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Parasites and Associated Haematological Changes In Some Fruit Bats (*Eidolon helvum and Epomops franqueti*) In Southwest Nigeria

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ABSTRACT

This study investigated the different types of ectoparasites and hemoparasites associated with fruit bats (*Eidolon helvum* and *Epomops franqueti*) that are prevalent in our environment. A total of 30 bat samples were collected at different sites within Obafemi Awolowo University (OAU) Ile-Ife and University of Ibadan (UI) campuses with the use of mist nets. The species of trapped bats were identified based on the morphological features, afterward, ectoparasites observed were collected for scientific identification and blood samples were also collected for full blood count with hemoparasites analysis. Data generated were analyzed and values of statistical significance were taken at $p<0.05$. *Eidolon helvum* had ectoparasites which were mainly bat flies (*Nycteribia alternata* and *Eucampsipoda africanum*) while *Epomops franqueti* had none. Both species of bats had hemoparasites with prevalence rates- *Babesia* sp (13.3%)*; Erhlichia sp.* (6.6%)*; Hemosporidia sp* (10%)*;* Microfilaria (3.3%)*; Anaplasma sp (*3.3%). There were no significant differences ($p<0.05$) in the haematological values and body weight of bats that had hemoparasites and those without hemoparasites. Therefore, the fruit bats investigated in this present study, though infested with parasites, were able to adapt favourably and the incidence of parasitism did not significantly affect their body weight and haematological values.

Keywords: *Eidolon helvum, Epomops franqueti, haemoparasites, Eucampsipoda africanum, Nycteribia alternata*

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1. INTRODUCTION

Over the past decade, there has been increasing interest in bats as reservoirs of infectious diseases being the only mammals capable of true or sustained flight, with their wings anatomically resembling the human hand, having extremely elongated fingers and a wing membrane stretched between. Bats are the second most diverse orders of mammals (behind rodent), being ubiquitous and found in each continent, except the Antarctica.

They have been recorded in deserts, grasslands and forests in the tropical, subtropical, and temperate zones (Kunz, 1988; Simmons, 2005). Bat species are poorly documented and classified especially in West Africa where the last comprehensive study was by Rosevear (1965), although a number of new species have been identified (Koopman, 1989; Fahr et al., 2002). Bats have been implicated as reservoirs of life-threatening zoonotic diseases such as Nipah, Hendra, Marburg and Ebola viruses (Newman et al., 2011; Olival et al., 2013; Baker et al., 2014), only a few studies have been conducted on the parasites associated with bats (Patterson et al., 2008; Hamilton et al., 2012; Gay et al., 2014).

The knowledge of the ecology of parasites that bats can harbour, the effects of the parasites on their system and on the human population will serve as a guide to epidemiologists, conservationists, physicians and veterinarians in order to effectively regulate disease outbreaks within bats and human populations, and also help to manage the health of the public worldwide. Some ectoparasites of bats are known to transmit haemoparasites and other disease causing agents like *Trypanosoma sp.* and *Bartonella sp.* to their hosts (Billetter et al., 2012; Kamari et al., 2014). Despite the numerous pathogens that bats harbour, they rarely show any clinical manifestation of diseases (Luis et al., 2013) because they are believed to have evolved to keep most pathogens in check (Hayman et al., 2008; Schneeberger, 2013) due to their great ability to adapt to changing environmental conditions through a higher genetic variability.

Studies have shown that some fruit bats e.g. *Eidolon helvum,* migrate seasonally especially during the middle of the wet season (Richter and Cumming, 2005; Ossa et al., 2012) and are likely to carry as well as shed some diseases across population of bats and humans in various areas they inhabit during migration. Some cases of the transmission of zoonotic diseases and the recent outbreak of Ebola in West Africa are suspected examples of such cases (Fletcher, 2007; Hayman et al., 2012; Moratelli and Calisher, 2015). Due to their migratory nature, they have developed adaptation to exploit varying habitats and vegetation types which predisposes them to parasitic infestation. This study was therefore designed to investigate the types of parasites associated with fruit bats found in this part of the country and to observe changes the presence of these parasites could cause on their haematological parameters and other health indices.

2. MATERIALS AND METHODS

Study Site

The samples used for this study were trapped from bat territories located at Obafemi Awolowo University (Lat 08° 28' N and Long 04° 33' E) situated in Ile-Ife, Osun state and University of Ibadan (Lat 07° 23' N and Long 03° 54' E), Ibadan, Oyo state, both in the South western part of Nigeria.

Sample collection

A total number of 30 bats were captured from both sample sites with the use of mist nets with four shelves and thereafter, they were removed, placed in cages and brought to the working area for species identification and examination for parasites. Gloves were used for removing the bats from the nets to prevent scratches and bites. Subsequently, the cages were opened and each bat species was first identified, their sex determined (using the reproductive condition and physical characteristics), the body weight (using a weighing scale) was recorded and then examined for the presence of

ectoparasites (bat flies, mites, fleas and ticks). This was done by physical examination of the fur, ear, face, wings and tail membranes. A pair of thumb forceps was used to extract the ectoparasites. Ectoparasites seen were extracted into sample bottles that was half filled with ethanol (70%) and labelled. Blood volume of 2ml per bat was collected through the heart into EDTA sample bottles with the use of 21gauge needle and 5ml syringe. Blood samples were immediately taken to pathology (clinical) laboratory for analysis while the parasites inside sample bottles containing 70% ethanol were taken to parasitology laboratory for proper identification.

Laboratory Analyses

Red Blood Cell Count Determination

1ml of red blood cell diluents was poured into a dilution bottle, and 10 microliter of blood was drawn with the aid of a micropipette and added to the dilution bottle containing the diluents. 3-5 drops of this mixture was dispensed to fill the Neubauer's counting chamber and allowed to settle for 3seconds, then it was viewed under the light microscope, all red cells in 80 small squares were counted and the figure multiplied by 10000 (Fankhauser, 2003).

White Blood Cell Count Determination

1ml of Turk's solution was dispensed into dilution bottles and 50 microlitres of blood was pipette and added to the dilution bottles. The mixtures were allowed to mix and thereafter dispensed onto the Neubauer's counting chamber. Under the light microscope, on the Neubauer's counting chamber, all white blood cells in 64 large squares were counted and the figure multiplied by 50 (Pagana and Pagana, 1997).

Determination of Leucocyte Differentials

A differential determines the percentage of each of the five types of mature WBCs. The five types of white blood cells are; Neutrophil, Basophil, Lymphocyte, Eosinophil, and Monocytes. The manual method of using differential to count each type on a stained slide using the light microscope at 1000 magnifications (Stamminger et al., 2002)

Determination of Packed Cell Volume (PCV)

Blood was drained into capillary tubes and sealed with plasticine at both ends of the capillary tube to avoid spillage. They were arranged in the centrifuge and the centrifuge was allowed to spin at 3000rpm for 5mins in order to separate red cells from plasma and also obtain the packed cell volume (PCV) values. After 5minutes, the PCV of each blood sample was read using a micro-hematocrit reader by placing the capillary tube on a reader (Fankhauser, 2003). The point between red cell and plasticine was positioned on the lowest line (black) on the reader while the topmost end of the plasma was adjusted to the uppermost line on the reader and the middle line of the reader was adjusted just below the buffy coat (area of white blood cell) in order to determine the PCV.

Haemoglobin Determination

Using the Sahli's apparatus graduated tube, normal HCl was poured into the tube up to 20ml (using lower meniscus). 20microlitres of blood was pipetted from the sample bottles using the micropipette and poured into the Sahli's apparatus tube containing normal HCl. This mixture was let to react for 5minutes. After 5minutes, the mixture was then compared with the standard Sahli's comparator in terms of colour. If the colors do not tally, the mixture was diluted with distilled water till the colours matched. (Schalm et al., 1975)

Mean Corpuscular Volume (MCV)

This is the average volume of each erythrocyte in a blood sample. The MCV is calculated as:

$$MCV = \frac{PCV\ (\%) \times 10}{RBC\ (million/\mu l)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Mean Corpuscular Haemoglobin Concentration (MCHC)

This is the average weight of haemoglobin content in a red blood cell and it was calculated as:

$$MCHC = \frac{HB\ concentration\ (g/dl) \times 100}{PCV\ (\%)} \quad \ldots\ldots\ldots (2)$$

Blood Smear Examination for Haemoparasites

This was carried out according to Houwen, (2000). A drop of the blood sample was placed on a clean glass slide and spreader was used to disperse out the blood over the slide' length forming a feathered end with the aim of producing a monolayer in order to be able to identify the cells. The smears were air dried, and thereafter immersed briefly in 99% methanol for about 3minutes for fixing. After fixing, the slide was stained with Giemsa stain for about 30minutes, after which the slides were rinsed with water and allowed to dry before viewing under the microscope. The stained slides were viewed under the microscope with magnification x1000 (oil immersion).

Ectoparasites Identification

The parasites that were preserved in ethanol and subsequently observed under a dissecting microscope. Identification and classification of the parasites was based on morphological criteria

Statistical Analysis

All data were presented as mean ± SD and statistical analysis was carried out by T-test using GraphPad Prism 5 software (GraphPad Software, Inc. La Jolla, California, US). Values of $P < 0.05$ were considered statistically significant.

3. RESULTS

Body weight comparison between species

As shown in Figure 1, the body weight of *Eidolon helvum* (285g ± 45) observed in this study was signifi-cantly higher ($p<0.05$) when compa red with the values of *Epomops franqueti* (77g ± 23)

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Comparison of haematological parameters of Eidolon helvum and Epomops franqueti

The haematological parameters show variations between *Eidolon helvum* and *Epomops franqueti* as shown in Table 1. Erythrocyte values (PCV, Hb, RBC, MCV, MCH) of *Eidolon helvum* (n=15) were significantly lower ($p<0.05$) than those observed in *Epomops franqueti* (n=15). Similar difference was observed in leucocyte parameter (neutrophil counts) and platelets of *Eidolon helvum* when compared with Epomops franqueti ($p<0.05$) but the lymphocyte and eosinophil values seen in *Eidolon helvum* were significantly higher than the values of *Epomops franqueti* (Tab. 1). However, the total WBC count did not show any significant difference between the two species.

Table 1. Hematological values of *Eidolon helvum* and *Epomops franqueti.*

Parameters	*PCV (%)*	*Hb (g/ dL)*	*RBC (x1012/L)*	*MCV (fL)*	*MCHC (g/dL)*	*MCH (pg)*	*WBC (103/ ml)*	*LYM (103/ ml)*	*NEU (103/ ml)*	*MON (103/ ml)*	*EOS (103/ ml)*	*Platelets (103/ml)*
Eidolon helvum n=15	42.3 ± 14.4a	13.8 ± 4.65 a	7.10 ± 2.53 a	56.0 ± 15.7 a	30.5 ± 8.44 a	18.3 ± 5.15 a	6154 ± 2630 a	4332 ± 2074 a	1048 ± 1044 a	151 ± 130 a	554 ± 482 a	83067 ± 28677 a
Epomops franqueti n=15	62.1 ± 12.0b	19.4 ± 3.09 b	9.16 ± 1.17 b	67.6 ± 8.23 b	31.5 ± 1.46 a	21.2 ± 1.76 b	5013 ± 2106 a	1504 ± 755 b	3306 ± 1762 b	137 ± 60.9 a	70.4 ± 76.2 b	115533 ± 42052 b
P Values	0.0003	0.0005	0.0077	0.0170	0.6487	0.0469	0.2005	< 0.0001	0.0002	0.6894	0.0006	0.0199

Mean ± SD values with different superscripts within columns a, b are significantly different ($P<0.05$).

Prevalence of parasitism across species

The incidence of ectoparasitism was restricted to *Eidolon helvum* samples while no ectoparasite was observed on *Epomops franqueti* as seen in Table 2. Figure 2 shows the two identified ectoparasites (bat flies), *Nycteribia alternata* and *Eucampsipoda africanum.* Out of the 30 blood samples analyzed, only 9 were positive for Hemoparasites; 6 from *Eidolon helvum* and 3 from *Epomops franqueti*. Hemoparasites identified, as seen in Fig 3-7, with the prevalence, were *Babesia sp* (13.3%)*; Erhlichia sp* (6.6%)*; Hemosporidia sp* (10%)*;* Microfilaria (3.3%)*; Anaplasma sp* (3.3%). Table 2 shows that both species had *Babesia sp. Eidolon helvum* samples were also positive for *Erhlichia sp* and *Hemosporidia sp* unlike *Epomops franqueti*. Microfilaria and *Anaplasma sp* were present in *Epomops franqueti* whereas they were not observed in *Eidolon helvum* samples.

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Effect of haemoparasitism on blood values

In Table 3, there was no significant difference (P>0.05) in the erythrocyte values and leucocyte parameters of both haemoparasite positive and negative samples.

Effect of haemoparasitism on the body weight

There was no significant difference in the body weight of bat species that were either positive (212g ± 118) or negative (168g ± 109) for hemoparasites used in this study (p>0.05). There was no significant difference in the body weight of both haemoparasite positive and negative *Eidolon helvum* bats likewise for *Epomops franqueti* as seen in Fig. 8.

Table 2. Parasitism observed in *Eidolon helvum* and *Epomops franqueti.*

Species	Ectoparasites	Hemoparasites				
		Babesia	Hemosporidia	Erhlichia	Microfilaria	Anaplasma
E. helvum	+	+	+	+	-	-
E.franqueti	-	+	-	-	+	+

Legends: *(+) present;* *(-) absent;*

Table 3. Hematological values of samples analyzed for haemoparasitism.

Parameters	*PCV (%)*	*Hb (g/dL)*	*RBC (x1012/L)*	*MCV (fL)*	*MCHC (g/dL)*	*MCH (pg)*	*WBC (103/ml)*	*LYM (103/ml)*	*NEU (103/ml)*	*MON (103/ml)*	*EOS (103/ml)*	*Platelets (103/ml)*
HEMOPARASITES (+ve) n=9	50.0 ± 8.77	16.2 ± 2.67	8.30 ± 1.50	60.4 ± 2.15	32.4 ± 0.638	19.6 ± 0.88	5856 ± 2214	3528 ± 2320	1851 ± 1021	113 ± 41.1	369 ± 577	101889 ± 25206
HEMOPARASITES (-ve) n=21	53.1 ± 19.0	16.8 ± 5.55	8.06 ± 2.48	62.4 ± 16.4	30.4 ± 7.09	19.8 ± 4.87	5467 ± 2534	2656 ± 2003	2317 ± 2089	157 ± 115	287 ± 345	98190 ± 44163
P Values	0.6402	0.7501	0.7849	0.7098	0.4011	0.8759	0.6932	0.3058	0.5323	0.2746	0.6315	0.8167

Mean ± SD values with different superscripts within columns a, b are significantly different (P<0.05).

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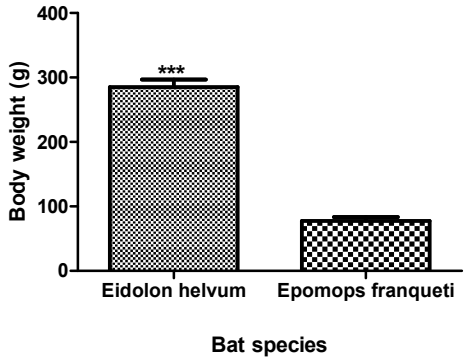

Figure 1: Body weight comparison of *Eidolon helvum* and *Epomops franqueti*. *** indicates significant difference ($p<0.05$).

Figure 2: Photographs of identified ectoparasites (bat flies) on *Eidolon helvum* as seen under the dissecting microscope.

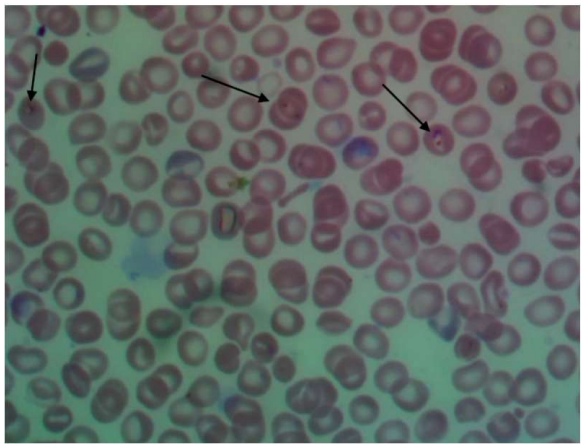

Figure 3: Photomicrograph of Giemsa stained blood smear showing presence of Babesia-like organisms (arrow) within bat erythrocytes. Mag x1000.

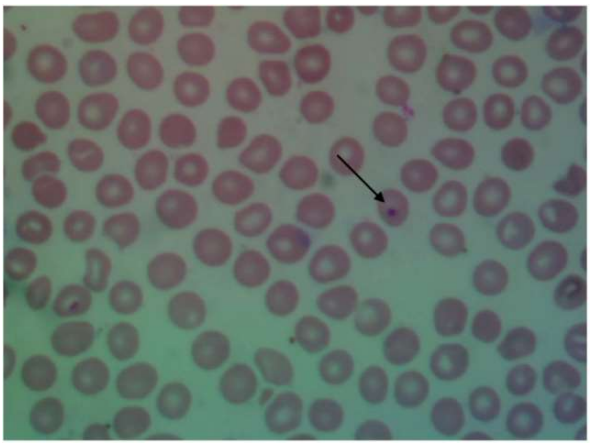

Figure 4: Photomicrograph of Giemsa stained blood smear showing presence of Anaplasma-like organisms (arrow) within bat erythrocytes. Mag x1000.

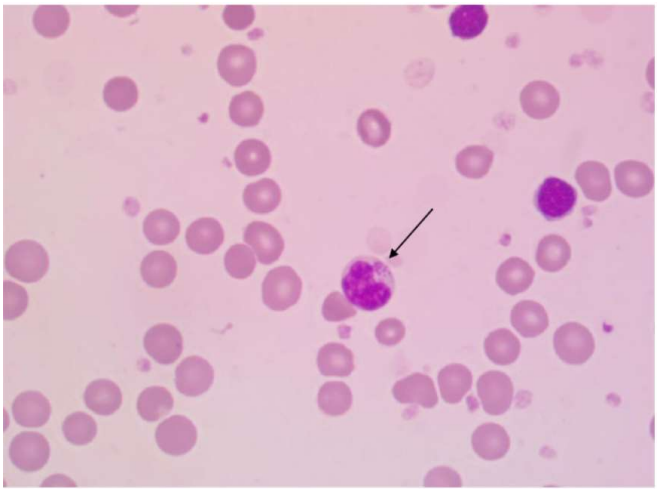

Figure 5: Photomicrograph of Giemsa stained blood smear showing presence of Erhlichia-like organisms (arrow) within bat granulocytes.

Mag x1000.

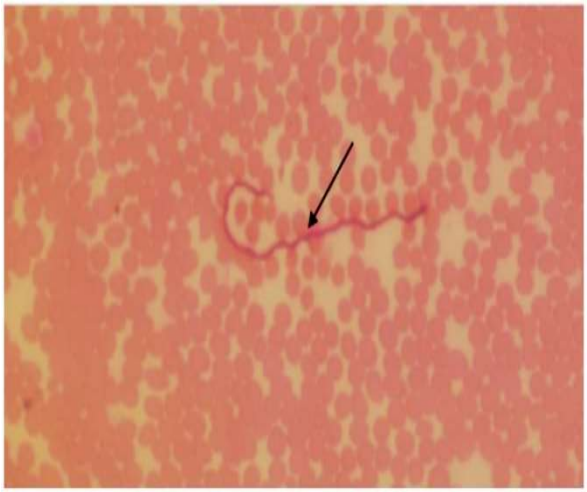

Figure 6: Photomicrograph of Giemsa stained blood smear showing presence of microfilaria organisms (arrow)

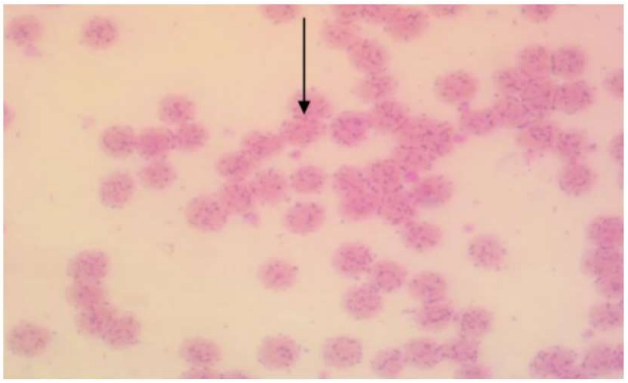

Figure 7: Photomicrograph of Giemsa stained blood smear showing presence of Hemosporidial organisms (arrow) within bat erythrocytes. Mag x1000.

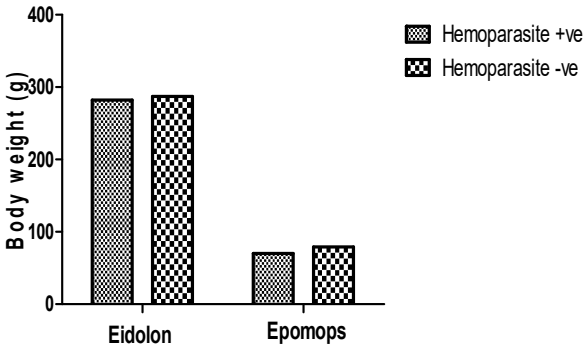

Figure 8: Body weight of bats species that were haemoparasite positive and negative.

4. DISCUSSION

In the present study, the hematological parameters of *Eidolon helvum* were essentially within the range of values found in other fruit bats (Olayemi *et al.,* 2006). The erythrocyte values of *Eidolon helvum* were however significantly lower when compared with the erythrocyte values of *Epomops franqueti*. The mean RBC count of *Eidolon helvum* in this study (7.10x10^{12}/L) considerably differs from the report of Selig *et al.* (2016) in the same species with a mean RBC count of 9.47 x1012/L. The mean RBC count of 9.16 x10^{12}/L in *Epomops franqueti* is similar to the findings of Ekeolu and Adebiyi, (2018) who reported a mean value of RBC count as 9.15 x10^{12}/L. However, these are lower than RBC values reported in some temperate breeds of bats, 12.39 x10^{12}/L in the Serotine bat (Wolk and Ruprecht, 1988) and 11.35 x10^{12}/L in *Myotis myotis* (Albayrak *et al.,* 2016).

The observed variations with regards to *E. helvum* RBC count in this study and the report of Selig *et al.* (2016) could be attributed to a difference in geographical location, sex, food quality and environmental factors where the experiment was carried out (Ratnasooriya *et al*., 2005). The PCV of 42.3% in *E. helvum* observed in this study is similar to the observations of Selig *et al.* (2016) but lower than 62.1% ob-served in *E. franqueti*. Ekeolu and Adebiyi, (2018) reported a PCV of 54.90% in *E. franqueti* but this is lower than the PCV of 62.1% seen in the same species in this present study. Arevalo *et al.* (1992) and Viljoen *et al.* (1997) concluded that bats have higher PCV and hemoglobin values when compared with other terrestrial mammals and that their varying blood-oxygen requirement during seasonal changes may also be responsible for the high hematocrit and hemoglobin levels reported in bats.

Leucocyte parameters are subject to changes depending on the health status of the sampled individuals. In this present study, there was no significant difference in the total WBC counts of the two species of bats sampled. The mean WBC count of 6.15 x10^{9}/L for *E. helvum* observed in this study was within the reference values reported by Selig *et al.* (2016). They also concluded that the WBC count of *E. helvum* was naturally lower when compared with other species of the pteropodid fruit bat. Furthermore, the WBC counts for *E. franqueti,* 5.03 x10^{9}/L, is lower than 13.46 x10^{9}/L which was reported by Ekeolu and Adebiyi (2018). The wide difference could be due to age, time and breeding season in which the animals were captured. There exists, however, variations within the cell types which make up the body's defence system. The mean values of neutrophils and platelets in *E. helvum* were significantly lower when compared with *E. franqueti*. On the contrary, mean values of lymphocytes and eosinophils were significantly higher in *E. helvum* when compared with the values obtained in *E. franqueti.*

The mean neutrophil count of 1.04 x10^{9}/L for *E. helvum* is however within the reference range de-scribed in previous works (Selig *et al.,* 2016). The mean neutrophil count of 3.31 x10^{9}/L for *E. franqueti* was lower than the mean value of 6.09 x10^{9}/L from the same bat species reported by Ekeolu and Adebiyi (2018). This observed reduced neutrophil count is subjective as the value recorded is close to the lower limit of neutrophil count of 5.62 x10^{9}/L reported in the study carried out by Ekeolu and Adebiyi (2018) which could have accommodated much variation in this parameter given a large sample size was used. However, the overall health status of the animals was not known and it is unlikely that they were free of pathogenic micro-organisms e.g. bacteria, which could possibly have caused the reduced neutrophil count without obvious clinical manifestation as bats are usually asymptomatic carriers of some diseases (Luis *et al.,* 2013).

Values of lymphocytes and eosinophils are indicators of the level of stress and parasitism/allergy within an animal respectively. Mean lymphocyte values of 4.33 x10^9/L in *E. helvum* observed in this present study is a little above the upper limit of the reference values (4.03 x10^9/L) reported by Selig *et al.* (2016). Prevalent environmental factors such as climatic conditions, food availability, diseases could contribute to the seeming lymphocytosis observed in this species. On the other hand, the apparent lymphopenia, 1.5 x10^9/L, seen in *E. franqueti* in this study is contrary to the mean value of 6.24 x10^9/L reported by previous authors (Ekeolu and Adebiyi, 2018). Stress factors and viral infections are some of the causes of lymphopenia and these, probably, could be the reason for the observed decreased lymphocyte count.

Eosinophil values, though significantly different between both species used in the present study, are within the reference range and values reported by previous authors (Selig *et al.,* 2016; Ekeolu and Adebiyi, 2018). The body weight of the two species of bats studied was significantly different with *E. helvum* higher than *E. franqueti*, both belonging to the sub-order *megachiroptera.* The mean body weight of *E. helvum* in this study was 285g and this is in agreement with the range of body weight reported by Mickleburgh *et al.* (2008). Similarly, *E. franqueti* had a mean body weight of 77g which is in consonance with the study conducted by Nowak and Walker (1994) where it was reported to range between 56-160g. Due to the nature of their habitats and feeding habits, bats are exposed to quite a number of parasites present within the environment. Both species of bats sampled in this present study were infested with either ectoparasites (bat flies), hemoparasites or both. *E. helvum* was infested with ectoparasites whereas none was observed on *E. franqueti*.

This gives credence to the reports of Nartey (unpublished data, 2015) who carried out a survey on bat species for parasites in Ghana in which he found out that *E. franqueti* had little or no ectoparasites infestation. According to his observation, most commonly encountered ectoparasites of bats include bat flies, mites, ticks, and fleas. Some species of bats harboured a high number of a particular kind of ectoparasite than other species of bats, indicating a high degree of host specialization among these parasites. In terms of bat flies, *Rousettus aegyptiacus, Lissonycterus angolensis* and *Eidolon helvum* were more heavily infested than the other species of bats and this may be attributed to the roosting habits of the three bat species (Nartey [unpublished data], 2015).

This report is in agreement with what was observed in this present study in which *Eidolon helvum* was found to be infested with bat flies of the family *Nycteribiidae* (*Nycteribia alternata* and *Eucampsipoda africanum*). *Eidolon helvum*, for instance, is the most widely distributed fruit bat in Africa which tend to live in groups of over 100,000; roosts can build up to millions at the same place at a time (Mickleburgh *et al.,* 2008). This results in individual bats being very close to each other for easy transfer of parasites across members of the colony. This may be the reason for the high number of parasites harboured by *E. helvum*.Furthermore, the present study had a prevalence of 30% for hemoparasitism in which hemoparasites were observed in both species of bats. The endoparasites reported in bats include protozoans [*Plasmodium* sp*., Nycteria* sp*., Hepatocystis* sp. and *Polychromophilus* sp. (Schaer *et al*., 2013)], trypanosomes (Thomas *et al.,* 2007). Nartey (unpublished data, 2015) reported that hemosporidial organisms; *Hepatocystis* sp., *Nycteria* sp. were observed in pteropodid bats, including *E. helvum* and *E. franqueti*, sampled in some region within Ghana. In this present study, out of 9 samples which were positive for hemoparasites.

4 samples were identified with *Babesia sp.* based on morphological identification criteria. Other hemoparasites identified were *Hemosporidia sp, Erhlichia sp,* Microfilaria and *Anaplasma sp.* The presence of ectoparasites on the body of bats has been linked with the prevalence of some hemoparasites as they serve as vectors for some of these protozoans (Kudo 1966). In this present study, there were no significant differences in body weight and hematological parameters of samples that were positive for hemoparasites when compared with the negative samples. This however means that the prevalence and occurrence of haemoparasitism did not alter, or better still, caused minimal change to the physiological status of the animals sampled.

Per-adventure, the system of the affected animals has been able to adapt favorably to accommodate the parasites and still maintain a stable homeostasis. Significant differences observed in haematological parameters and body weight of the species of bats that were ectoparasites positive when compared with those that had no ectoparasites was mostly due to species differences. Of the two species sampled in this study, *E. helvum* was the only species positive for ectoparasites while there was none on *E. franqueti.* Therefore, suffice to say that the observed variation in the body weight was expected as *E. helvum* are usually bigger than *E. franqueti* (Nowak and Walker, 1994; Mickleburgh *et al.,* 2008).

5. CONCLUSION

In conclusion, this present study reveals that fruit bats found in this environment, especially *Eidolon helvum,* are infested with ectoparasites which are mostly bat flies (*Nycteribia alternata* and *Eucampsipoda africanum*). The predominant protozoans are *Babesia-like* organism and *Hemosporidial* organisms which still require further identification. Therefore, fruits bats investigated in this present study were infested with parasites and were able to adapt favourably as parasitism did not affect the blood values.

REFERENCES

1. Albayrak I, Özcan HB, Baydemir M. (2016). Some hematological parameters in Myotis myotis and Myotis blythii (Mammalia: Chiroptera) in Turkey. Turk J Zool. 40:388–91.
2. Arevalo F, Parez SG, Lopez LP. (1992). Seasonal changes in blood parameters in the bat species Rhinolophus ferrumequinum Miniopterus schreibersi. Arch Physiol Biochem. 100:385–7.
3. Baker, K. S., Suu-Ire, R., Barr, J., Hayman, D. T. S., Broder, C. C., Horton, D. L., Wood, J. L. (2014). Viral antibody dynamics in a chiropteran host. *Journal of Animal Ecology*, *83*(2), 415–428. doi:10.1111/1365-2656.12153
4. Billeter, S. A., Hayman, D. T. S., Peel, A. J., Baker, K., Wood, J. L. N., Cunningham, A., Suu-ire, R, Dittmar, K. and Kosoy, M. Y. (2012). *Bartonella species* in bat flies *(Diptera: Nycteribiidae)* from Western Africa*. Parasitology* Pp 1-6. Cambridge University Press.
5. Ekeolu, O.K., Adebiyi, O.E. (2018). Hematology and erythrocyte osmotic fragility of the Franquet's fruit bat (*Epomops franqueti*). J Basic Clin Physiol Pharmacol; doi.org/10.1515/jb-cpp-2017-0169.
6. Fahr, J., Vierhaus, H., Hutterer, R., Kock, D. (2002). A revision of the Rhinolophus maclaudi spe-cies group with the description of a new species from West Africa (Chiroptera : Rhinolophidae). *Myotis*, *40* (December), 95–126.
7. Fankhauser, D.,B. (2003): Hemacytometer and Diluting Pipette Practice.
8. Fletchet, G. (2007). The reservoir of Marburg virus identified in a Species of Fruit Bat. *Actualite Scientifique, Institut de Recherche Pour Le Developpement*, *27*.
9. Gay, N., Olival, K. J., Bumrungsri, S., Siriaroonrat, B., Bourgarel, M., Morand, S. (2014). International Journal for Parasitology : Parasites and Wildlife Parasite and viral species richness of Southeast Asian bats : Fragmentation of area distribution matters. *Int. J. Parasitol: Parasites Wildlife*, *3*(2), 161–170. doi:10.1016/j.ijppaw.2014.06.003
10. Hamilton, P. B., Cruickshank, C., Stevens, J. R., Teixeira, M. M., Mathews, F. (2012). Parasites reveal movement of bats between the New and Old Worlds. *Molecular Phylogenetics and Evolution*, *63*(2), 521–526.
11. Hayman, D. T., Fooks, A. R., Horton, D., Suu-Ire, R., Breed, A. C., Cunningham, A. A., Wood, J. L. (2008). Antibodies against Lagos bat virus in megachiroptera from West Africa. *Emerging Infectious Diseases*, *14*(6), 926–928.
12. Hayman, D. T., Yu, M., Crameri, G., Wang, L.-F., Suu-Ire, R., Wood, J. L., Cunningham, A. (2012). Ebola virus antibodies in fruit bats, Ghana, West Africa. *Emerging Infectious Diseases*, *18*, 1207–9. doi:10.3201/eid1807.111654
13. Houwen, B. (2000). Blood film preparation and staining procedures. *Laboaratory Hematology*, *6*, 1–7.
14. Kamani, J., Baneth, G., Mitchell, M., Mumcuoglu, K. Y., Gutiérrez, R., and Harrus, S. (2014). *Bartonella Species in Bats (Chiroptera) and Bat Flies (Nycteribiidae) from Nigeria, West Africa.* Vector-borne and zoonotic diseases, *14*(9), 625–632. doi:10.1089/vbz.2013.1541.
15. Koopman, K. F. (1989). Systematic notes on Liberian bats. New York, NY: American Museum of Natural History.
16. Kudo, R. R. (1966). *Protozoology.* 5th edn. Thomas Books. Springfield, IL. pp 718-732.

17. Kunz, T.H. (1988). *Ecological and behavioral methods for the study of bats*. (T. H. Kunz, Ed.). London: Smithsonian Institution Press.
18. Luis, A. D., Hayman, D. T. S., O'Shea, T. J., Cryan, P. M., Gilbert, A. T., Pulliam, J. R. C., Webb, C.T. (2013). A comparison of bats and rodents as reservoirs of zoonotic viruses: are bats special? *Proceedings. Biological Sciences/The Royal Society*, *280*(1756), 20122753. doi:10.1098/ rspb.2012.2753.
19. Mickleburgh, S., Hutson, A. M., Bergmans, W., Fahr, J. and Racey, P. A. (2008). *Eidolon helvum.* In: IUCN 2009. IUCN Red List of Threatened Species.
20. Moratelli, R., & Calisher, C. H. (2015). Bats and zoonotic viruses : can we confidently link bats with emerging deadly viruses ? *Mem Inst Oswaldo Cruz, Rio de Janeiro*, *110*(1), 1–22. doi:10.1590/0074-02760150048
21. Nartey, N.A. (2015). Common parasites of fruit-eating bats in southern Ghana. (Unpublished M.Phil dissertation). Department of Animal Biology and Conservation Science, University of Ghana, Legon.
22. Newman, S. H., Field, H. E., de Jong, C. E., Epstein, J. H. (Eds.). (2011). *Investigating the role of bats in emerging zoonoses*.
23. Nowak R.M., Walker E.P. (1994). Walker's bats of the world, illustrated ed. Maryland: Johns Hopkins University Press, 64–65. ISBN 978-0-8018-4986-2.
24. Olayemi F.O., Fagbohun O.A., Aiki-Raji C.O., Oluwayelu D.O., Roberts O.O., Emikpe B.O., (2006). Hematology of the African fruit bat (Eidolon helvum). Trop Vet. 24: 81–4.
25. Olival, K. J., Islam, A., Yu, M., Anthony, S. J., Epstein, J. H., Khan, S. A., Daszak, P. (2013). Ebola virus antibodies in fruit bats, Bangladesh. *Emerging Infectious Diseases*, *19*(2), 270–273.
26. Ossa, G., Kramer-Schadt, S., Peel, A. J., Scharf, A. K., Voigt, C. C. (2012). The Movement Ecology of the Straw-Colored Fruit Bat, Eidolon helvum, in Sub-Saharan Africa Assessed by Stable Isotope Ratios. *PLoS ONE*, *7*(9), 1–9. doi:10.1371/journal.pone.0045729
27. Pagana, K.D., Pagana, T.J. (1997): Mosby's diagnostic and Laboratory Test Reference. 3rd Ed. St.Louis: Mosby.
28. Patterson, B. D., Dick, C. W., Dittmar, K. (2008). Parasitism by bat flies (Diptera : Streblidae) on neotropical bats : effects of host body size, distribution and abundance, 1091–1100. doi:10.1007/s00436-008-1097-y.
29. Ratnasooriya WD, Udagama-Randeniya PV, Yapa WB, Digana PM, Dharmasiri MG. (2005). Haematological parameters of three species of wild caught microchiropteran bats, Miniopterus schreibersii, Taphozous melanopogon and Hipposideros lankadiva in Sri Lanka. SLAFAS 2005; 2:27–40.
30. Richter, H. V., Cumming, G. S. (2005). Food availability and annual migration of the straw colored fruit bat (Eidolon helvum). *Journal of Zoology*, *268*(1), 35–44. doi:10.1111/j.1469-7998.2005.00020.x
31. Rosevear, D. R. (1965). *The bats of West Africa*. Kent: Her Majesty's Printers at The Thanet Press, Margate, Kent.
32. Schaer, J., Perkins, S. L., Decher, J., Leendertz, F. H., Fahr, J., Weber, N. Matuschewski, K. (2013). *High diversity of West African bat malaria parasites and a tight link with rodent Plasmodium taxa.* Proceedings of the National Academy of Science, 110 (43): 17415-17419
33. Schalm, O.W., Jain, N.C., Carrol, E.J. (1975). Veterinary Haematology 3rd Edn Lea and Febiger, Philadephia: pp. 15 – 81.

34. Schneeberger, K., Czirják, G. Á., & Voigt, C. C. (2013). Measures of the Constitutive Immune System Are Linked to Diet and Roosting Habits of Neotropical Bats. *PLoS ONE*, *8*(1), 2–8. doi:10.1371/journal.pone.0054023
35. Selig M, Lewandowski A, Kent MS. (2016). Establishment of reference intervals for hematology and biochemistry analytes in a captive colony of straw-colored fruit bats (*Eidolon helvum*). J Zoo Wildl Med. 47(1): 106–112.
36. Simmons, N. B. (2005). *Mammal species of the world: a taxonomic and geographic reference*.
37. Stamminger, G., Auch, D., Diem, H., Sinha, P. (2002). Performance of the XE-2100 leucocyte(W.D.E.&R.D.M.,Eds.)(3rded.).Baltimore, Maryland: John Hopkins differential. International Journal of Laboratory Hematology. 24(5), 271-280.
38. Thomas M.E, Rasweiler J.J., D'Alessandro A. (2007). *Experimental transmission of the parasitic flagellates Trypanosoma cruzi and Trypanosoma rangeli between triatomine bugs or mice and captive Neotropical bats.* Mem Inst Oswaldo Cruz, Rio de Janeiro, Vol. 102(5): 559-565.
39. Viljoen M, Merwe MV, Bower G, Levay PE, Grobler AS. (1997). Peripheral blood characteris-tics of gravid Schreiber's long-fingered bats, Miniopterus schreibersii natalensis. S Afr J Sci. 93:414–8.
40. Wołk E, Ruprecht A.L. (1988). Haematological values in the serotine Bat, *Eptesicus serotinus* (*Schreber, 1774*). Acta Theriol. 33:545–53