceous* was only observed to be 12 in frequency at the fresh phase of decay; it was not recorded in the other phases of decay. *Philonthus sp* was 6 at the bloated, and increased to 21 and 16 at the active and dry decay phase of decay respectively but was not recorded at the fresh and advanced decay phases of decay.

N. ruficolis was absent at the fresh phase of decay but was 11 and 27 at the bloat and active decay phases and 16 and 22 at the advance and dry decay phases respectively. The *N. rufipes* was not equally present at the fresh phase but was 12 at both the bloated and active decay phases of decay but increased to 22 and 18 at the advanced and dry decay phases of decay respectively.

However, the *Pagia litura* was observed to be 10 in frequency at the active phase of decay but was not recorded at the other phases of decay but the *D. maculatus* was 19 at the active decay phase of decay, but reduced to 11 and 17 at the advance and dry phases respectively and the *D. ater* was just 7 at the active decay phase of decay and 11 at the dry decay phases which were the only phases that they recorded but the *Hister monitor* was only observed at the advance and dry decay phases of decay which the frequencies were 12 and 16 respectively, the *Onthophagous sp* was 6 at the advance decay phase which was the only phase that it was recorded (Figure 2)

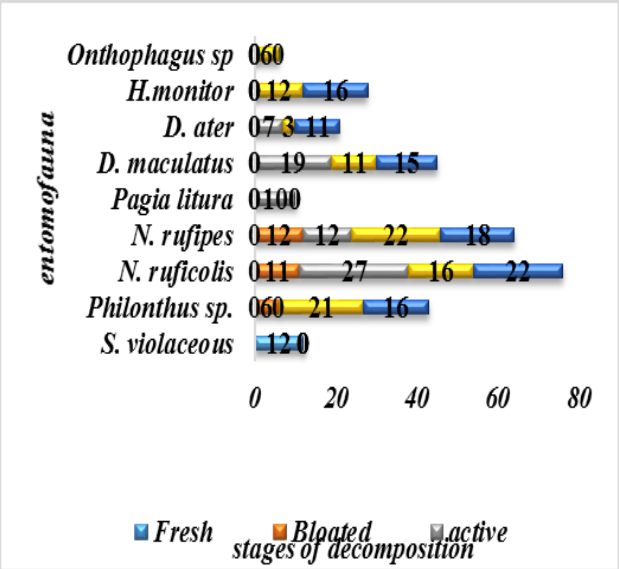

Fig. 2 Succession of Coleopterans on the carrions

The succession of the non-necrophagous insects

There were only 3 species of the non-necrophagous group of insects on the carrions. They belong to the same family of Formicidae (order Hymenoptera). *M. senaarensis* was 18 at the fresh phase of decay, and reduced to 12 at the bloat phase and active decay phases but increased to 18 and 21 at the advanced and dry decay phase decay phases of decay respectively. The *Camponotus pennsylvanicus* was 9 at the bloated phase and increased to 17 at the active decay phase of decay whereas it was absent at the other phases of decays. However, the *Camponotus sp*. was 12 at the advanced decay phase which was the only phase that it was recorded (Figure 3).

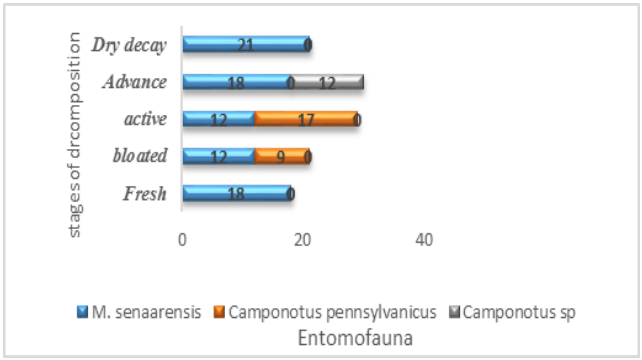

Figure 3 Succession of the non necrophages insects on the pig carrion

The period of decay of pig carrion

The period of decay of the pig carrion took 60 days, from the fresh to the dry decay phase of decay. The fresh phase was the phase with the shortest period, it only took 2 days from the day 0 to the day two while the bloat phase of decay began on day three (3) and stopped on day five (5), took only 3 (three) days, active phase began on 6th day and was completed on day 6, lasted for 7days, advance decomposing phase began on 13th but stopped on 18th day, persisted for only 18 days while dry/skeletal phase began on 19th day and was completed on day 60, was the longest period of 41 days.

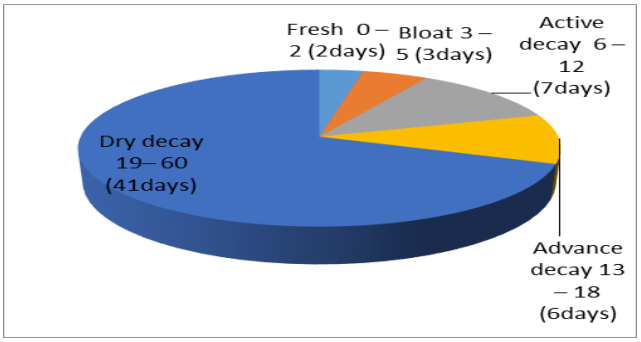

Figure 4 The period of decay of pig carrion

Frequency of occurrence of insect orders encountered at phases of decay

The total number of insects encountered was 1495. 244 were encountered at the fresh phase of decay, 273 at the bloated phase, 437 at the active decay phase and 346 at the advance decay phase and 195 at the dry decay phase of decay. At the fresh phase, out of the 244 insects, 213 were Dipterans, 19 were Hymenopterans, while 12 were Coleopterans but at the bloated phase, out of the 273, 223 were Diptera, 21 were Hymenoptera, and only 29 were Coleoptera. However, at the active decay phase, 33 are Diptera, 29 were hymenoptera and 75 were Coleoptera making it 437 insects. At the advanced decay phase of decay, 225 were Diptera, 30 were hymenoptera and 91 were Coleoptera but at the dry decay phase of decay, Diptera were 96, 21 were Hymenoptera and 78 were Colоeptera. Out of these 1495 insects 3encountered, 1090 were Diptera, 120 were Hymenoptera and 285 were Coleoptera. The Diptera were 213 at the fresh phase, 223 at the bloated phase, and increased to 333 at the active decay phase but reduced to 225 and 96 at the dry decay phases of decay respectively

The Coleoptera were 285 in the entire period of decay, 12 were observed at the fresh phase of decay, 29 at the bloated phase while 75 and 91 were at the active and advanced decay phases respectively but 78 were documented at the dry stage of decay. However, Hymenoptera were only 19 at the fresh phase of decay, 21 at the bloated phase, 29 and 30 at the active and advanced decay phases of decay but only 21 at the dry decay phase of decay respectively (Figure 5).

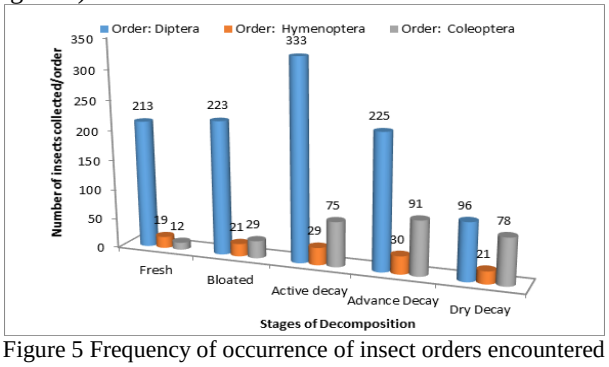

Figure 5 Frequency of occurrence of insect orders encountered at phases of decay

Diversity index for the insect species in pig carrion at different phases of succession

The **Simpson index** was high (0.94) in the active decay phase but low (0.87) in the fresh phase. The dominance index was high (0.13) in the fresh phase but low (0.06) in the active decay phase.

While the **Shannon–Wiener index** (H) was high (2.96) in the active decay phase but low (2.19) in the fresh phase. The evenness index (E) was high (0.92) in the active decay phase but low (0.75) in the dry decay phase (Figure 6).

Richness index for the insect species in pig carrion at different phases of decay

The **species richness; Margalef** (R) was high (3.32) in the advanced decay phase but low (1.88) in the fresh phase (Figure 6). **Equitability index for the insect species in pig carrion at different phases of decay**

The equitability index was high (0.97) in the active decay phase but low (0.89) in the dry decay phase (Figure 6).

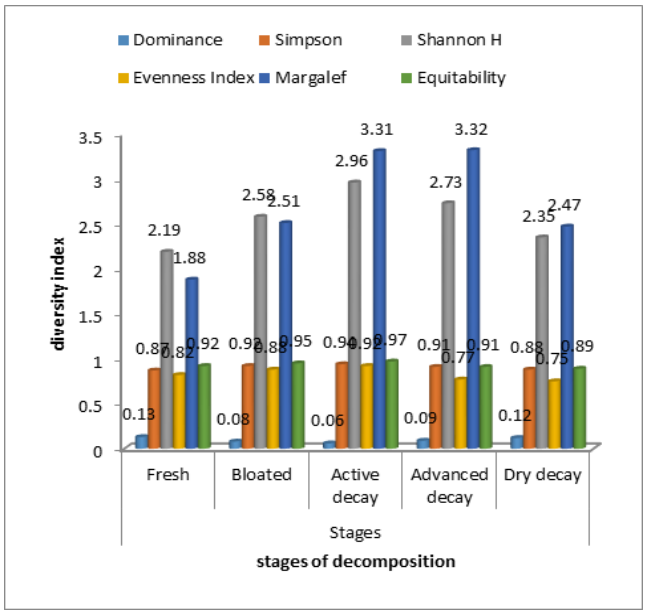

Figure 6 Diversity of insect species on pig carrion at different phases of decay

The distribution of frequency of occurrence of species at the different phases of decay.

The score plot of the PCA displays a scatter plot of species spreading in carrion for 1st and 2nd Constituent, the 1st constituent stood for 47.9% of the discrepancy in the dataset as the 2nd constituent stood for 30.8% making an overall of 78.7%. The loading plot indicates that fresh and bloated phases are crowded together and absolutely interconnected with the 1st and 2nd constituent. The active decay phase is also affirmatively interrelated with 1st and 2nd constituent. The advanced decay and dry decay phases are bunched together, affirmatively associated with 1st constituent and adversely interrelated with 2nd constituent (Figure 7).

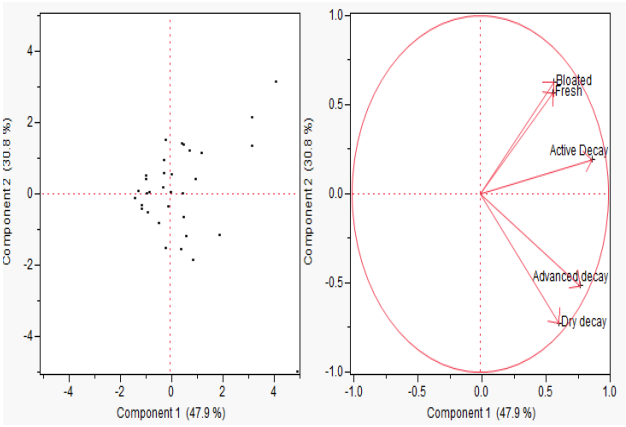

Figure 7 PCA for the distribution of frequency of occurrence of species at the different phases of decay

V. Discussion

In this study, there were 5 recognised phases of decay of the pig carrions, these include fresh phase, bloat phase, active decay phase, advanced decay phase, dry decay/skeletal phases of decay respectively while insects collected during this phase of decay were grouped in the order Diptera, Coleopteran and Hymenoptera. It was found in this study that the main insects of forensic importance were the orders Diptera, Coleoptera and Hymenoptera.

The orders; Diptera and Coleoptera were both necrophages and omnivorous hence may be useful in the assessment of time after an animal died as the Hymenoptera as a matter of fact were equally forensic importance as they could be cradle of blunder in the valuation of time of death due to the tears and wears that they caused on the carrion while their predatory acts on both the adult and immature phases of the Diptera and Coleoptera could equally create issues on the documentation of the insects of the forensic importance on the pig carrions.

Insect succession as was recorded in this work followed a analogous configuration perceived by other authors, [48, 49, 50, 51] Calliphoridae family to arrive and were equally the predominant carrion insects' species to arrive and were also the predominant species recorded at initial phases of decay. Killers of these necrophages species comprising the ants and several members of coleoptera were recorded at the scene as a result of the huge records of the blowflies' immatures collected on the decaying pig carrions.

The ants (Hymenoptera: Formicidae) were initially recorded on the facial parts of the decaying carrions especially on the eyes, nose, mouth and on the fluids, eggs and larvae of the blowflies, they were raiders and detached higher numbers of immatures from the carrions in the initial periods of decay that also retards the numbers of the blowflies larvae found on the carrions, this could be cause error in the estimation of the PMI and on the creation of the database of the entomofauna found on the carrions.

This report is in accordance with the report of [48] that reported similar activities in O'ahu and stated the

predatory role of the ants on the decaying carrions and equally the extension of the PMI up to 15 days. [52] likewise recorded ants as well on the carcasses in the decay demonstrating that they were usual insects found on the dead bodies.

Indispensable requisite to take consider the influence of predation of ants on the maggots and eggs of the Diptera species in the approximation of time of death. More researches in the field of forensic entomology should be carried out on the bioaccumulation and insects' metabolism of toxins, forensic insects' communities and composition of different areas, towns, cities, states, regions, habitats and environmental types so as to create and establish dependable and useful baseline data on all the cities in this countries for usage by law enforcement agents, further researchers on carrion ecology and the general public as obtainable in the developed world. Government at all level in Nigeria and Government agents should equally sponsor young scholars in this area son as to begin the usefulness of this concept in our judiciary system for proper investigation of criminal cases.

VI. Conclusion

Based on the finding of this study, the insects' orders of Isoptera, Diptera, Hymeoptera and Coleoptera were the insects' orders recovered from the decaying pig cadavers in Neke, Enugu State, Nigeria. The effects of the season and climatic condition were parameters that facilitated the presence and absence of the insect's species as many insects recovered in this study were not collected during the dry season. Diptera were the insects group with uppermost occurrence on the pig carrion in this study**.** For the fact that insects' life cycle can differ from one location to other and from a season to the other. There is therefore need for more research work to be continued in both seasons and locations with different animal models to make sure that carrion ecology is utilized in the determination of hidden truth during criminal investigation related to unexplainable death in Edjeba and other neighboring communities. Forensic entomologists should equally be involved in the investigations during criminal and civil tenures especially for usage in court litigations.
Law enforcement agents, lawyers and legal officers as well as university teachers and students are to be encouraged to acquire the forensic entomological skills and attitudes needed in the investigation in issues related to insects and dead bodies.

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