

4.2.1.5.2 Parasitic load of bats captured in urban and rural sites

Bats captured at the rural areas carried a higher ectoparasite load than bats captured at the urban areas (Figure 4.5). The number of bat flies recorded on individual bats in the rural areas ranged from one to six with an average of 0.24. Bats captured at the rural areas harboured mites ranging from 1 - 25 with an average of 0.40. Finally, the number of ticks recorded on individual bats in the rural areas ranged from 1 - 88 with an average of 0.66.

A Kruskal-Wallis H test showed a significant difference in bat fly infestation in rural and urban sites ($X^2= 4.58$, $df = 1$, $p\text{-value}= 0.03233$) with bats at the urban areas harbouring more ectoparasites per individual bat. There was no significant difference in load of mites and ticks infestations between urban and rural dwellings ($X^2= 0.21$, $df = 1$, $p\text{-value}- 0.6441$ and $X^2= 2.51$, $df = 1$, $p\text{-value}= 0.1133$ respectively).

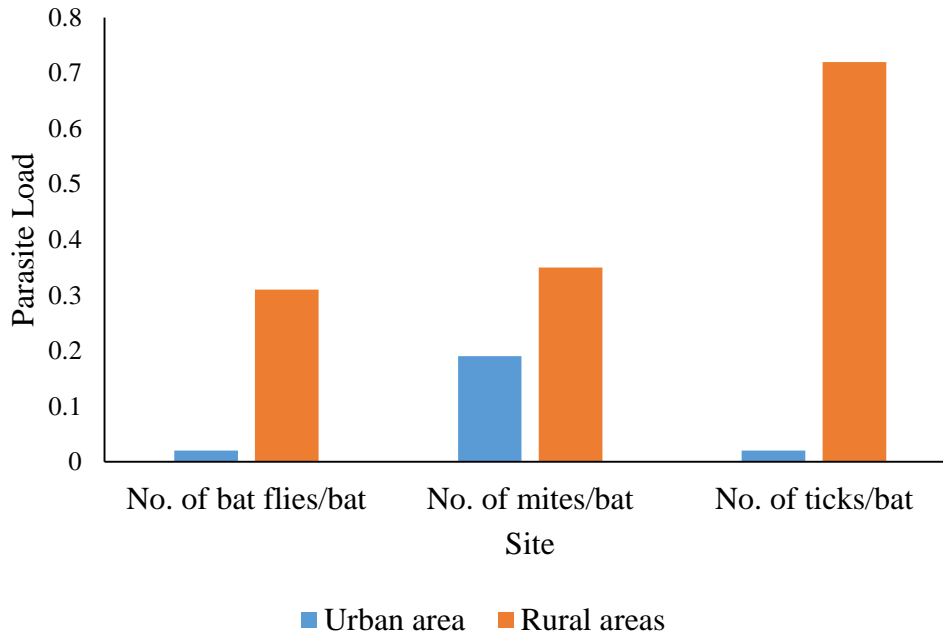


Figure 4.5: Comparison of the load of ectoparasite infestation on bats at urban and rural dwellings.

The highest load of bat flies (0.78) and mite (0.61) infestation per bat was harboured by bats captured at the Tanoboase Sacred Grove (Figure 4.5). In contrast, the lowest load of bat flies (0.02) and mites (0.19) per bat was harboured by bats at the '37' Military Hospital. Bats captured at Ve-Golokuati (Figure 4.6) harboured the highest load of ticks per bat (1.13) while the least infestation of ticks per bat occurred at the Tanoboase Sacred Grove (0.02).

A Kruskal-Wallis H test was used to test for significance in parasite load across the four study sites. Bats at the Tanoboase Sacred Grove harboured a significantly higher number of bat flies ($\chi^2=91.10$, $df=3$, $p\text{-value}<0.01$) while '37' Military Hospital harboured the least load (Figure 4.6). On the contrary, the differences in load of mites and ticks were not significant ($\chi^2=6.83$, $df=3$, $p\text{-value}=0.0774$ and $\chi^2=6.93$, $df=3$, $p\text{-value}=0.0742$ respectively).

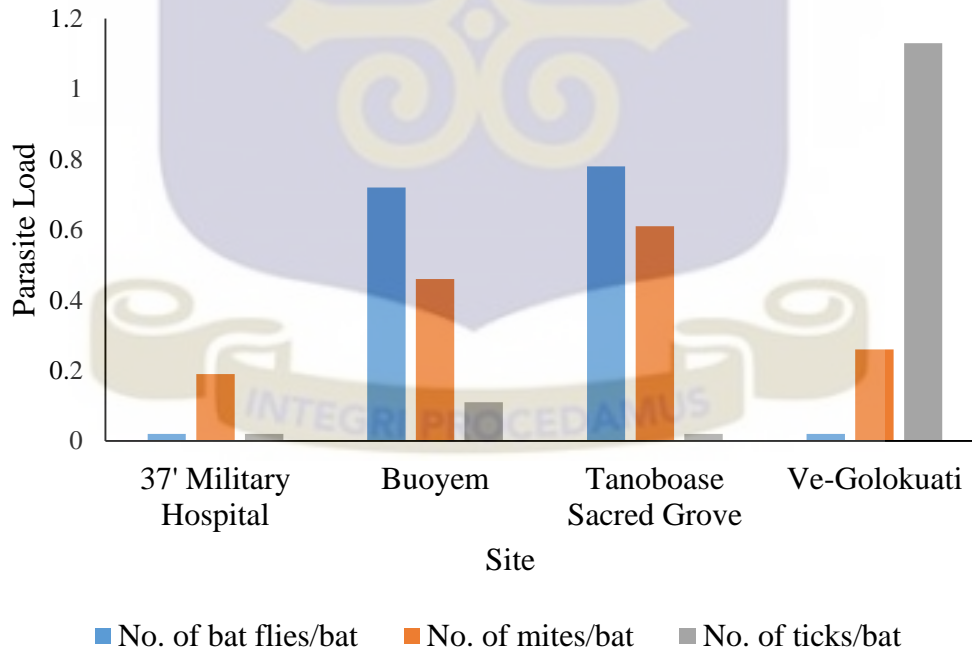


Figure 4.6: Comparison of load of bat fly, mite and tick infestations at the four capture sites.

4.2.1.6 Monthly variation in ectoparasite prevalence and intensity of infestation

4.2.1.6.1 Monthly variation in prevalence

The highest proportion of infested bats was recorded in the month of March (44.06%) while the lowest proportion was recorded in August (20%) (Figure 4.7).

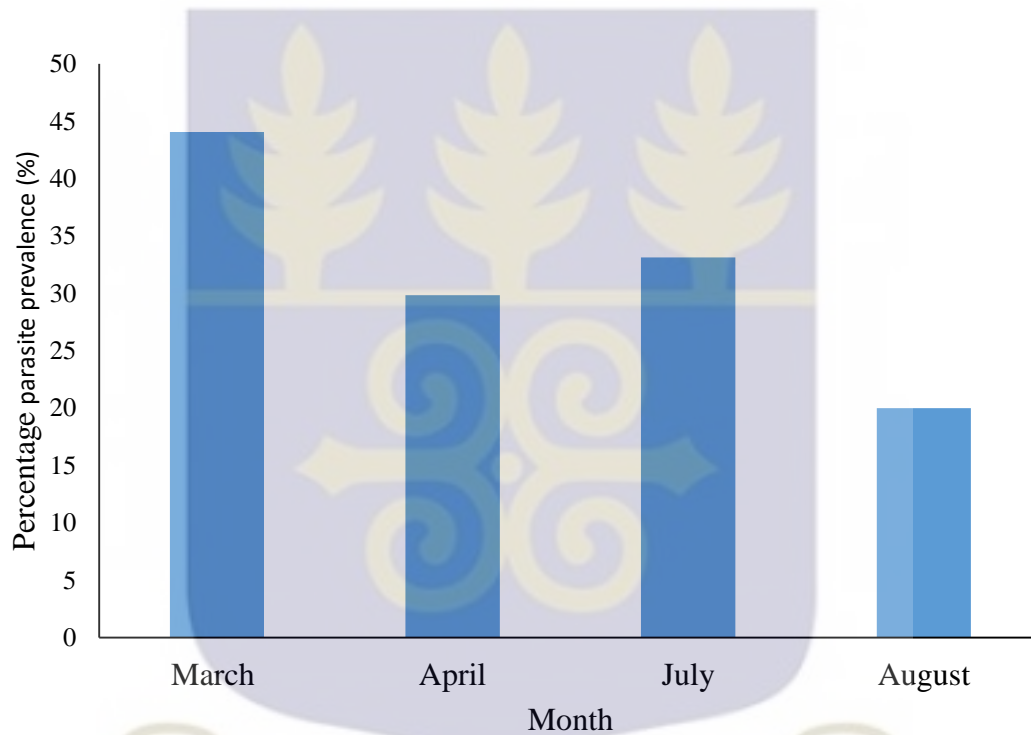


Figure 4.7: Monthly prevalence of ectoparasite on bats.

4.2.1.6.2 Monthly difference in ectoparasite load

Bats captured in March harboured the highest load of bat flies (0.53) than bats captured in the other months (April, July, August). No bat flies were recorded in April. The highest load of mites was recorded in July (0.41) and the lowest in April (0.09). The difference in bat fly and mite infestations among the months was significant (Kruskal-Wallis H test: $X^2= 27.43$, $df = 3$, $p\text{-value} < 0.01$ and Kruskal-Wallis H test: $X^2= 8.28$, $df = 3$, $p\text{-value}= 0.04$ respectively). In contrast, the highest number of ticks per bats occurred in the month of April (5.00) while the least number of ticks per bat was recorded in August (0.02) (Figure 4.8). There was also a significant difference in tick infestation among the months (Kruskal-Wallis H test: $X^2= 24.76$, $df = 3$, $p\text{-value} < 0.01$). For the three ectoparasite groups studied, their mean ectoparasite load varied significantly between the months.

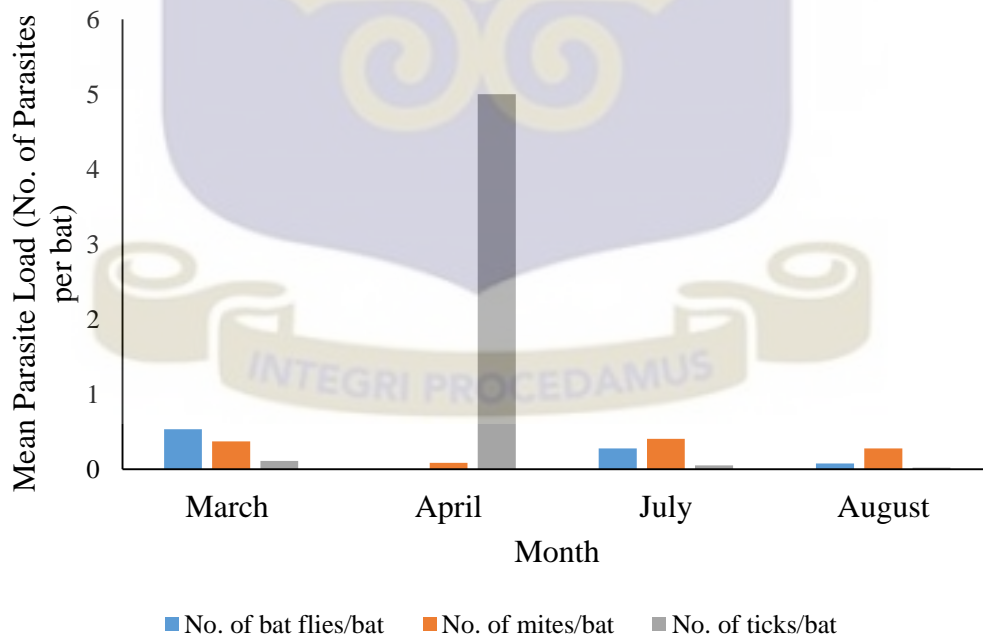


Figure 4.8: Monthly comparison of ectoparasitic load on total number of bats captured.

4.2.1.7 Influence of reproductive status on ectoparasite infestation of female bats

4.2.1.7.1 Differences in ectoparasite prevalence in reproductive and non-reproductive female bats

Female bats that were sampled from the various sites included pregnant and lactating females. *Epomophorus gambianus* had the highest proportion of pregnant female bats (31 out of 115) captured and *R. aegyptiacus* had the least number of pregnant females (1 out of 11) (Figure 4.11). Lactating females of *E. gambianus* captured (18 out of 115) were more than lactating females of the other species. No lactating females of *R. aegyptiacus*, *E. helvum* and *H. monstrosus* were captured.

All pregnant females of *R. aegyptiacus*, *E. helvum* and *H. monstrosus* were infested with ectoparasites. Pregnant females of *E. buettikoferi* and *E. franqueti* showed no infestation.

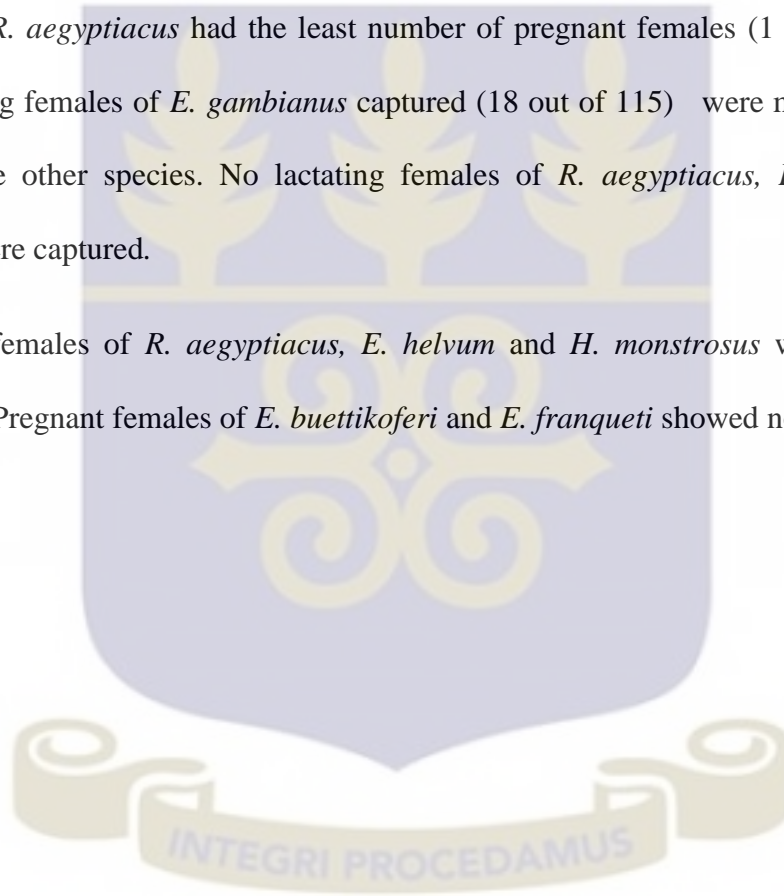
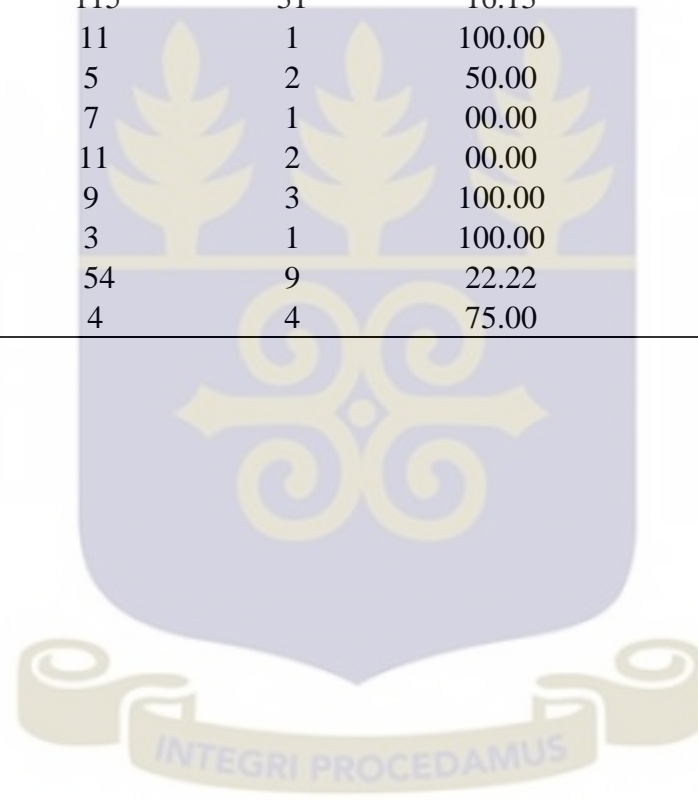


Table 4.11: Ectoparasite infestation prevalence of pregnant and lactating females examined from the different study sites.

Species	Total no. of females captured	No. of pregnant females	Proportion of pregnant females infested (%)	No. of lactating females	Proportion of lactating females infested (%)
<i>Epomophorus gambianus</i>	115	31	16.13	18	22.22
<i>Rousettus aegyptiacus</i>	11	1	100.00	0	00.00
<i>Lissonycteris angolensis</i>	5	2	50.00	1	00.00
<i>Epomops buettikoferi</i>	7	1	00.00	4	25.00
<i>Epomops franqueti</i>	11	2	00.00	2	50.00
<i>Eidolon helvum</i>	9	3	100.00	0	00.00
<i>Hypsignathus monstrosus</i>	3	1	100.00	0	00.00
<i>Micropteropus pusillus</i>	54	9	22.22	3	66.70
<i>Nanonycteris veldkampi</i>	4	4	75.00	1	100.00



4.2.1.7.2 Parasitic load of reproductive and non-reproductive females

The number of bat flies harboured by non-reproductive females ranged from 1-3 with a mean load of 0.15 bat flies per bat. The number of mites ranged from 1-5 with a mean of 0.34 mites per bat. Pregnant females harboured bat flies with numbers ranging from 1-5 with a mean of 0.26 bat flies per bat. The number of mites harboured by pregnant females ranged from 1 to 25 with a mean of 0.63 mites per bats. Lactating female bats harboured bat flies (0.07 bat flies per bat) and mites (0.24 mites per bat). The number of ticks on lactating females ranged from 1- 32 with a mean of 1.55 ticks per bats; there was no significant difference in tick infestation between lactating and non-reproductive females (Kruskal-Wallis H test: $X^2 = 1.68$, $df = 2$, p -value = 0.4317). Pregnant females did not harbour any ticks. There was no significant difference in bat fly (Kruskal-Wallis H test: $X^2 = 0.84$, $df = 2$, p -value = 0.6557) and mite (Kruskal-Wallis H test: $X^2 = 1.58$, $df = 2$, p -value = 0.4547) infestations between reproductive and non-reproductive females.

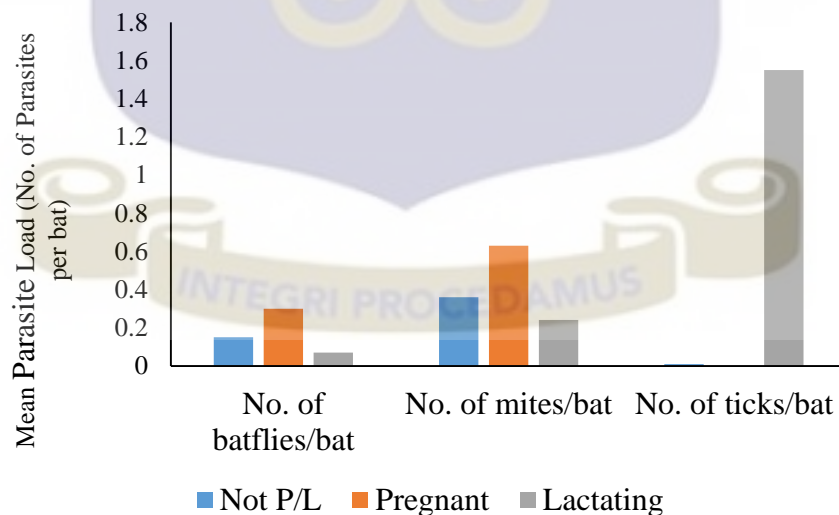
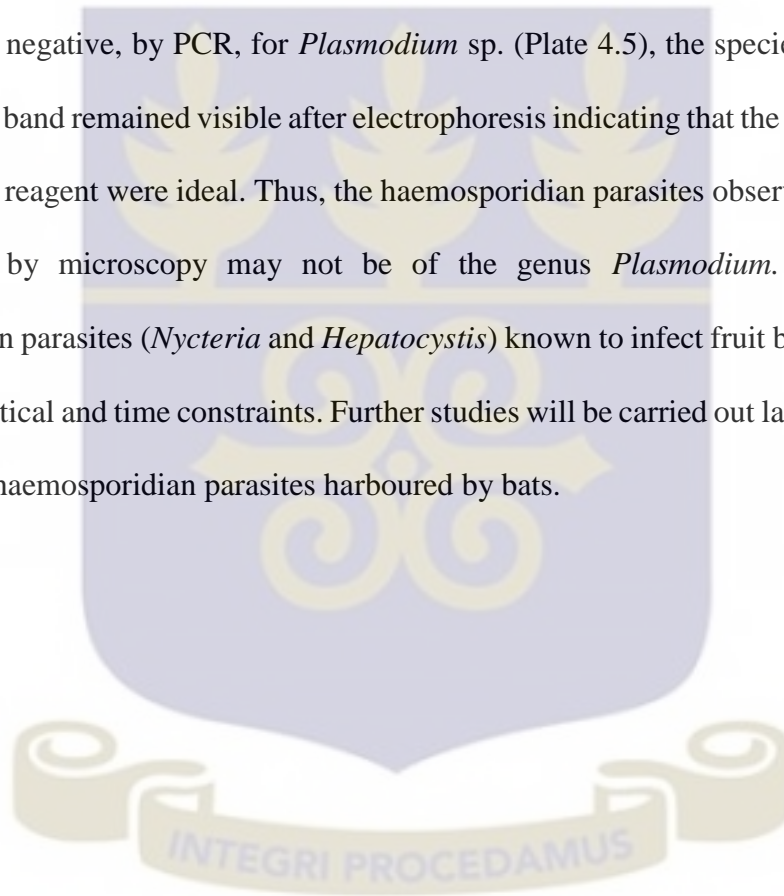


Figure 4.9: Comparison of load of bat fly, mite and tick infestations of female bats (non-reproductive, pregnant and lactating).

4.2.2 Bat infestation with endoparasites

4.2.2.1 Identification of haemoparasites

Approximately 48 percent of the total number of bats captured for which blood samples were taken and examined microscopically (Plate 4.4), were infected with haemoparasites. These haemoparasites were recorded in all the nine species of bats captured in the present study. Positive samples were molecularly tested to determine the species of haemoparasites. All samples tested negative, by PCR, for *Plasmodium* sp. (Plate 4.5), the species of interest. The control sample band remained visible after electrophoresis indicating that the PCR amplification conditions and reagent were ideal. Thus, the haemosporidian parasites observed in the blood of sampled bats by microscopy may not be of the genus *Plasmodium*. Other genera of haemosporidian parasites (*Nycteria* and *Hepatocystis*) known to infect fruit bats were not tested for due to logistical and time constraints. Further studies will be carried out later on to determine the species of haemosporidian parasites harboured by bats.



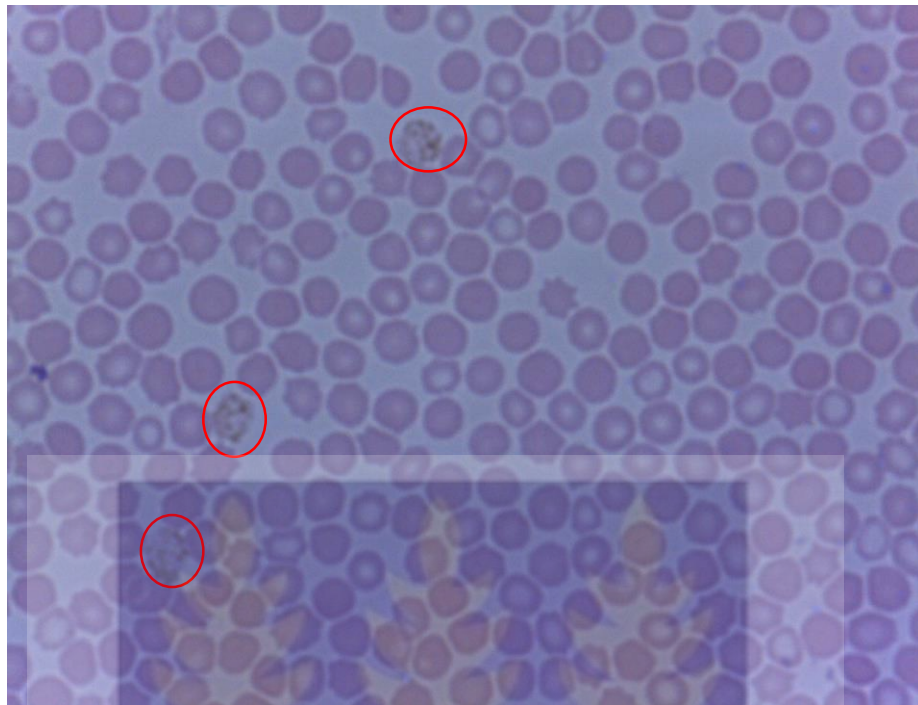
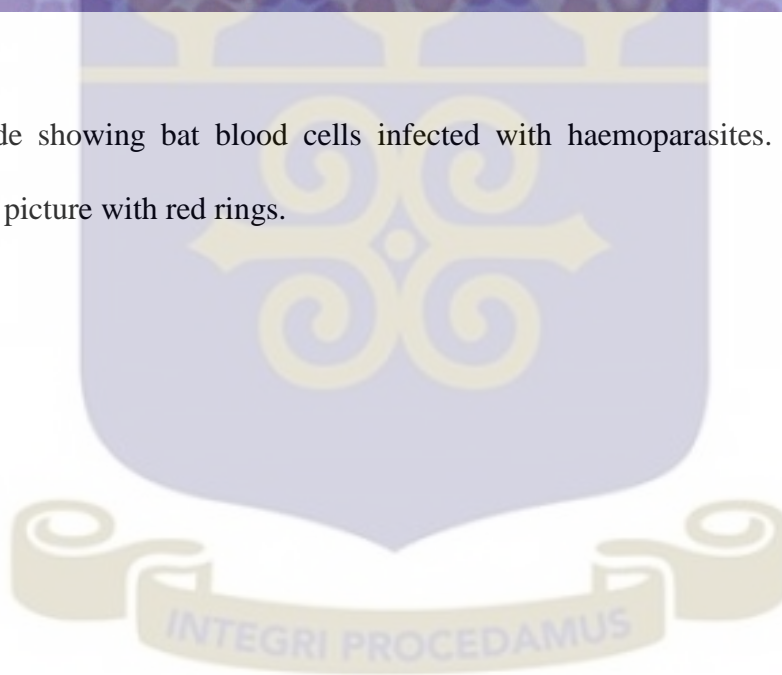


Plate 4.4: Slide showing bat blood cells infected with haemoparasites. Infected cells are depicted in the picture with red rings.



4.2.2.2 Prevalence of haemoparasite infection

The proportions of the different species of bats infected with haemoparasites are as shown in Figure 4.10. Prevalence of blood parasites infection was highest in *Nanonycteris veldkampi* (80%) with the lowest observed in *H. monstrosus* (33.33%).

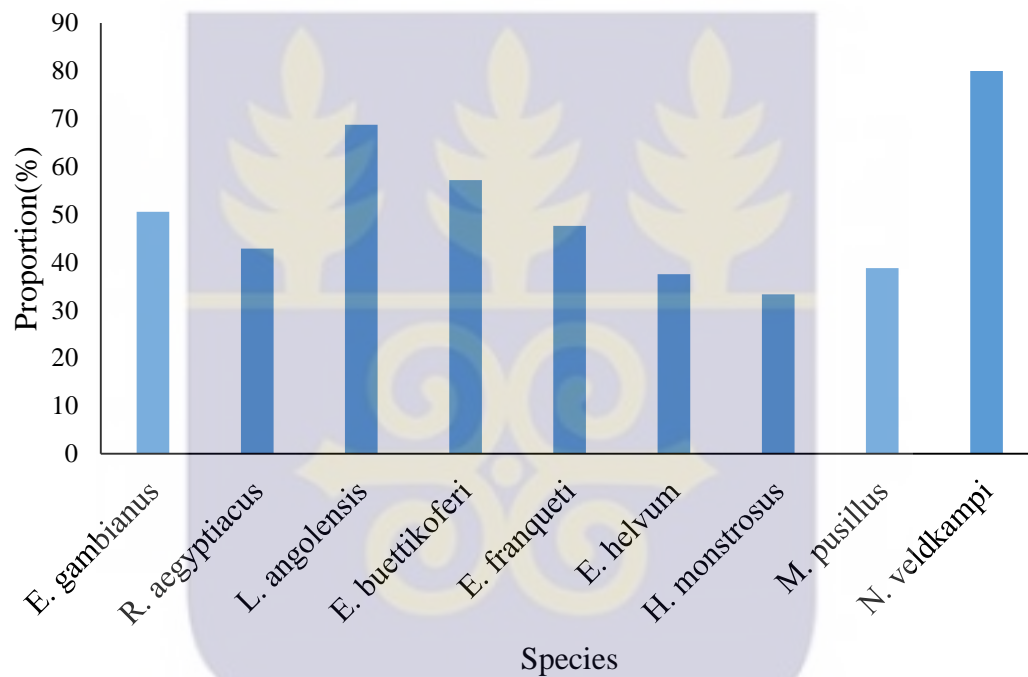


Figure 4.10: Percentage prevalence of haemoparasite infection among the nine species of bats examined during the study.

A higher proportion of male bats (48.85% [128 out of 262]) were infected with haemoparasites as compared to female bats (46.54% [101 out of 217]) (Figure 4.11), however the difference was not significant (Mann-Whitney test: $U = 28335$, $df = 1$, $p\text{-value} = 0.9438$). With respect to age categories, the highest prevalence of haemoparasitic infections occurred among juvenile bats (50.34% [75 out of 149] showed infection), with the least observed in sub-adult bats (45.52% (66 out of 145)) (Figure 4.12). There was again no significant difference in infestation among the age categories (Kruskal-Wallis H test: $X^2 = 0.26$, $df = 2$, $p\text{-value} = 0.8766$).

Comparing infection prevalence in bats at the different capture sites, bats captured at the '37' Military Hospital showed the highest prevalence of 54.17% [26 out of 48] (Figure 4.13). In contrast, bats captured at Ve-Golokuati (43.35% [114 out of 263]) were the least infected. There was no significant difference in infection of bats at the different capture sites (Kruskal-Wallis H test: $X^2 = 3.74$, $df = 3$, $p\text{-value} = 0.2911$).

Comparing infection prevalence in bats in the different capture months, the highest proportion of infection was recorded in August (53.14%) while the least proportion was recorded in July (33.33%) (Figure 4.14).



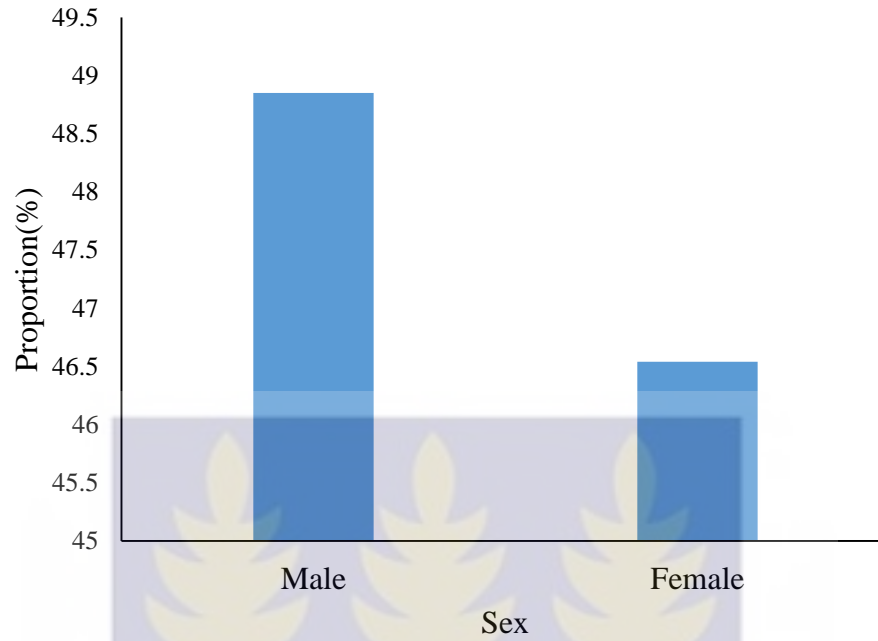


Figure 4.11: Proportion of male and female bats infected with haemoparasites.

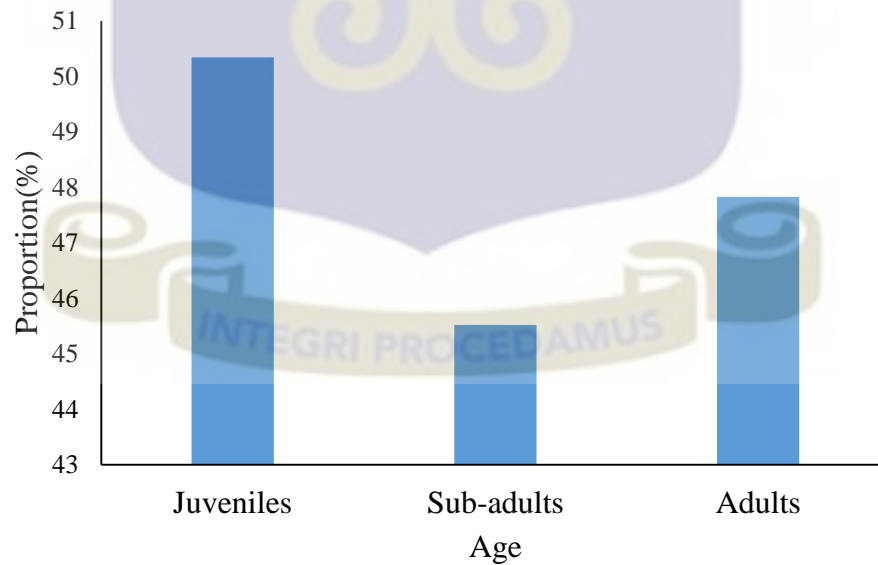


Figure 4.12: Prevalence of haemoparasitic infection among the different age categories of bats.

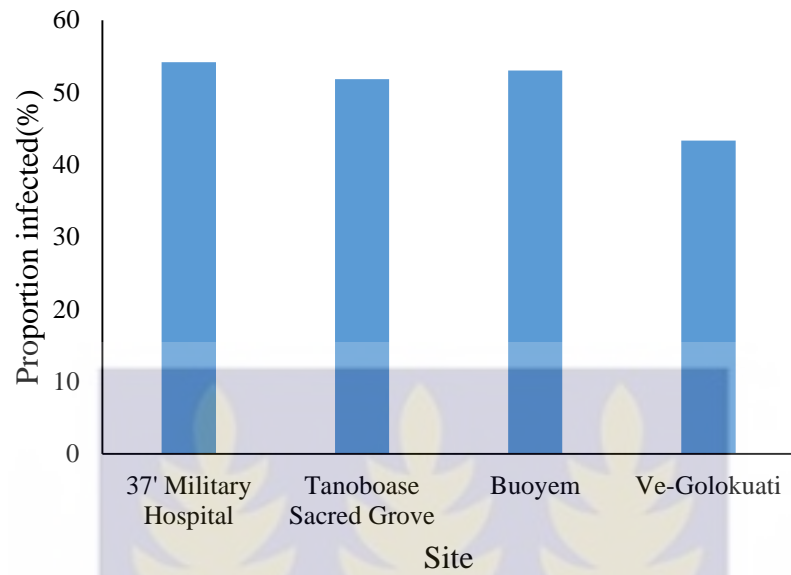


Figure 4.13: Prevalence of haemoparasitic infections among bats at the different capture sites.

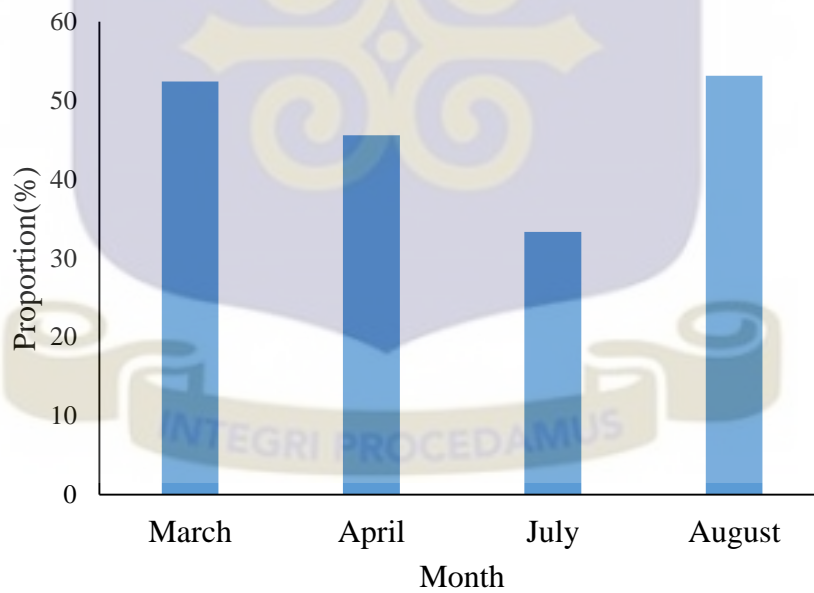


Figure 4.14: Proportion of bats infected with haemoparasites in the different months of capture.

The highest proportion of bats infected with haemoparasites were lactating female bats (68.97% [20 out of 29]) (Figure 4.15). Pregnant female bats were the least infected (42.59% [23 out of 54]). A Pearson Chi-Square test indicated that there was a significant difference in haemoparasite infection among female bats in the different reproductive status ($X^2 = 37.738$, $df = 102$, $p\text{-value} < 0.01$).

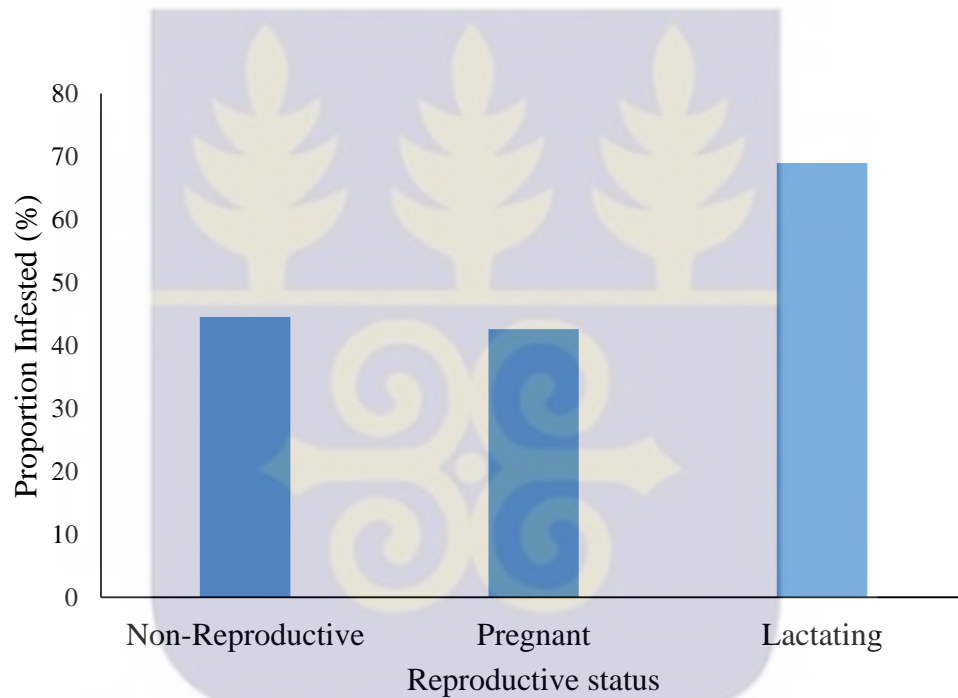


Figure 4.15: Proportion of female bats infected with haemoparasites.

4.2.2.3 Helminth Infestation

Faecal samples of 29 bats were screened by PCR for helminthes (nematodes, cestodes and trematodes). Positive and negative controls were used to assess the fidelity of the PCR reagents and thermal cycling conditions as well as serve as standards to compare with samples that were tested. Extracted DNA of *Schistosoma mansoni* and *Wuchereria bancrofti* were used for the controls for trematodes and nematodes respectively. *Taenia saginata* DNA was used as control for cestodes. All 29 samples tested negative.



CHAPTER FIVE

5.0 DISCUSSION

5.1 Ectoparasite distribution and role in disease transmission

All species of bats captured and examined were infested with both ectoparasites (bat flies, ticks, mites, bat bug) and endoparasites (hemoparasites). The four species of bat flies recorded belonged to the superfamily Hippoboscoidea. This family is primarily found in the Old World tropics and only a few of the 274 known species occur in the Neotropics and in Europe (Gracioli and Dick, 2008). *Nycteribia alternata*, a common species of bat fly, was recorded on several of the bat species examined. These flies have been reported on bats from the Afadzato Agumatsa Range in a previous study (Nartey, Unpublished data). Maa (1962) indicated that this bat fly was first observed on *E. helvum* in Cameroun by Kerr in 1936. In this study, they were recorded on bats from the '37' Military Hospital, Buoyem and the Tanoboase Sacred Grove but not at Ve-Golokuati, which comes as a surprise considering the fact that Ve-Golokuati (N 06° 59.851', E 000° 26.218') is geographically not far from the Afadzato Agumatsa Range (N 7° 1.00', E 0° 34.00'). The bat species that harboured *N. alternata* were *Epomophorus gambianus*, *Rousettus aegyptiacus*, *Lissonycteris angolensis*, *Eidolon helvum* and *Nanonycteris veldkampii*. This confirms the fact that *N. alternata* is a common parasite of bats and is not host specific.

Cyclopodia greefi greefi, another common bat fly, has been reported to occur on *Rousettus angolensis* (now *Lissonycteris angolensis*) and *Epomophorus* sp. (Maa, 1962), but more commonly on *E. helvum*. In this study, *C. greefi greefi* was recorded on *R. aegyptiacus*, *E. gambianus* and *L. angolensis*, with the highest infestation occurring on *E. helvum* which confirms that, indeed, these bat fly species commonly occur on *E. helvum*. Funmilayo (1976)

also reported that *E. helvum* harboured higher numbers of *C. greefi greefi* than other species of bats in a study done in Nigeria. *C. greefi greefi* was also observed on *E. helvum* specimens from Ghana (Billeter *et al.*, 2012). The occurrence of *C. greefi greefi* on *E. gambianus* is uncommon (ACR, 2014).

The bat fly *Eucampsipoda africanum*, on the other hand, was not as common as *N. alternata* and *C. greefi greefi*. Of the nine individual *E. africanum* recorded, five were picked from *R. aegyptiacus* and four from *L. angolensis*. *E. africanum* has been reported previously to occur commonly on these two species of bats as well as on *E. helvum* (Theodor, 1956). *E. africanum* is reported also to be widely distributed over the Ethiopian region and recorded from localities in Senegal to the Sudan and southwards to the Cape (Haeselbarth *et al.*, 1966). Despite previous reports of *E. africanum* as a common bat fly of *E. helvum*, *R. aegyptiacus* and *L. angolensis* and the high numbers of these species of bats examined in the study, only four bats were found to be infested with this bat fly. The findings from this study suggests that the species may not be as common in Western Africa.

Eremoctenia vandeuseni was the most uncommon bat fly recorded in the study with just four individuals recorded on *Lissonycteris angolensis*. *E. vandeuseni* was first recorded on *Miniopterus* sp. from West New Guinea (Maa, 1962). According to Anciaux de Faveaux (1971), bat flies usually encountered on *Lissonycteris angolensis* include *Cyclopodia greeffi*, *Dipseliopoda biannulata* and *Dipseliopoda setosa*. However, none of these bat fly species were collected on *L. angolensis* in this study. The bat species *Epomops buettikoferi*, *Epomops franqueti*, *Micropteropus pusillus* and *Hypsignathus monstrosus* were not infested with bat flies and this supports the fact that no reported cases of infestation of the four bat species with bat

flies were found in the literature. These species of bats are known to roost singly or in small groups (Kunz, 1996; Jones, 1972; Bradbury, 1977) and this may limit cross infestation with bat flies common on other bat species. Incidentally, these bat species also rarely harboured mites and ticks.

Mites recorded on bats in this study belonged to the families Spinturnicidae, Carpglyphidae, Psoroptidae, Tyroglyphidae, Trombiculidae and Pyemotidae. The highest incidence of mite infestation on bats occurred with mites belonging to the family Spinturnicidae which comprise three genera (*Spinturnix*, *Ancystropus* and *Meristaspis*). Mites of the family Spinturnicidae were recorded on all species of bats examined in this study.

Spinturnix sp. were the most common mites recorded and were found on six different bat species (*E. gambianus*, *R. aegyptiacus*, *E. helvum*, *H. monstrosus*, *L. angolensis* and *H. monstrosus*). According to Bruyndonckx *et al.* (2009), different species of the genus *Spinturnix* rarely occur on the same individual bat. However, in this study, an individual *Eidolon helvum*, was found to harbour three different *Spinturnix* species (*Spinturnix verutus*, *Spinturnix americana* and *Spinturnix* sp.). The mite species *Meristaspis kenyaensis* has been reported on *R. aegyptiacus* (Hafez *et al.*, 1994) and also on *E. helvum* (Dusbabek and Bergmans, 1980). In this study, *M. kenyaensis* was shown to infest *R. aegyptiacus* and *E. helvum* and may therefore be host specific to these species of bats (*E. helvum* and *R. aegyptiacus*). *Ancystropus zeleborii*, another common mite, was first reported from *R. aegyptiacus* by Kolenati (1857). In this study, *A. zeleborii* was collected from *E. helvum* and *H. monstrosus*. The only two species of bats from which mites were collected were *Epomops buettikoferi* and *Nanonycteris veldkampii*, probably due to the low number of these bat species captured, as suggested by Bertola *et al.* (2005). Not much is known

about ectoparasites infesting *E. buettikoferi* and *N. veldkampii* (ACR, 2014). However, a mite species *Ancystropus aethiopicus* has been recorded on *N. veldkampii* and *M. pusillus* (Hirst, 1923). In this study, *Trombicula* sp. (biting mites) were found on a single individual of *N. veldkampii*. This is a significant finding since *Trombicula* sp. have been reported to transmit *Orientia tsutsugamushi*, the causative agent of typhus fever in Asia and the Pacific region (Watt and Parola, 2003; Kelly *et al.*, 2009). Of significance also is the record of the Ebola virus reported in *N. veldkampii* species captured in Ghana (Hayman *et al.*, 2012). *N. veldkampii* thus remains an important bat species worth further investigation in order to shed light on their potential role as reservoirs of human pathogens.

Mites in general cause mainly severe allergic responses, eczema and asthma in humans causing discomfort and pain (Walker, 1996). However, *Spinturnix americana* and *Spinturnix verutus* have not yet been implicated in the transmission of any pathogens or diseases and therefore may not be of any public health importance immediately. *Otodectes cynotis* is found around the world (Hering, 1838) and is known to occur in the ears of canids, foxes, cats, ferrets (Curtis, 2004; Otranto *et al.*, 2004). This mite was collected on four species of bats; *E. gambianus*, *E. franqueti*, *E. helvum* and *M. pusillus* in this study with the highest number occurring on *M. pusillus* (55.56%) and the least number occurring on *E. helvum* (11.11%) and *E. gambianus* (11.11%). *O. cynotis* feed on the epidermal debris inside the ear of the host and mainly causes *otitis externa*, which is associated with thick reddish-brown crusts in the ear canals. *O. cynotis* infection causes severe pruritis in these animals (Griffin *et al.*, 2001). It is possible for humans to acquire ear mites but this is rare. There are a few reports of suspected infections with *Otodectes* mites in people (Weese, 2010). One report cited ear mites on the torso and extremities of the owner of a cocker spaniel and another reported six mites from crusts on a woman's

eardrum (Curtis, 2004). *O. cynotis* infestation can lead also to secondary microbial infections with bacteria and fungi (Roy *et al.*, 2011) hence they are of significant public health importance. Several *Acarus* sp. were recorded on the bats examined in the current study and were found on *R. aegyptiacus*, *E. franqueti* and most abundantly on *E. gambianus*. *Acarus* sp. affect humans in various ways. Human cases of enteric acariasis, caused by *Acarus* sp., have been reported where mites were found in excreta, suggesting their presence in the digestive tract (Martinez-Marañón and Hoffman, 1976). Most of the acarid mites implicated in these cases belong to the genera *Acarus*, *Suidasia*, or *Tyrophagus*. *Acarus* sp. could have significant effects on the health of humans in communities where they are endemic due to their role in causing enteric acariasis. *Suidasia ponsifica* was recovered from the feces of a woman and two infants in Mexico (Martinez- Marañón and Hoffman, 1976) while various stages of an *Acarus* sp. together with eggs, were recovered from the bile of a Romanian patient with chronic cholecystitis (Pitariu *et al.*, 1978).

Carpoglyphus sp. recorded on six bat species (*E. gambianus*, *R. aegyptiacus*, *L. angolensis*, *E. franqueti*, *E. helvum* and *M. pusillus*) in the current study, has been associated previously with a case of pulmonary acariasis (presence of mites in sputum) in Spain (Taboada, 1954). Pulmonary acariasis causes allergies which could lead to severe allergic sensitization and discomfort in humans. *Carpoglyphus* sp. can cause also Grocer's itch, which is a cutaneous condition characterized by pruritic dermatitis (William *et al.*, 2006). The public health importance of other mite species recorded rarely in this study (*Periglischrus* sp., *Pyemotis* sp. and *Steatonyssus longipes*) is unknown.

Species belonging to two families of ticks (*Argas vespertilionis* and *Ixodes* sp.) were infected on *E. gambianus*, *R. aegyptiacus* and *M. pusillus*. *Argas vespertilionis* is a common tick

occurring on bats and has been reported to infest the bat species *R. aegyptiacus*, *Pipistrellus pipistrellus*, *Pipistrellus kuhlii* and *Tadarida teniotis* (Latreille, 1802). It would appear therefore that this tick species infest both fruit-eating and insect-eating bats. The rarity of *Ixodes* ticks on bats examined in this study suggests that ticks of the family Ixodidae do not commonly infest bats. Tick bites may cause severe allergic reactions and tick paralysis which in turn causes unsteady gait, weakness of the limbs, multiple rashes, headache, fever, flu-like symptoms, tender lymph nodes and partial facial paralysis (Traub and Cummins, 2011). Tick typhus caused by a bacterium, *Rickettsia* sp., which is transmitted by the tick *Amblyomma maculatum*, may also cause headaches, multiple rashes, swollen glands, fever and flu-like symptoms. The disease is rarely fatal and readily responds to antibiotic therapy (Webb *et al.*, 2012). *Borrelia* sp. is transmitted by the tick *Ixodes scapularis* and some common symptoms in humans infected include aches, fever, muscle and joint pain, and arthritis. According to Webb *et al.* (2012), twenty people died from tick paralysis between 1925 and 1945, but improvements in modern medicine and the development of a tick antitoxin have prevented further deaths in the last 65 years.

Tick infestation in livestock and domestic animals is equally important as tick infestation causes significant losses in livestock (cattle, rabbits, guinea pigs) and discomfort to domestic animals. Losses in cattle arise from damage to hides, loss of productivity, anaemia, death and weakness leading to greater mortalities (Merck Veterinary Manual, 1998). The tick *Dermacentor variabilis* which transmits *Rickettsia rickettsia* causes tick paralysis in cattle, dogs, cats as well as humans (Dryden and Payne, 2004). The tick *Ixodes scapularis* has also been implicated in the transmission of *Borrelia* sp. in cats, dogs in addition to the reported cases in humans. *Argas vespertilionis*, is known to transmit *Borrelia* sp., *Rickettsiae* sp. and *Ehrlichia* sp. in bats

(Socolovschi *et al.*, 2012). Hoogstraal (1952) noticed that the nymphs and adult of *A. vespertilionis* bite humans in caves hence they have the potential to transmit pathogens from bat ticks to humans.

5.2 Ectoparasitic prevalence on bat species

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, *R. aegyptiacus*, *L. angolensis* and *E. 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. *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*. *Rousettus aegyptiacus* roost in caves (Albayrak *et al.*, 2008) which create favourable conditions for the spread of parasites among these bats since there could be hundreds of bats in a single cave at a time. Despite the few individuals of *L. angolensis* captured, a high proportion of them were infested with bat flies (70.59%). *R. aegyptiacus* and *L. angolensis* appeared to share similar parasites, specifically bat flies. Weber and Fahr (2006) indicated that *L. angolensis* also depends largely or exclusively on the availability of caves as day roosting sites so this would explain why the two species share similar parasites. Until recently, the two species were considered to be one species until they were separated into different species on the basis of the differences in the use of the limbs, and the absence of echolocation in *L. angolensis* (Lawrence and Novick, 1963).

5.3 Ectoparasite infestation prevalence in different sexes and age groups of bats

A number of studies found female bats to harbour more ectoparasites than male bats (Schalk and Forbes, 1997; McCurdy *et al.*, 1998; Morales- Montor *et al.*, 2004; Lučan, 2006), but in the current study, male bats were found to harbour more bat flies than female bats. Other studies that have reported higher infestation in male bats than female bats include Moore and Wilson (2002) and Morrand *et al.* (2004). The higher burdens of ectoparasites in female bats has been attributed to immunosuppression during reproduction and aggregation in nursery colonies (Christe *et al.*, 2007). However, another theory postulates that abundance of ectoparasite on bats is influenced by host body size, sex and age of bat. Based on this theory that larger habitats support more individuals, and as a result, more species than smaller habitats (Rosenzweig, 1995), Presley and Willig (2008) hypothesize that larger hosts (male bats) would be expected to harbour more parasites than smaller hosts (female bats) since male bats are generally larger than female bats. Flemming (1988) provides a more plausible explanation based on the fact that male bats may have more than one harem in different shelter sites while females are isolated in harems, thus minimizing the exposure of females to bat flies.

With the above inference, it is interesting to note that some studies have reported juvenile bats to harbour more parasites than adult and sub-adult bats (Christe *et al.*, 2000; Lučan, 2006). Ectoparasites are transferred to the pups when female bats care for them during the breeding season and as the pups may be inexperienced in grooming, they have minimal ability to reduce ectoparasite burdens. With regards to mite and tick infestations on bats, sex and age of bat were not observed to influence intensity of parasite load.

A number of studies found reproductive females (pregnant and lactating) female bats to harbour more ectoparasites than non-reproductive females (Schalk and Forbes, 1997; McCurdy *et al.*, 1998; Morales-Montor *et al.*, 2004). During pregnancy and lactation, the immune system of female bats tend to be compromised (Zenon and Hugh, 2011) to allow for the foetus to be successfully carried to term and subsequently breastfed properly. It is possible that parasites take advantage of this compromise in immune competence and parasitize pregnant and lactating females which may not have enough time to groom in order to reduce ectoparasite abundance. As such they are most likely to harbour more ectoparasites than non-reproductive females. There was no such evidence in this study as there was no significant difference in ectoparasite infestation between reproductive and non-reproductive females. Schad *et al.* (2012) and Komeno and Linhares (1999) made similar observations where they found no significant difference in infestation of ectoparasites between reproductive and non-reproductive female bats.

5.4 Ectoparasite infestation prevalence at the different roosting sites

Buoyem had the most diverse ectoparasite occurrence among all the capture sites. The site had a wide variety of vegetation that supported a highly diverse bat population (eight species of bats) and also a wider variety of ectoparasites. Majority of *R. aegyptiacus* bats from which most of the bat flies were collected, were captured from the Buoyem site. The two rare bat flies (*E. africanum* and *E. vandeuseni*) also were collected from *R. aegyptiacus* and *L. angolensis* captured in Buoyem and were absent from Tanoboase Sacred Grove although these two sites are geographically not far apart (N 07° 43.416', W001° 59.266' and N 07° 39.942', W 001° 51.448' respectively).

The highest number of bats infested with ectoparasites, however, was recorded at the Tanoboase Sacred Grove (62.96%) and the least at the '37' Military Hospital (22.92%). However, a higher proportion of bats captured at Buoyem were infested with bat flies (31.30%), probably because most of the bat species (*R. aegyptiacus* and *L. angolensis*) which harboured bat flies were captured at this site. On the contrary, the highest proportion of bats infested with mites was recorded at the Tanoboase Sacred Grove (33.33%). The Tanoboase Sacred Grove and Buoyem study sites had roosting sites that were mainly caves while the roosting sites at the '37' Military Hospital and Ve-Golokuati comprised of trees. Hence, the higher parasites burdens at the Tanoboase Sacred Grove and Buoyem study sites. This outcome is not surprising as these two capture sites are similar. Bats captured at the Tanoboase Sacred Grove harboured a significantly heavier load of bat flies than bats captured at the other three study sites ($\chi^2= 91.10$, $df = 3$, p -value < 0.01).

5.5 Seasonal patterns of ectoparasite load

Seasonal differences in ectoparasite abundance on bats were observed and were influenced by various factors. Months in which bats were captured were categorized into beginning of rains (March and April) and short dry season (July and August). At the beginning of the rains, bats had higher burdens of ticks as compared to the short dry season probably due to the influence of temperature and humidity. The current results indicated an abundance of ticks that coincided with the onset of the rainy season and declined steadily as the season progressed to the end of the rainy season. Climate is known to be a better predictor of tick distribution than other factors such as vegetation type (Cumming, 2002). In the temperate regions, parasites are usually abundant in the summer, when the temperature is warm than in the winter when it is cold (Lučan,

2006) and tick development has been reported to be influenced by humidity and temperature variations (Ntiamoah-Baidu, 1987a; b; Olenev, 1927).

Most of the ticks recorded in this study were collected in the month of April and were mostly *Argas vespertilionis*. Hosseini-Chegeni and Tavakoli (2013) established the optimum temperature for growth of *A. vespertilionis* to be between 22 – 28°C at 80% relative humidity. In Ghana, the average temperature (24 - 28°C) and relative humidity (80%) in April fall within the optimal temperature and relative humidity for *A. vespertilionis* development. Milne (1948) and MacLeod (1934) also noted that unfed ticks require a relative humidity above 80% to survive, with anything less having a detrimental effect on their survival.

Mites are very diverse with so many species that may require a range of temperature and humidity conditions for optimal reproduction and survival. Mite distribution show clear seasonal patterns in the temperate regions but not in the tropics. Although it is cooler in the rainy season than it is in the dry season in the tropics, the temperature difference is not as steep a change as compared to the sharp temperature difference experienced in the temperate regions (Houghton and Woodwell, 1989). This may account for the reason why mite abundance and intensity was not affected by seasonal changes.

The highest prevalence of bat flies was recorded in the month of March, which marks the beginning of the rainy season in southern Ghana. From all indication, bat fly infestation was at its peak before the rains began. It is possible that the rains may have washed away some of the bat flies harboured by bats as Pilosof *et al.* (2012) indicated that precipitation may directly affect the survival of fly pupae hence the low numbers of bat flies during the rains.

Another interesting observation was made of bat flies which were not recorded in Ve-Golokuati until in August. Seasonal flowering of plants (*Ficus elastica*) and fruits (guava, mango) on which bats feed on may account for this. Some fruits on which bats feed on flower and fruit seasonally and will therefore not be available to bats throughout the year. An example of such fruits include *Ficus elastica*, an important food source for bats which flower from March to April (Mahbubur and Khanom, 2013) and the fruits will therefore be depleted by August. Bats therefore move further away from their roosts in search of food and by so doing disperse parasites to other roosting sites. It is assumed that the few individuals of the bat species *R. aegyptiacus* and *E. helvum*, on which the few bat flies were collected from, may have come from roosts further away from Ve-Golokuati.

5.6 Endoparasite distribution

5.6.1 Endoparasites prevalence of bat species

Bats are not only infested with ectoparasites but endoparasites as well. Bats had a surprisingly high infection with haemoparasites corresponding to an overall prevalence of 47.71% (128 out of 262). This result is similar to a study done by Schaer *et al.* (2013), which also reported approximately 40% prevalence of bats infection with haemoparasites. Kudo (1966) suggested that since arthropods, specifically bat flies, are known to transmit haemoparasites especially malaria, it would be expected that individuals heavily infested with bat flies would be highly infected also with haemoparasites. This was confirmed as *R. aegyptiacus*, *L. angolensis* and *E. helvum* which had heavy infestations with bat flies were also highly infected with haemoparasites.

On the contrary, *E. gambianus*, which had a low bat fly infestation, was highly infected with

haemoparasites than *E. helvum* which were heavily infested with bat flies. This suggests haemoparasite transmission from sources other than the bites of bat flies. Haemoparasite infection could be influenced by the eating habits of the bats (Kudo, 1966) where fruit-eating bats sometimes supplement their diet with insects which provide them with the nutrients, particularly proteins that they do not get from feeding exclusively on fruits (Thomas, 1984; Herrera *et al.*, 2001). Bats captured at the '37' Military Hospital, although not heavily infested with bat flies, carried the heaviest infection with haemoparasites.

Infection with haemoparasites seemed not to be affected by sex, age, species or roosting site of bats but was influenced by reproductive status of female bats. Hence, although there was no significant difference in ectoparasite infestation between reproductive and non-reproductive females, lactating female bats tended to have heavier infection with haemoparasites than pregnant and non-reproductive females. This may be, as noted earlier, due to the immunocompetence of female bats during pregnancy and lactation (Zenon and Hugh, 2011).

Several studies (eg. Kamani *et al.*, 2014) have reported *Bartonella* sp., a bacteria infection, and bat flies on the same bat. The bat flies get infected as they continuously feed on the bacteria infected bats and may transmit the pathogens through urine, droppings and saliva to humans when they bite humans (Wenzel *et al.*, 1966). Nycteribiid bat flies also transmit *Polychromophilus* spp. to bats (Gardner and Molyneux, 1988) therefore are of more concern compared to the streblid bats flies which have not been implicated in the transmission of haemoparasites. In the case of this study, all bat flies recorded were of the family Nycteribiidae hence a high possibility of pathogen transmission to humans.

Transmission of trypanosomes is likely also to occur by an oral route when the vector insects are eaten by insectivorous bats (Lima *et al.*, 2012). Insectivorous bats would therefore be more

likely carriers of trypanosomes than fruit-eating bats. Bat bugs of the family Cimicidae have been known to harbour and transmit trypanosomes among bats and the grooming habits of the bats probably facilitate transmission (Marinkelle, 1976; Gardner and Molyneux, 1988; Molyneux, 1991). The absence of trypanosomes in bats in this study would be because of the absence of bat bugs except for a single specimen collected from an *Epomophorus gambianus* in Buoyem. According to Cavazzana *et al.* (2010), Hoare (1972), Marinkelle (1976) and Molyneux (1991), there is no evidence that trypanosomes cause harm to bats. However, it is very possible that these bats can be reservoirs for pathogenic trypanosome species which could harm humans.

5.6.2 Molecular analysis

Samples that tested positive for haemoparasites by microscopy were molecularly tested to determine the species of *Plasmodium* in order to ascertain the impact of haemosporidian parasite on bat biodiversity and possibly the role of bats as hosts of zoonotic malaria. The haemoparasite of interest was the *Plasmodium* species which is the species of protozoan that causes malaria in people. The agarose gel electrophoresis done yielded no results and further studies could not be done. DNA extraction was done using the Chelex protocol of Wooden *et al.* (1993) which was a reliable method of extraction. The lack of results may be because the haemoparasites observed were not of the genus *Plasmodium* sp. but rather of other genera (eg. *Nycteria* sp. or *Hepatocystis* sp.) that also infect bats. Several tests were run on samples to confirm the results. A lot of troubleshooting was done to determine the shortcomings but none yielded results. The microscopy showed that parasitemia was generally low with just a few cells showing high was infection. The DNA extracted would therefore be very little which could be the reason why it was not detected when an agarose gel electrophoresis was run on the samples.

The volume of DNA was exponentially increased in each PCR cycle to cater for these low levels of DNA. In the study done by Schaer *et al.* (2013), PCR was done using illustra* PuRe Taq Ready-To-Go PCR beads (GE Health Sciences), which was reported to be more sensitive and could determine very low concentrations of DNA. This however was not readily available for the study and therefore the conventional form of PCR was used. Perhaps PCR done using the normal PCR machine could not detect and amplify the low concentration of DNA enough for detection. The cycling conditions for PCR were also changed in each cycle but this also did not yield any results. Initially 35 cycles was used followed by 40 cycles. Throughout all these changes, the control which had thousands of malaria parasites was visible when an agarose gel electrophoresis was run. It was concluded that either the DNA extracted was too little to be detected or the DNA extracted was not that of *Plasmodium* sp..

Apart from haemoparasites that were of interest, some bacteria were also observed in the blood. Although the study of bacteria was not an aim of the study, it would be interesting to study the species of bacteria that is harboured by bats since humans can also be plagued with bacteria harboured by bats. Bats are known to harbour bacteria such as *Bartonella* sp. (Loftis *et al.*, 2005), *Rickettsia* sp. (Diaz, 2010), and *Borrelia* sp. (Sonenshine, 1991) which can infect humans.

5.6.3 Helminth Infestation

Bats are known to be infected with helminthes but in this study, none of the faecal samples of the twenty nine bats screened molecularly showed any helminth infestation. Several studies of helminth infections of bats have focused on insectivorous bats (Esteban *et al.*, 1999; Okafor *et al.*, 2004; Tinnin *et al.*, 2008; Junker *et al.*, 2008) and a few on fruit-eating bats (Nogueira *et*

al., 2004) where most of the helminthes were sampled from the gastrointestinal tract. This difference in method could be a reason why helminthes were not detected in the bat stool samples examined in this study. Due to the fact that this study was under a bigger project, Dynamic Drivers of Disease in Africa Conservation (DDDAC), whose main aim was to conserve bats, it was not possible to kill bats in order to observe gut contents. Therefore a less intrusive method was used which was to sample faecal pellets and observe if there were any helminth eggs in them.

The prevalence and incidence of helminthes are strongly influenced by the feeding habits and foraging strategies of bats (Marshall and Miller, 1979), with most of them found in insect-eating bats, that are prone to ingest an infected insect serving as intermediate host, than in fruit-eating bats (Coggins, 1988). In a study by Saoud and Ramadan (1976), none of the *R. aegyptiacus* bats captured harboured any helminth parasite, probably because these were strictly fruit eating bats. This could be the reason why none of the screened bats assessed in this study had any helminth infections since all were fruit eating bats. It could also be explained in that these bats may have had either a single male or female adult infection and therefore there could not be any reproduction to produce eggs. It could also be that bats harboured adult helminths that may have exceeded their reproductive age hence the parasites shedding no eggs to be detected by PCR. Not only do the intestines of bat sustain various helminths but diverse microbiota as well, including insects, mites, bacteria and fungi (Estrada-Bárcenas, 2010). Hence further studies are required to shed light on the role these groups of pathogens play in bat biodiversity and the potential transmission of zoonotic diseases to humans.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The findings of the study indicated that bats indeed harbour a wide array of ectoparasites (bat flies, mites and ticks) and endoparasites. Four species of bat flies, eighteen species of mites, two species of ticks and a bat bug were collected from the 480 bats examined. Two unidentified mites were also recorded. Mites were the most abundant ectoparasite recorded on all species of bats. From literature, some of these ectoparasites were vectors of diseases of public health importance to humans. For example bat flies have been implicated in the transmission of malaria and mites in the transmission of bacteria which cause allergies in humans among others.

Ectoparasites were collected from all four study sites. Buoyem, however had the most species of ectoparasites and the '37' Military Hospital the least. Adult bats were significantly infested with more bat flies than sub-adult and juvenile bats. There was no significant difference in mite and tick infestations in the different age categories of bats. Male bats were significantly infested with bat flies than female bats. There was no significant difference in infestation with ticks and mites between male and female bats. There was a significant difference in ectoparasite infestation between reproductive and non-reproductive female bats.

Bats captured at the Tanoboase Sacred Grove harboured the highest load of bat flies and mites while bats captured at the Ve-Golokuati harboured the highest load of ticks. A relationship between month of capture and ectoparasite infestation was established where bats captured in March had the heaviest bat fly load. The heaviest mite and tick loads were recorded in the months of July and April.

Approximately 48% of the total number of bats, comprising of all nine species, were infected with haemoparasites. A higher proportion of male bats were infected with haemoparasites than female bats. There was no significant difference in infection among the different age categories. Also, bats captured at the '37' Military Hospital were heavily infected than bats captured at the other sites. The highest proportion of bats infected with haemoparasites was captured in August while the least proportion was recorded in July. Here, lactating female bats were significantly infected with haemoparasites than pregnant and non-reproductive females. Finally, none of the bats captured were infested with helminths based on examination of faecal samples.

In summary, bats were noted to harbour parasites (bat flies, mites, ticks, bat bug and haemoparasites) of noticeable public health importance.

6.2 Recommendations

- ❖ To the best of my knowledge, for the first time, several ectoparasites comprising of four bat fly species, twenty mite species and two tick species have been isolated from bats in Ghana. These ectoparasites may be of public health significance and also of importance in relation to bat conservation efforts. Further studies are thus required to shed light on the importance of these parasitic infestations to public health and biodiversity conservation efforts. Additionally, more extensive studies at other locations in Ghana are required to give a more complete overview of bat ectoparasites towards creating a national database.
- ❖ The major haemoparasite observed was bat malaria parasites; a few bacteria infections were also observed. Due to logistical and time constraints, an extensive study could not be carried out to investigate further the specific species of malaria parasites. I would

therefore recommend studies be carried out in order to identify the exact species of haemoparasites infecting bats in Ghana.

- ❖ Although bats are known to harbour parasites of zoonotic importance which could potentially be vectored by ectoparasites, very little or no information exists on the role of these arthropod ectoparasites (including those found in the present study) in pathogen transmission either from bat to bat or bat to human. As such additional investigations are required to determine the vectoral role of bat ectoparasites in disease transmission to humans and animals, if any.



REFERENCES

- Accra Metropolitan Assembly (2006).** *Climate and Vegetation.*
www.ama.ghanadistricts.gov.gh Accessed on 15/08/2014.
- Adam, J. P. and Landau, I. (1973).** *Developmental stages of Polychromophilus sp., a parasite of insectivorous bats from Congo-Brazzaville, in Nycteribiid fly Penicillidia-Fulvida Bigot 1889.* Transactions of the Royal Society of Tropical Medicine and Hygiene, 67:5-6.
- Aeschlimann, A. and Freyvogel, T. A. (1995).** *Biology and distribution of ticks of medical importance.* Handbook of Clinical toxicology of Animal Venoms and Poisons, CRC Press, pp. 177-189.
- Africa Chiroptera Report (2014).** *African Bats.* Pretoria. i – xix, pp. 1 - 6591, Ed Victor Van Cakenberghe and Ernest C.J. Seamark, retrieved from <http://www.africanbats.org>
- Airas, M. (2003).** *Echolocation in bats.* HUT, Laboratory of Acoustics and Audio Signal Processing, pp 4.
- Albayrak, I., Asan, N. and Yorulmaz, T. (2008).** *The Natural History of the Egyptian Fruit Bat, Rousettus aegyptiacus, in Turkey (Mammalia: Chiroptera).* Turkish Journal of Zoology, 32 (1): 11 - 18.
- Altringham, J. D. (1996).** *Bats, Biology and Behaviour.* Oxford University Press.
- Ambrosio, R. E. and De Waal, D. T. (1990).** *Diagnosis of parasitic disease.* Rev. sci. tech. Off. int. Epiz, 1990, 9 (3), 759-778.
- American Museum of Natural History (2013).** *Scientists find soaring variety of malaria parasites in bats.* Accessed on 05/04/14.
- Anciaux de Faveaux, M. (1971).** *Catalogue des Acariens parasites et commensaux des*

Chiroptères. (Seconde et troisième parties). Koninklijk Belgisch Instituut voor Natuurwetenschappen. MededelingenDoc. de travail no 7..

Anderson, R. M. and May, R. M. (1978). *Regulation and stability of host-parasite population interactions: I. Regulatory processes*. Journal of Animal Ecology 47: 219–247.

Awwad, M. A., El kheir, S. M. A. and Lashien, G. H. (2002). *Molecular Identification of Three Argas Species Using Polymerase Chain Reaction (PCR) Amplification and Restriction Analysis of the Small-Subunit Ribosomal RNA Gene*. Egyptian Journal of Hospital Medicine 9: 112 – 121.

Aznar-Lopez, C., Vazquez-Moron, S., Marston, D. A., Juste, J., Ibanez, C., Berciano, J. M., Salsamendi, E., Aihartza, J., Banyard, A. C., McElhinney, L., Fooks, A. R. and Echevarria, J. (2013). *Detection of rhabdovirus viral RNA in oropharyngeal swabs and ectoparasites of Spanish bats*. Journal of General Virology 94, 69–75.

Bai, Y., Kosoy, M., Recuenco, S., Alvarez, D., Moran, D., Turmelle, A., Ellison, J., Garcia, D. L., Estevez, A., Lindblade, K. and Rupprecht, C. (2011). *Bartonella spp. in Bats, Guatemala*. Centers for Disease Control and Prevention. Emerging Infectious Diseases Volume 17, Number 7.

Bartonicka, T. and Gailsler, J. (2007). *Seasonal dynamics in the numbers of parasitic bugs (Heteroptera, Cimicidae): a possible cause of roost switching in bats (Chiroptera, Vespertilion-idae)*. Parasitology Research, vol. 100, pp. 1323–1330.

Bertherat, E., Bekhoucha, S., Chougrani, S., Razik, F., Duchemin, J. B., Houti, L., Deharib, L., Fayolle, C., Makrerougrass, B., Dali-Yahia, R., Bellal, R., Belhabri, L., Chaieb, A., Tikhomirov, E. and Carniel, E. (2007). *Plague reappearance in Algeria after 50 years, 2003*. Emerg Infect Dis 13: 1459-1462.

- Bertola, P. B., Aires, C. C., Favorito, S. E., Gracioli, G., Amaku, M. and Pinto-da-Rocha (2005).** *Bat flies (Diptera: Streblidae, Nycteribiidae) parasitic on bats (Mammalia: Chiroptera) at Parque Estadual da Cantareira, São Paulo, Brazil: parasitism rates and host-parasite associations.* Mem Inst Oswaldo Cruz, Rio De Janeiro, 100(1): 25-32.
- Billeter, S. A., Levy, M. G., Chomel, B. B. and Breitschwerdt, E. B. (2008).** *Vector transmission of Bartonella species with emphasis on the potential for tick transmission.* Med Vet Entomo 22: 1-15.
- 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.
- Bishop, R., Musoke, A., Morzaria, S., Gardner, M. and Nene, V. (2004).** *Theileria: intracellular protozoan parasites of wild and domestic ruminants transmitted by ixodid ticks.* Parasitology 129: 271-283.
- Bitam, I., Dittmar, K., Parola, P., Whiting, M. F. and Raoult D. (2010).** *Fleas and flea-borne diseases.* International Journal of Infectious Diseases 14: 667–676.
- Blehert, D. S., Hicks, A. C., Behr, M., Meteyer, C. U., Berlowski-Zier, B. M., Buckles, E. L., Coleman, J. T. H., Daling, S. R., Gargas, A., Niver, R., Okoniewski, J. C., Rudd, R. J. and Stone, W. B. (2009).** *Bat white-nose syndrome: an emerging fungal pathogen?* Science 323: 227.
- Boyles, J. G., Cryan, P. M., McCracken, G. F. and Kunz, T. H. (2011).** *Economic importance of Bats in Agricultural.* Science, 332 (6025): 41-42.
- Bradbury, J. W. (1977).** *Lek mating behavior in the hammer-headed bat.* Zeitschrift für

Tierpsychologie - Journal of Comparative Ethology, 45 (3): 225 - 255.

Brassard, P., Rau, M. E. and Curtis, M. A. (1982). *Parasite induced susceptibility to predation in diplostomiasis.* Parasitology 85: 495–501.

Briggs, P. (2010). *Ghana.* 5th edition, Jellfish Print Solutions, UK.

Brown, C. R. and Brown, M. B. (1986). *Ectoparasitism as a cost of coloniality in cliff swallows (*Hirundo pyrrhonota*).* Ecology, 67, 1206-1218.

Brown, C. R. and Brown, M. B. (2004). *Group size and ectoparasitism affect daily survival probability in a colonial bird.* Behav. Ecol. Sociobiol. 56, 498–511.

Bruyndonckx, N., Dubey, S., Ruedi, M. and Christe, P. (2009). *Molecular cophylogenetic relationships between European bats and their ectoparasitic mites (Acari, Spinturnicidae).* Molecular Phylogenetics and Evolution, 51 (2): 227–237.

Calisher, C. H., Childs, J. E., Field, H. E., Holmes, K. V. and Schountz, T. (2006). *Bats: important reservoir hosts of emerging viruses.* Clinical Microbiology Reviews, 19: 531–545.

Cavazzana, Jr. M., Marcili, A., Lima, L., Maia da Silva. F., Junqueira, A.C., Veludo, H. H., Viola, L. B., Campaner, M., Nunes, V. L., Paiva, F., Coura, J. R., Camargo, E. P. and Teixeira, M. M. G. (2010). *Phylogeographical, ecological and biological patterns shown by nuclear (SSU rRNA and gGAPDH) and mitochondrial (Cyt b) genes of trypanosomes of the subgenus Schizotrypanum parasitic in Brazilian bats.* Int J Parasitol 40:345–355.

Chang, C.C., Chomel, B. B., Kasten, R. W., Romano, V. and Tietze, N. (2001). *Molecular evidence of Bartonella spp. in questing adult Ixodes pacificus ticks in California.* J. Clin. Microbiol. 39: 1221-1226.

- Chomel, B.B., Kasten, R. W., Floyd-Hawkins, K., Chi, B., Yamamoto, K., Roberts-Wilson, J., Gurfield, A. N., Abbott, R. C., Pedersen, N. C. and Koehler, J. E. (1996).** *Experimental transmission of Bartonella henselae by the cat flea.* J. Clin. Microbiol. 34: 1952-1956.
- Chomel, B. B., Boulouis, H. J., Maruyama, S. and Breitschwerdt, E. B. (2006).** *Bartonella sp. in pets and effect on human health.* Emerg Infect Dis 12: 389-94.
- Christe, P., Arlettaz, R. and Vogel, P. (2000).** *Variation in intensity of a parasitic mite (Spinturnix myoti) in relation to the reproductive cycle and immunocompetence of its bat host (Myotis myotis).* Ecology Letters, 3 (3): 207–212.
- Christe, P., Glaizot, O., Evanno, G., Bruyndonckx, N., Devevey, G., Yannic, G., Patthey, P., Maeder, A., Vogel, P. and Arlettaz, R. (2007).** *Host sex and ectoparasites choice: preference for, and higher survival on female hosts.* Journal of Animal Ecology 76, 703–710.
- Chua, K. B., Bellini, W. J., Rota, P. A., Harcourt, B. H., Tamin, A., Lam, S. K., Ksiazek, T. G., Rollin, P. E., Zaki, S. R., Sheih, W. J., Goldsmith, C. S., Gubler, D. J., Roehrig, J. T., Eaton, B., Gould, A. R., Olson, J., Field, H., Daniels, P., Ling, A. E., Peters, C. J., Anderson, L. J. and Mahy, B. W. J. (2000).** *Nipah virus: a recently emergent deadly paramyxovirus.* Science, 288:1432-1435.
- Coggins, J. R. (1988).** *Methods for the ecological study of bat endoparasites.* In: KUNZ, T. H. (ed.) Ecological and behavioral methods for the study of bats. Smithsonian, Washington D.C.
- Comer, J.A., Paddock, C. D. and Childs, J. E. (2001).** *Urban zoonoses caused by Bartonella, Coxiella, Ehrlichia, and Rickettsia species.* Vector Borne Zoon. Dis. 1: 91-118.

- Concannon, R., Wynn-Owen, K., Simpson, V. R. and Birtles, R. J. (2005).** *Molecular characterization of haemoparasites infecting bats (Microchiroptera) in Cornwall, UK.* Parasitology, 131: 489-496.
- Cox, A., Tilley, A., McOdimba, F., Fyfe, J., Eisler, M., Hide, G. and Welbum, S. (2005).** *A PCR based assay for detection and differentiation of African trypanosome species in blood.* Experimental Parasitology 111: 24-29.
- Cumming, G. S. (2002).** *Comparing climate and vegetation as limiting factors for species ranges of African ticks.* Ecology 83(1): 255-268.
- Curtis, C. F. (2004).** *Current trends in the treatment of Sarcoptes, Cheyletiella and Otodectesmite infestations in dogs and cats.* Vet Dermatol 15(2):108-114.
- Da Rosa, E. S. T., Kotait, I., Barbosa, T. F. S., Carrieri, M. L., Brandã, P. E., Pinheiro, A. S., Begot, A. L., Wada, M. Y., de Oliveira, R. C., Grisard, E. C., Ferreira, M., da Silva Lima, R. J., Montebello, L., Medeiros, D. B. A., Sousa, R. C. M., Bensabath, G., Carmo, E. H. and Vasconcelos, P. F. C. (2006).** *Bat-transmitted human rabies outbreaks, Brazilian Amazon.* Emerg Infect Dis. 12 (8): 1197-1202.
- Dalgic, A., Kandogan, T., Kavak, H., Ari, A., Erkan, N. and Ozuer, M. Z. (2010).** *Ticks in the external auditory canal.* Hong Kong Journal of Emergency Medicine 17 (2): 190-192.
- Daszak, P., Cunningham, A. A. and Hyatt, A. D. (2000).** *Emerging infectious disease of wildlife- Threats to biodiversity and human health.* Science, 287, 443-449.
- Daszak, P., Cunningham, A. A. and Hyatt, A. D. (2001).** *Anthropogenic environmental change and the emergence of infectious diseases in wildlife.* Acta Tropica, 78, 103-116.
- Delfinado, M. D. and Baker, E. W. (1963).** *Mites of the family spinturnicidae from the Philippines (Acarina).* Pacific Insects 5 (4): 905-920.

- Dias, E. (1936).** *Revisao geral dos hemoflagellados de chiropteros. Estudio experimental do Schizotrypanum de Phyllostomus hastatus: Identidade con Schizotrypanum cruzi. Ogrupo vespertiionis.* IX. Reunion Soc. Argentina Patol. Reg. Norte, 1: 10-88.
- Diaz, J. H. (2010).** *Endemic mite-transmitted dermatoses and infectious diseases in the South.* J La State Med Soc 162(3):140-145,147-149.
- Dick, C. W., Gannon, M. R., Little, W. E. and Patrick, M. J. (2003).** *Ectoparasite Associations of Bats from Central Pennsylvania.* Journal of Medical Entomology 40 (6): 813–819.
- Dick, C. W. and Gettinger, D. (2005).** *A faunal survey of streblid flies (Diptera: Streblidae) associated with bats in Paraguay.* The Journal of Parasitology, 91, 1015–1024.
- Dick, C. W. and Patterson, B. D. (2006).** *Bat flies-obligate ectoparasites of bats.* In *Micromammals and Macroparasites: From evolutionary ecology to management.* Edited by Morand, S., Krasno, B. R., Poulin, R. New York: Springer; pp 179-194.
- Dick, C. W. and Patterson, B. D. (2007).** *Against all odds: Explaining high host specificity in dispersal-prone parasites.* International Journal for Parasitology, 37, 871–876.
- Dick, C. W. and Patterson, B. D. (2008).** *An excess of males: skewed sex ratios in bat flies (Diptera: Streblidae).* Evol Ecol 22: 757-769.
- Dittmar, K., Porter, M. I., Murray, S. and Whiting, M. F. (2006).** *Molecular phylogenetic analysis of nycteribiid and streblid bat flies (Diptera: Brachycera, Calyptratae): Implications for host associations and phylogeographic origins.* Mol Phylogen Evol 38(1):155.
- Drancourt, M., Roux, V., Dang, L. V., Tran-Hung, L., Castex, D., Chenal-Francisque, V., Ogata, H., Fournier, P. E., Crubézy, E. and Raoult, D. (2004).** *Genotyping,*

- Orientalis-like Yersinia pestis, and plague pandemics*. Emerg Infect Dis 10: 1585-1592.
- Dryden, M. W. and Payne, P. A. (2004)**. *Biology and Control of Ticks Infesting Dogs and Cats in North America*. Veterinary Therapeutics 5(2): 139-154.
- Duchemin, J. B., Fourrier, P. E. and Parola, P. (2006)**. *Les puces et les maladies transmises à l'homme*. Med Trop 66: 21-29.
- Dusbabek, F. and Bergmans, W. (1980)**. *Spinturnicid mites from some Nigerian bats (Acarina, Spinturnicidae)*. Bull. Zool. Mus., Univ. Amsterdam, 7:65-72.
- Edlow, J. A. and Kulkarni, R. (2008)**. *Tick-Borne Diseases*. Retrieved from <http://emedicine.com> accessed on 18th May, 2014.
- Eisen, R. J., Borchert, J. N., Holmes, J. L., Amatre, G., Van Wyk, K., Enscoe, R. E., Babi, N., Atiku, L. A., Wilder, A. P., Vetter, S. M., Bearden, S. W., Monteneri, J. S. and Gage, K. L. (2008)**. *Early phase transmission of Yersinia pestis by cat fleas (Ctenocephalides felis) and their potential roles as vectors in a plague-endemic region of Uganda*. Am J Trop Med, 78: 949- 956.
- Epstein, J. H., Field, H. E., Ludy, S., Pulliam, J. R. C. and Daszak, P. (2006)**. *Nipah Virus: Impact, origins, and causes of emergence*. Current Infectious Disease Reports, 8, 59-65.
- Esteban, J. G., Botella, P., Toledo, R. and Oltra-Ferrero, J. L. (1999)**. *Helminthfauna of bats in Spain. IV. Parasites of Rhinolophus Ferrumequinum (Schreber, 1774) (Chiroptera: Rhinolophidae)*. Parasitology 59(1-2), 57-68.
- Estrada-Peña, A. and Jongejan, F. (1999)**. *Ticks feeding on humans: a review of records on human-biting Ixodoidea with special reference to pathogen transmission*. Exp. App. Acarol. 23: 685–715.
- Estrada-Bárceñas, D. A., Palacios-Vargas, J. G., Estrada-Venegas, E., Klimov, P. B.,**

- Martínez-Mena, A. and Taylor, M. L. (2010).** *Biological activity of the mite Sancassania sp. (Acari: Acaridae) from bat guano associated with the pathogenic fungus Histoplasma capsulatum.* Mem Inst Oswaldo Cruz, Rio de Janeiro, 105(2): 127-131.
- Feliu, C., Torres, J., Miquel, J., Segovia, J. M. and Fons, R. (2006).** *Digenean trematodes. In Micromammals and Macroparasites: From Evolutionary Ecology to Management.* (ed. Morand, S., Krasnov, B. R. and Poulin, R.), pp. 13–28. Springer, Tokyo, Japan.
- Flemming, T. H. (1988).** *The Short-tailed Fruit Bat: A Study in Plant-animal Interaction.* The University of Chicago Press, Chicago, IL, pp 363.
- Florin-Christensen, M. and Schnittger, L. (2009).** *Piroplasmids and ticks: a long lasting intimate relationship.* Frontiers in Biosciences 14: 3064-3073.
- Food and Agriculture Organisation of the United Nations (1984).** *Ticks and tick-borne disease control. A practical field's manual, Vol. 1, Tick control,* FAO, Rome, Pp 299.
- Food and Agriculture Organisation of the United Nations (2011).** *Investigating the role of bats in emerging zoonoses: Balancing ecology, conservation and public health interests.* Edited by Newman, S. H., Field, H. E., de Jong, C. E. and Epstein, J. H.. FAO Animal Production and Health Manual No. 12. Rome.
- Friedman, L. (2014).** *Bubonic Plague is Still Shockingly Common, and it's Ravaging Madagascar Right Now.* Business Insider.
- Froschauer, A. and Coleman, J. (2012).** *“North American bat death toll exceeds 5.5 million from white-nose syndrome”.* U. S. Fish and Wildlife Service. Retrieved 27/09/2014.
- Funmilayo, O. (1976).** *Diet and roosting damage and environmental pollution by the straw-coloured fruit bat in south western Nigeria.* Nigerian Field 41:136-142

- Gage, K. L. and Kosoy, M. Y. (2005).** *Natural history of plague: perspectives from more than a century of research.* *Annu Rev Entomol* 50: 505–528.
- Galuzo, I. G. (1957).** *Argasid ticks (Argasidae) and their epizootiological significance.* Akademyia Nauk Kazakhskoi SSR, Institut Zoologii, Alma-Ata. (In Russian, English).
- Gannon, M. R. and Willig, M. R. (1995).** *Ecology of ectoparasites from tropical bats.* *Environmental Entomology*, 24 (6): 1495–1503.
- García-Vargas, F. D., Osório, S. and De león, G. P. P. (1996).** *Helminth parasites of bats (Mormoopidae and Phyllostomidae) from the Estación de Biología Chamela, Jalisco State, México.* *Bat Research News*, 37, 7–8.
- Gardner, R. A. and Molyneux, D. H. (1987).** *Babesia vesperuginis: natural and experimental infections in British bats (Microchiroptera).* *Parasitology* 95:461–469.
- Gardner, R. A. and Molyneux, D. H. (1988).** Trypanosoma (Megatrypanum) incertum from Pipistrellus pipistrellus: development and transmission by cimicid bugs. *Parasitology* 96:433-447.
- Garnham, P. C. C. and Heisch, R. B. (1953).** *On a new blood parasite of insectivorous bats.* *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 47, 357-363.
- Garnham, P. C. C. (1966).** *Malaria Parasites and Other Haemosporidia.* 1 edition. Oxford: Blackwell Scientific Publications.
- Garnham, P. C. C. (1973).** *The zoogeography of Polychromophilus and description of a new species of a gregarine (Lankesteria galliadi).* *Annales de Parasitologie(Paris)*, 48: 231-242.
- Georges, A. J., Leroy, E. M., Renaut, A. A., Benissan, T. C., Nabias, R. J., Ngoc, M. T., Obiang, P. I., Lepage, J. P. M., Bertherat, E. J., Bénoni, D. D., Wickings, E. J.,**

- Amblard, J. P., Lansoud-Soukate, J. M., Milleliri, J. M., Baize, S. and Marie-Claude, G. (1999).** *Ebola hemorrhagic fever outbreaks in Gabon, 1994-1997: epidemiologic and health control issues.* J Infect Dis 179:65-75.
- Ghana Population Census (2000).** *Population Statistics.* Retrieved from www.statsghana.gov.gh/popstats.html
- Gill, J. S., Rowley, W. A., Bush, P. J., Viner, J. P. and Gilchrist, M. J. (2004).** *Detection of human blood in the bat tick *Carios (Ornithodoros) kelleyi* (Acari: Argasidae) in Iowa.* J Med Entomol 41:1179–1181.
- Giorgi, M. S., Arlettaz, R., Christe, P. and Vogel, P. (2001).** *The energetic grooming costs imposed by a parasitic mite (*Spinturnix myoti*) upon its bat host (*Myotis myotis*).* Proceedings of the Royal Society B, 268 (1480): 2071–2075.
- Gracioli, G. and Dick, C. W. (2008).** *Checklist of World Nycteribiidae (Diptera: Hippoboscoidea).* Field Museum of Natural History.
- Greiman, S. E. and Tkach, V. V. (2012).** *Description and phylogenetic relationships of *Rodentolepis gnoskei* n. sp. (Cyclophyllidea: Hymenolepididae) from a shrew *Suncus varilla minor* in Malawi.* Parasitology International 61: 343-350.
- Griffin, C. E., Miller, W. H. and Scott, D. W. (2001).** *Small Animal Dermatology.* W.B. Saunders Company, 6th ed..
- Grubb, P., Jones, T. S., Davies, A. G., Edberg, E., Starin, A. D. and Hill, J. E. (1988).** *Mammals of Ghana, Sierra Leone and the Gambia.*
- Guardone, L., Deplazes, P., Macchioni, F., Magi, M. and Mathis A. (2013).** *Ribosomal and mitochondrial DNA analysis of *Trichuridae* nematodes of carnivores and small mammals.* Veterinary Parasitology 197: 364-69.

- Haeselbarth, E., Sererman, J. and Zumpt, F. (1966).** *The arthropod parasites of vertebrates in Africa south of the Sahara (Ethiopian Region)*. Volume III. Insecta excl. Phthiraptera. South African Institute for Medical Research, 13 (52): 1-283.
- Hafez, S. M., Ebaid, N. M., Tharwat, M. E. and Abdel-Megeed, A. E. (1994).** *Bat mites of Egypt (Acari: Spinturnicidae)*. Ann. Agric. Sci. AinShams University, Cairo 39 (1): 463-471.
- Halliday, R. B., OConnor, B. M. and Baker, A. S. (2000).** *Global Diversity of Mites*. In Raven, P. H. and Williams, T.. *Nature and human society: the quest for a sustainable world*. Proceedings of the 1997 Forum on Biodiversity. National Academies. pp. 192–212.
- Hamilton, P. B., Stevens, J. R., Gaunt, M. W., Gidley, J and Gibson, W. C. (2004).** *Trypanosomes are monophyletic: evidence from genes for glyceraldehyde phosphate dehydrogenase and small subunit ribosomal RNA*. International Journal for Parasitology 34, 1393-1404.
- Hamilton, P. B., Cruickshank, C., Stevens, J. R., Teixeira, M. M. G. and Mathews, F. (2012).** *Parasites reveal movement of bats between the New and Old Worlds*. Molecular Phylogenetics and Evolution 63: 521-526.
- Hart, B. L. (1992).** *Behavioral adaptations to parasites: an ethological approach*. Journal of Parasitology, 78, 256–265.
- Hayman, D. T. S., Bowen, R. A., Cryan, P. M., McCracken, G. F., O’Shea, T. J., Peel, A. J., Gilbert, A., Webb, C. T. and Wood, J. L. N. (2012).** *Ecology of zoonotic infectious diseases in bats: current knowledge and future directions*. Zoonoses and Public Health, 60 (1): 2 – 21.

- Heithaus, R., Opler, P. A. and Baker, H. G. (1974).** *Bat activity and pollination of Bauhinia Pauletia: Plant-pollinator coevolution.* Ecology 55(2): 412-419.
- Herrera, M. L. G., Hobson, K. A., Manzo, A. A., Estrada, B. D., Sánchez-Cordero and Méndez, G. C. (2001).** *The Role of Fruits and Insects in the Nutrition of Frugivorous Bats: Evaluating the Use of Stable Isotope Models.* Biotropica 33(3): 520-528.
- Hering, M. (1838).** *Otodectes cynotis.* American Association of Veterinary Parasitologists.
- Hill, J. and Smith, J. (1984).** *Bats: A Natural History.* Austin: University of Texas Press.
- Hilton, C. D. and Best, T. L. (2000).** *Gastrointestinal helminth parasites of bats in Alabama.* Occasional Papers of the North Carolina Museum of Natural Sciences and the North Carolina Biological Survey, 12: 57–66.
- Hirst, S. (1923).** On some new or little-known species of Acari. Proceedings of the Zoological Society of London, IV: 971 - 1000.
- Hoare, C. A. (1972).** *The Trypanosomes of Mammals. "A Zoological Monograph."* Blackwell Scientific Publications, Oxford, 1–748.
- Holmes, K. V. (2003).** *SARS coronavirus: a new challenge for prevention and therapy.* The Journal of Clinical Investigation, 111(11): 1605-1609.
- Hoogstraal, H. (1952).** *Notes on Egyptian ticks (Ixodoidea). I. The genus Argas (Argasidae) in the Cairo area.* Proceedings of the Egyptian Academy of Science 7: 114-127.
- Hoogstraal, H. (1956).** *African Ixodoidea. I. Ticks of the Sudan (with special reference to Equatoria province and with preliminary reviews of the genera Boophilus, Margaropus, and Hyalomma.* Dept. of the Navy, Bureau of Medicine and Surgery, Washington, D.C.
- Hopla, C. E., Durden, L. A. and Keirans, J. E. (1994).** *Ectoparasites and classification.* Rev. sci. tech. Off. int. Epiz., 13 (4): 985-1017.

- Horváth, G. (1913).** *La distribution géographique des cimicides et l'origine des punaises des lits*. Pp.: 294–299. In: JouBin L. (ed.): *Éxtrait du IXe Congrès International de Zoologie*. 25–30 March, Monaco. Monaco, 928 pp.
- Hosseini-Chegeni, A. and Tavakoli, M. (2013).** *Argas vespertilionis (Ixodida: Argasida): A parasite of Pipistrel bat in Western Iran*. *Persian Journal of Acarology* 2(2): 321-330.
- Houghton, R. A. and Woodwell, G. M. (1989).** *Global climate change*. *Sci. Am.* 260, 36-44.
- Hudson, P. and Greenman, J. (1998).** *Competition mediated by parasites: biological and theoretical progress*. *Trends in Ecology and Evolution*, 13, 387–390.
- Johannesburg Zoo (2014).** *Animal of the month, bats*. Johannesburg City Parks.
- Jones, C. (1972).** *Comparative ecology of three pteropid bats in Rio Muni, West Africa*. *Journal of Zoology*, 167: 353 - 370.
- Jones, K. E., Patel, N. G., Levy, M. A., Storeygard, A., Balk, D., Gittleman, J. L. and Daszak, P. (2008).** *Global trends in emerging infectious diseases*. *Nature*, 451: 990-93.
- Jongejan, F. and Uilenberg, G. (1994).** *Ticks and Control Methods*. *Rev. Sci. Tech. Off. Int. Epiz.* 13(4): 1201–1226.
- Junker, K., Bain, O. and Boomker, J. (2008).** *Helminth parasites of Natal long-fingered bats, *Miniopterus natalensis* (Chiroptera: Miniopteridae), in South Africa*. *Onderstepoort Journal of Veterinary Research*, 75:261–265.
- 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*, Volume 14, Number 9.
- Kamins, A. O., Restif, O., Ntiama-Baidu, Y., Suu-Ire, R., Hayman, D. T., Cunningham, A. A., Wood, J. L. and Rowcliffe, J. M. (2011).** *Uncovering the fruit bat bushmeat*

- commodity chain and the true extent of fruit bat hunting in Ghana, West Africa. Biol Conserv. 144(12): 3000-3008.*
- Keirans, J. E. (1984).** *George Henry Falkiner Nuttall and the Nuttall Tick Catalogue.* U.S. Department of Agriculture Miscellaneous Publications, number 1438, 1–1785.
- Kelly D. J., Fuerst P. A., Ching W. M. and Richards A. L. (2009).** *Scrub typhus: the geographic distribution of phenotypic and genotypic variants of Orientia tsutsugamushi.* Clin. Infect. Dis. 48(3): 203–230.
- Kerr, A. F. G. (1936).** *Vernonia Schreb.* Flora Siamensis Enumeratio 2(3): 236-245.
- Klimpel, S. and Mehlhorn, H. (2014).** *Bats (Chiroptera) as Vectors of Diseases and Parasites: Facts and Myths.* Parasitology Research Monographs 5.
- Knowles, G. (2009).** *Animals and Witchcraft (The Witches Familiar)-Bats.* Accessed on 7th April, 2014 at www.controversial.com/Bats.htm
- Kohls, G. M. and Hoogstraal, H. (1961).** *Observations on the subgenus Argas (Ixodoidea, Argasidae, Argas). A. neghmei, new species, from poultry houses and human habitations in northern Chile.* Annals Ent. Soc. Amer. 54: 844–851.
- Kolenati, F. A. (1856).** *Die Parasiten der Chiroptern.* Brünn Rudolph Rohrer's Erben.
- Kolenati, F. A. (1857).** *Synopsis prodromal der Flughaut-Milben (Pteroptida) der Fledermäuse.* Wiener Entomologische Monatschrift 1:59-61.
- Komeno, C. A. and Linhares, A. X. (1999).** *Batflies parasitic on some phyllostomid bats in Southeastern Brazil: parasitism rates and host-parasite relationship.* Mem Inst Oswaldo Cruz 94(2): 151-156.
- Kosoy, M. Y. (2010).** *Ecological associations between bacteria of the genus Bartonella and mammals.* Biology Bulletin, 37 (7): 716 – 724.

- Krantz, G. W. (1978).** *A Manual of Acarology*. Oregon State University Book Store, USA.
- Krantz, G. W. and Walter, D. E. (2009).** *A Manual of Acarology*. Third Edition; Texas Technical University Press, Lubbock, Texas, USA.
- Krief, S., Escalante, A. A., Pacheco, M. A., Mugisha, L., André, C., Halbwx, M., Fischer, A., Krief, J., Kasenene, J. M., Crandfield, M., Cornejo, O. E., Chavatte, J., Lin, C., Letourneur, F., Grüner, A. C., McCutchan, T. F., Rénia, L. and Snounou, G. (2010).** *Diversity of Malaria Parasites in African Apes and the Origin of Plasmodium falciparum from Bonobos*. PLoS Pathog 6(2).
- Kudo, R. R. (1966).** *Protozoology*. 5th edition. Thomas Books. Springfield, IL. pp 718-732.
- Kuk, S., Yazar, S. and Cetinkaya, U. (2012).** *Stool sample storage conditions for preservation of Giardia intestinalis DNA*. Memórias do Instituto Oswaldo Cruz 107(8): 965-968.
- Kunz, T. H. (1984).** *Bats facts and folklore*. Boston University. Vol 46, pp 394-399.
- Kunz, T. H. (1996).** *Obligate and opportunistic interactions of Old-World tropical bats and plants*. In Hasan, Z.A.A. and Akbar, Z.: Conservation and faunal biodiversity in Malaysia. Penerbit Universiti Kebangsaan Malaysia, Kuala Lumpur, Malaysia: 37 – 65.
- Kuzmin, I. V., Bozick, B., Guagliardo, S. A., Kunkel, R., Shak, J. R., Tong, S. and Rupprecht, C. E. (2011).** *Bats, emerging infectious diseases, and the rabies paradigm revisited*. Emerging Health Threats Journal, Vol 4.
- Kwiecinski, G. G. and Griffiths, T. A. (1999).** *Rousettus egyptiacus*. Mammalian Species, 611: 1 - 9, 3 figs..
- Lametti, D. (2011).** *What is killing America's bats?* Discover. Accessed from www.discovermagazine.com Retrieved on 02/04/2015.
- Latreille, P. A. (1802).** *Histoire naturelle de fourmis, et recueil de mémoires et d'observations*

sur les abeilles, les araignées, les faucheur, et autres insectes. Paris. pp 1-445.

Laudisoit, A., Leirs, H., Makundi, R. H., Van Dongen, S., Davis, S., Neerinckx, S., Deckers, J. and Libois R. (2007). *Plague and the human flea, Tanzania.* Emerg Infect Dis 13, 687-693.

Lawrence, B. and Novick, A. (1963). *Behavior as a taxonomic cçe: relationships of Lissonycteris (Chiroptera).* Breviora, 184:16.

Leroy, E. M., Rouquet, P., Formenty, P., Souquière, S., Kilbourne, A., Froment, J., Bermejo, M. Smit, S., Karesh, W., Swanepool, R., Zaki, S. R. and Rollin, P. E. (2004). *Multiple Ebola virus transmission events and rapid decline of central African wildlife.* Science 303: 387-390.

Leroy, E. M., Epelboin, A., Mondonge, V., Pourrut, X., Gonzalez, J. P., Muyembe-Tamfum, J. J. and Formenty, P. (2009). *Human ebola outbreak resulting from direct exposure to fruit bats in Luebo, Democratic Republic of Congo, 2007.* Vector-Borne and Zoonotic Diseases, 9: 723-728.

Lewis, R. E. (1983). *The collection and preservation of ectoparasites for bats - an appeal.* Bat Res. News. 24: 24-25.

Lewis, R. E. (1999). *Resume of the Siphonaptera (Insecta) of the World.* J Med Entomol 35: 377-389.

Levine, N. D. (1988). *The Protozoan Phylum Apicomplexa.* CRC Press, Boca Raton, Florida, USA.

Lima, L. Da Silva, F. M., Neves, L., Attias, M., Takata, C. S. A., Campaner, M., De Souza, W., Hamilton, P. B. and Teixeira, M. M. G. (2012). *Evolutionary Insights from Bat Trypanosomes: Morphological, Developmental and Phylogenetic Evidence of a New*

- Species, Trypanosome (Schizotrypanum) erneyi sp. nov.*, in *African Bats Closely Related to Trypanosoma (Schizotrypanum) cruzi and Allied Species*. Protist 163: 856-872.
- Lloyd J. E. (2002).** *Louse flies, keds, and related flies (Hippoboscoidea)*. In *Medical and Veterinary Entomology*. Edited by: Mullen G, Durden L. New York: Academic Press; pp 349-362.
- Lo, M. K., Lowe, L., Hummel, K. B., Sazzad, H. M. S., Gurley, E. S., Hossain, M. J., Luby, S. P., Miller, D. M., Comer, J. A., Rollin, P. E., Bellini, W. J. and Rota, P. A. (2012).** *Characterization of Nipah Virus from Outbreaks in Bangladesh, 2008-2010*. Emerging Infect Dis 18(2):248-255.
- Loftis, A. D., Gill, J. S., Schriefer, M. E., Levin, M. L., Ereemeeva, M. E., Gilchrist, M. J., and Dasch, G. A. (2005).** *Detection of Rickettsia, Borrelia, and Bartonella in Carios kelleyi (Acari: Aragasidae)*. J Med Entomol. 42: 473– 80.
- Lopez, A., Miranda, P., Tejada, E. and Fishbein, D. B. (1992).** *Outbreak of human rabies in the Peruvian jungle*. Lancet 15; 339 (8790): 408-411.
- Lourenço, S. I. and Palmeirim, J. M. (2007).** *“Can mite parasitism affect the condition of bat hosts? Implications for the social structure of colonial bats,”* Journal of Zoology, 273 (2): 161–168.
- Lučan, R. K. (2006).** *Relationships between the parasitic mite Spinturnix andegavinus (Acari: Spinturnicidae) and its bat host, Myotis daubentonii (Chiroptera: Vespertilionidae): seasonal, sex- and age-related variation in infestation and possible impact of the parasite on the host condition and roosting behaviour*, Folia Parasitologica, 53 (2): 147–152, 2006.

- L'vov, D. K., Karas, F. R., Timofeev, E. M., Tsyarkin, Y. M., Vargina, S. G., Veselovskaya, O. V., Veselovskaya, N. Z., Osipova, Yu. I., Grebenyuk, V. L., Gromashevski, S. N., Steblyanko, S. N. and Fomina, K. B. (1973).** *“Issyk-Kul” virus, a new arbovirus isolated from bats and Argas (Carios) vespertilionis (Latr., 1802) in the Kirghiz S.S.R. Brief report.* Arch Gesamte Virusforsch. (42): 207–209.
- L'vov, D. K., Kostiukova, M. A., Pak, T. P. and Gromashevskii, V. L. (1980).** *Isolation of an arbovirus antigenically related to Issyk-Kul virus from the blood of a human patient [in Russian].* Vopr Virusol., pp 61–62.
- Maa, T. C. (1962).** *Records and Descriptions of Nycteribiidae and Streblidae (Diptera).* Pacific Insects 4 (2): 417-436.
- Machado-Allison, C. E. and Antequera, R. (1971).** *Notes on Neotropical Mesostigmata VI: Four new Venezuelan species of the genus Periglischrus (Acarina: Spintumicidae).* Smithsonian Contributions to Zoology 93: 1-16.
- MacLeod, J. (1934).** *Ixodes ricinus in relation to its physical environment: the influence of climate on development.* Parasitology (26): 282-305.
- Mahbubur, R. A. H. M. and Khanom, A. (2013).** *A Taxonomic and Ethno-Medicinal Study of Species from Moraceae (Mulberry) Family in Bangladesh Flora.* Research in Plant Sciences 1 (3): 53-57.
- Maizels, R. M. and Yazdanbakhsh, M. (2003).** *Immune regulation by helminth parasites: cellular and molecular mechanisms.* Nature Reviews Immunology 3: 733–744.
- Manzano-Román, R., Díaz-Martín, V., De la Fuente, J. and Pérez-Sánchez, R. (2012).** *Soft Ticks as Pathogen Vectors: Distribution, Surveillance and Control.* Parasitology, Dr. Mohammad Manjur Shah (Ed.), pp 125-161.

- Marinkelle, C. J. (1976).** *The Biology of the Trypanosomes of Bats*. In Lumdsen WHR, Evans DA (eds) *Biology of the Kinetoplastida*. Academic Press, New York, pp 175–216.
- Marshall, A. G. (1982).** *Ecology of insects ectoparasitic on bats*. In: Kunz, J. H. (ed.) *Ecology of Bats*. Plenum Publishing, London, 369-401.
- Marshall, M. E. and Miller, G. C. (1979).** *Some digenetic trematodes from Ecuadorian bats including five new species and one new genus*. *J. Parasitol*, 65: 909-917.
- Martinez Marañón, R. and Hoffman, A. (1976).** *Three cases of human intestinal mite infestation in the South of Veracruz*. *Rev Invest Salud Publica* 36(4): 187-201.
- Maudlin, I., Eisler, M. C. and Welburn, S. C. (2009).** *Neglected and endemic zoonosis*. *Philos Trans R Soc Lond B Biol Sci*. 364: 2777-87.
- McCosker P. J. (1979).** *Global aspects of the management and control of ticks of veterinary importance*. In *Recent advances in acarology* (J. Rodriguez, ed.). Academic Press, New York, 2: 45-53.
- McCurdy, D. G., Shutler, D., Mullie, A. and Forbes, M. R. (1998).** *Sex-biased parasitism of avian hosts: relations to blood parasite taxon and mating system*. *Oikos*, 82, 303– 312.
- McKendrick, A. G. (1941).** *A ninth analytical review of reports from Pasteur Institutes*. *Bull.W. H. O.* 9:31–78.
- Megali, A., Yannic, G. and Christ, P. (2011).** *Disease in the dark: molecular characterization of Polychromophilus murinus in temperate zone bats revealed a worldwide distribution of this malaria-like disease*. *Molecular Ecology*, 20, 1039-1048. *Morbidity and Mortality Weekly Report*, 63 (25): 548-551.
- Merck Veterinary Manual (1998).** *Boophilus microplus*. National Publishing Inc. Eight ed, Philadelphia, Pp 674-675

- Meredith, G., Dixon, M. D. and Schafer, I. J. (2014).** *Ebola Virus Disease Outbreak-West Africa, 2014*. Morbidity and Mortality Weekly Report 63(25); 548-551.
- Mickleburgh, S. P., Hutson, A. M. and Racey, P. A. (2002).** *A global review of the global conservation status of bats*. Oryx Vol 36: 1, 18-34.
- 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.
- Milne, A. (1948).** *The ecology of the sheep tick, Ixodes ricinus: microhabitat economy of the adult tick*. Parasitology 40: 14-34.
- Møller, A. P. and Rózsa, L. (2005).** *Parasite biodiversity and host defences: chewing lice and immune response of their avian hosts*. Oecologia, 142, 169–176
- Morimoto, S., Kurtti, T. S. and Noda, H. (2006).** *In vitro cultivation and antibiotic susceptibility of a Cytophaga-like intracellular symbiote isolated from the tick Ixodes scapularis*. Current Microbiology 52 (4):324-329.
- Molyneux, D. H. (1991).** *Trypanosomes of bats*. In Parasitic Protozoa. Edited by Kreier, J. P., Baker, J. R. New York: Academic; 195-223.
- Mooring, M. S., Patton, M. L., Reisig, D. D., Osborne, E. R., Kanallakan, A. L. and Aubery, S. M. (2006).** Sexually dimorphic grooming in bison: influence of body size, activity budget and androgens. Anim Behav. 72:737–745.
- Moore, S. L. and Wilson, K. (2002).** *Parasites as a viability cost of sexual selection in natural populations of mammals*. Science, 297, 2015–2018.
- Morales-Montor, J., Chavarria, A., De Leon, M.A., Del Castillo, L.I., Escobedo, E.G., Sanchez, E.N., Vargas, J.A., Hernandez-Flores, M., Romo-Gonzalez, T. and Larralde, C. (2004).** *Host gender in parasitic infections of mammals: an evaluation of*

- the female host supremacy paradigm*. Journal of Parasitology, 90: 531–546.
- Morrison, D. W. (1980).** *Efficiency of food utilization by fruit bats*. Oecologia, 45: 270-273.
- Morrand, S., Gouy de Bellocq, J., Stanko, M. and Miklisova, D. (2004).** *Is sex-biased ectoparasitism related to sexual size dimorphism in small mammals of Central Europe?* Parasitology 129:505-510.
- Mühldorfer, K. (2013).** *Bats and Bacterial Pathogens: A Review*. Zoonoses and Public Health.
- Muller-Graf, C. D., Collins, D. A. and Woolhouse, M. E. (1996).** *Intestinal parasite burden in five troops of olive baboons (*Papio cynocephalus anubis*) in Gombe Stream National Park, Tanzania*. Parasitology 112 (5): 489-497.
- Mullen, G. R., Mullen, G. and Durden, L. (2009).** *Medical and Veterinary Entomology*. Academic Press. p. 637.
- Munene, E., Otsyula, M., Mbaabu, D. A., Mutahi, W. T., Muriuki, S. M. and Muchemi, G. M. (1998).** *Helminth and protozoan gastrointestinal tract parasites in captive and wild-trapped African non-human primates*. Vet Parasitol 78: 195-201.
- Nartey, N. A. N. (2011).** *Ectoparasites of fruit-eating bats*. (Unpublished BSc thesis). Department of Animal Biology and Conservation Science, University of Ghana, Legon.
- Neerinckx, S. B., Peterson, A. T., Gulinck, H., Deckers, J. and Leirs, H. (2008).** *Geographic distribution and ecological niche of plague in sub-Saharan Africa*. Int J Health Geogr 23(7): 5460, 93–1032.
- Neuhaus, P. (2003).** *Parasite removal and its impact on litter size and body condition in Columbian ground squirrels (*Spermophilus columbianus*)*. Biol. Lett. 270, 213–215.
- Nelson, J. E. (1989).** *Pteropodidae*. Australian Journal of Zoology, pp 2-18.
- Nogueira, M. R., De Fabio, S. P. and Peracchi, A. L. (2004).** *Gastrointestinal helminth*

parasitism in fruit-eating bats (Chiroptera, Stenodermatinae) from western AmazonianBrazil. Rev. Biol. Trop. 52(2): 387-392.

Northrop-Clewes, C. A. and Shaw, C. (2000). *Parasites.* British Medical Bulletin 56(1): 193-208.

Nowak, R (1991). *Order Chiroptera.* In Walker's Mammals of the World, 1 (5): 190-194.
Baltimore: Johns Hopkins University Press.

Ntiamoa-Baidu, Y. (1987a). *Life Cycle of Ixodes (Afrixodes) aulacodi (Acari: Ixodidae) in the Laboratory.* J. Med. Entomol. 24: 444-447.

Ntiamoa-Baidu, Y. (1987b). *Rhipicephalus simpsoni (Acari: Ixodidae) Development Under Controlled Conditions.* J. Med. Entomol. 24:438-443

Okafor, F. C., Igbinsosa, I. B. and Ezenwaji, H. M. G. (2004). *Helminth fauna of Tadarida (Chaeraphon) nigeriae (Thomas, 1913) (Microchiroptera: Molossidae).* Animal Research International 1(1): 64 – 69.

Okulova, N. M. and Aristova, V. A. (1973). *Influence of ectoparasites on a population of the northern red-backed vole in southwestern Siberia.* Soviet Journal of Ecology, 4: 522–527.

Olenev, N. (1927). *Contribution to the biology of Ixodes ricinus L. in the Novgorod Government.* Defenses des plantes 4: 354- 356.

Omanwar, S. R. Jr, Basagoudanavar, S. H., Singh, R. K. and Butchalah, G. (1999). *Direct and sensitive detection of Trypanosoma evansi by polymerase chain reaction.* Acta Vet Hung, 47: 351-359.

Otranto, D., Milillo, P., Mesto, P., De Caprariis, D., Perrucci, S. and Capelli, G. (2004). *Otodectes cynotis (Acari: soroptidae): examination of survival off-the-host*

under natural and laboratory conditions. Exp Appl Acarol 32(3):171-9.

- Pader, V., Buniak, J. N., Abdissa, A., Adamu, H., Tolosa, T., Gashaw, A., Cutler, R. R. and Cutler, S. J. (2012).** *Candidatus Rickettsia hoogstraalii* in Ethiopian *Argas persicus* ticks. *Ticks and Tick-borne Diseases* 3: 337-344.
- Patterson, B. D., Dick, C. W. and Dittmar, K. (2007).** *Roosting habits of bats affect their parasitism by bat flies (Diptera: Streblidae).* *Journal of Tropical Ecology*, 23: 177–189.
- Patterson, B. D., Dick, C. W. and Dittmar, K. (2008).** *Parasitism by bat flies (Diptera: Streblidae) on neotropical bats: effects of host body size, distribution, and abundance.* *Parasitology Research*, 103: 1091–1100.
- Péricart, J. (1996).** *Family Cimicidae Latreille, 1802 – bed-bugs.* In: Aukema B. & Rieger C. (eds.): *Catalogue of the Heteroptera of the Palearctic Region.* Netherlands Entomological Society, Amsterdam, Netherlands, pp 141–144.
- Perez-Orella, C. and Schulte-Hostedde, A. (2005).** *Effects of sex and body size on ectoparasite loads in the northern flying squirrel (Glaucomys sabrinus).* *Can. J. Zool.* 83: 1381–1385.
- Pérez-Ponce De León, G. (2001).** *The diversity of digeneans (Platyhelminthes: Cercomeria: Trematoda) in vertebrates in Mexico.* *Comparative Parasitology*, 68: 1–8.
- Phiri, B. J., Benschop, J. and French, N. P. (2010).** *Systematic review of causes and factors associated with morbidity and mortality on smallholder dairy farms in eastern and southern Africa.* *Preventive Veterinary Medicine*, 94 (1-2): 1-8.
- Pilosof, S., Dick, C. W., Korine, C., Patterson, B. D. and Krasnov, B. R. (2012).** *Effects of Anthropogenic Disturbance and Climate on Patterns of Bat Fly Parasitism.* *PLOS ONE* 7(7): e41487.

- Pitariu, T., Dinulescu, N., Panaitescu, D. and Silard, R. (1978).** *Cholangiocholecystitis, an acute attack with acarids in B bile.* Rev Ig Bacteriol Virusol Parazitol Epidemiol Pnemoftiziol Bacteriol Virusol Epidemiol 23: 189-92.
- Poinar, G. O. Jr. (2011).** *Vetufebrus ovatus n. gen., n. sp. (Haemospororida: Plasmodiidae) vectored by a streblid bat fly (Diptera: Streblidae) in Dominican amber.* Parasites & Vectors, 4:229.
- Pollitzer, R. (1954).** *Plague.* WHO monograph series No. 22 Geneva: World Health Organization.
- Presley, S. J. and Willig, M. R. (2008).** *Intraspecific patterns of ectoparasite abundances on Paraguayan bats: effects of host sex and body size.* Journal of Tropical Ecology 24:75–83.
- R Core Team (2014).** *R: A language and environment for statistical computing.* R Foundation for Statistical Computing, Vienna, Austria. URL <http://www.R-project.org/>
- Radford, C. D. (1947).** Two new bat mites of the genus *Ancystropus* (Acarina: Spinturnicidae). Proc. Zool. Soc. London 117:305-12.
- Radovsky, F. J. and Yunker, C. E. (1963).** *Four new species of Steatonyssus from Africa (Acarina: Dermanyssidae).* J. Parasitol. 49 (2): 334-339.
- Radovsky, F. J. (1967).** *The Macronyssidae and Laelapidae (Acaria: Mesostigmata) parasitic in bats.* University of California Publications in Entomology 46, 1-288.
- Ramel, G. (2014).** *Bats and Humanity.* The Earthlife Web.
- Randolph, S. E. (2010).** *To what extent has climate change contributed to the recent epidemiology of tick-borne diseases?* Veterinary Parasitology 167 (2-4):92-94.
- Raoult, D., Aboudharam, G., Crubezy, E., Larrouy, G., Ludes, B. and Drancourt M.**

- (2000). *Molecular Identification by 'suicide PCR' of Yersinia pestis as the agent of the Medieval Black Death*. Proc Natl Acad Sci USA 97; Pp 2800-2803.
- Reckardt, K. and Kerth, G. (2009).** *Does the mode of transmission between hosts affect the host choice strategies of parasites? Implications from a field study on bat fly and wing mite infestation of Bechstein's bats*. Oikos, vol. 118, no. 2, pp. 183–190.
- Reeves, W. K., Loftis, A.D., Gore, J. A. and Dasch, G. A. (2005).** *Molecular evidence for novel Bartonella species in Trichobius major (Diptera: Streblidae) and Cimex Adjunctus (Hemiptera: Cimicidae) from two south-eastern bat caves, U.S.A.* J Vector 30:339–341.
- Reeves, W. K., Rogers, T. E., Durden, L. A. and Dasch, G. A. (2007).** *Association of Bartonella with the fleas (Siphonaptera) of rodents and bats using molecular techniques*. J Vector Ecol. 32:118- 22.
- Reiss, F. (1966).** *Tungiasis in New York City*. Arch Dermatol 93; pp 404-407.
- Ricci, M. (1995).** *Trematode parasites of Italian bats*. Parassitologia 37, 199–214.
- Ristic M. and Montenegro-James S. (1987).** *Progress in the immunoprophylaxis of hemoparasitic diseases of cattle*. Agribusiness Worldwide, 19, 9-10.
- Rosenzweig, M. L. (1995).** *Species diversity in space and time*. Cambridge University Press, Cambridge, pp 436.
- Rosevear, D. R. (1965).** *Bats of West Africa*. British Museum (Natural History), London. Vol 150.
- Rosin, G., Landau, I. and Hugot, J. P. (1978).** *Considérations sur le genre Nycteria (Haemoproteidae) parasite de Microchiroptères Africains avec description de quatre espèces nouvelles*. Ann Parastologie (Paris), 53:447-459.

- Roy, J., Bédard, C. and Moreau, M. (2011).** *Treatment of feline otitis externa due to Otodectes cynotis and complicated by secondary bacterial and fungal infections with Oridermyl auricular ointment.* Canadian Veterinary Journal 53(3): 277-282.
- Rubenstein, D. I. and Hohmann, M. E. (1989).** *Parasites and social behavior of island feral horses.* Oikos, 55: 312–320.
- Rudnick, A. (1960).** *A revision of the mites of the family Spinturnicidae (Acarina).* University of California Publications in Entomology, 17: 157–284, 1960.
- Saoud, M. F. A. and Ramadan, M. M. (1976).** *Studies on the helminth parasites of bats in Egypt and the factors influencing their occurrence with particular reference to digenetic Trematodes.* Zeitschrift für Parasitenkunde, 51: 37–47.
- Sarasa, M., Pérez, J. M., Alasaad, S., Serrano, M., Soriguer, R. C, Granados, J., Fandos, P., Joachim, J. and Gonzalez, G. (2011).** *Neatness depends on season, age, and sex in Iberian ibex Capra pyrenaica.* Behavioural Ecology: 1070-1078.
- Sawatsky, B., Ranadheera, C., Weingartl, H. M. and Czub, M. (2008).** *Hendra and Nipah Virus.* Animal Viruses: Molecular Biology. Caister Academic Press.
- Schad, J., Dechmann, D. K. N., Voigt, C. C. and Sommer, S. (2012).** *Evidence for the ‘Good Genes’ Model: Association of MHC Class II DRB Alleles with Ectoparasitism and Reproductive State in the Neotropical Lesser Bulldog Bat, Noctilio albiventris.* PLoS One 7(5): e37101.
- Schaer, J., Perkins, S. L., Decher, J., Leendertz, F. H., Fahr, J., Weber, N. and 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, volume 110 no. 43 pp 17415-17419.

- Schalk, G. and Forbes, M. R. (1997).** *Male biases in parasitism of mammals: effects of study type, host age, and parasite taxon.* *Oikos*, 78: 67–74.
- Schnipper, J., Chanson, J. S., Chiozza, F., Cox, N., Hoffmann, M. K., Lamoreux, J., Rodrigues, A. S. L., Stuart, S. N., Temple, H. J., Baillie, J. E. M., Boitani, L., Lacher, T. E., Mittermeier, R. A., Smith, A. T., Absolon, D. et al. (2008).** *The status of the world's land and marine mammals: diversity, threat and knowledge.* *Science* 322: 225-230.
- Schwan, T. G., Corwin, M. D. and Brown, S. J. (1992).** *Argas (Argas) monolakensis, new species (Acari: Ixodoidea: Argasidae), a parasite of California gulls on islands in Mono Lake, California: description, biology, and life cycle.* *J. Med. Entomol.* 29: 78–97.
- Schwarz, J., Silverman, F. N., Adriano, S. M., Straub, M. and Levine, S. (1955).** *The relation of splenic calcification to histoplasmosis.* *N Engl J Med* 252:887–891.
- Scott, M. E. (1988).** *The impact of infection and disease on animal populations: implications for conservation biology.* *Conservation Biology* 2: 40–56.
- Service, M. W. (1996).** *Scrub typhus mites (Trombiculidae).* In: Service, M. W., ed. *Medical entomology for students.* London: Chapman and Hall, 256-262.
- Shimalov, V. V., Demyanchik, M. G. and Demyanchik, V. T. (2002).** *A study on the helminth fauna of the bats (Mammalia, Chiroptera: Vespertilionidae) in Belarus.* *Parasitology Research* 88, 1011.
- Socolovschi, C., Kermif, T., Raoult, D. and Parola, P. (2012).** *Borrelia, Rickettsia and Ehrlichia Species in Bat Ticks, France, 2010.* *Emerging Infectious Diseases*; 18(12): 1966-1975.
- Sonenshine, D. E. (1991).** *Biology of ticks.* Oxford University press, Oxford UK, Pp 447.

- Stenseth, N. C., Atshabar, B. B., Begon, M., Belmain, S. R., Bertherat, E., Carniel, E., Gage, K. L., Leirs, H. and Rahalison, L. (2008).** *Plague: past, present and future.* PLOS Med 5:1(3).
- Sustainable Development Success Stories (2000).** *Buoyem Sacred Grove Conservation Project.* United Nations. Volume 4: 40-42.
- Swanepoel, R., Smit, S. B., Rollin, P. E., Formenty, P., Leman, P. A., Kemp, A., Burt, F. J., Grobbelaar, A. A., Croft, J., Bausch, D. G., Zeller, H., Leirs, H., Braack, L. E. O., Libande, M. L., Zaki, S., Nichol, S. T., Ksiazek, T. G. and Paweska, J. T. (2007).** *Studies of Reservoir Hosts for Marburg Virus.* Emerging Infectious Diseases 13(12): 1847-1851.
- Taboada, M. D. F. (1954).** *Pulmonary acariasis in Spain; an illustrative case report.* British medical journal 1(4859): 437-438.
- Taylor, L. H., Latham, S. M. and Woolhouse, M. E. (2001).** *Risk factors for human disease emergence.* Philosophical Transactions of the Royal Society B, 356 (1411): 983-989.
- Ter Hofstede, H. M., Fenton, M. B. and Whitaker Jr, J. O. (2004).** *Host and host- site specificity of bat flies (Diptera: Streblidae and Nycteribiidae) on Neotropical bats (Chiroptera).* Canadian Journal of Zoology, 82: 616–626.
- Theodor, O. (1956).** *On the genus Tripselia and the group of Basilia bathybothyra (Nycteribiidae, Diptera).* Parasitology, 46: 353 - 394.
- Thomas, D. W. (1984).** *Fruit intake and energy budgets of frugivorous bats.* Physiol. Zool 57: 457-467.
- Thomas, M. E., Rasweiler, J. J. IV. and 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.

- Tinnin, D. S. Gardner, S. L. and Ganzorig, S. (2008).** *Helminths of Small Mammals (Chiroptera, Insectivora, Lagomorpha) from Mongolia with a Description of a New Species of Schizorchis (Cestoda: Anoplocephalidae)*. University of Nebraska, Lincoln.
- Tompkins, D. M., Jones, T. and Clayton, D. H. (1996).** *Effect of vertically transmitted ectoparasites on the reproductive success of swifts (Apus apus)*. Func. Ecol. 10: 733–740.
- Traub, S. J. and Cummins, G. A. (2011).** *Tick-borne diseases*. In: Auerbach PS, ed. Wilderness Medicine. 6th ed. Philadelphia, Pa: Mosby Elsevier, chap 51.
- Uhrin, M., Kaňuch, P., Krištofik, J. and Paule, L. (2010).** *Phenotypic plasticity in the greater mouse-eared bat in extremely different roost conditions*. Acta Theriologica, 55: 153–164.
- Vahedi, A., Mahdavi, M., Ghazanchaei, A. and Shokouhi, B. (2014).** *Genotypic characteristics of hydatid cysts isolated from humans in East Azerbaijan Province (2011-2013)*. J Anal Res Clin Med, 2(3), 152-157.
- Van Overbeek, Gassner, L. F., van der Plas, C. L., Kastelein, P., Rocha, U. N. D. and Takken, W. (2008).** *Diversity of Ixodes ricinus tick-associated bacterial communities from different forests*. Fems Microbiology Ecology 66 (1):72-84.
- Vaughan, T., Ryan, J. and Czaplewski, N. (2000).** *Mammalogy*. 4th Edition. Toronto: Brooks Cole.
- Walker, H. W. (1996).** *Rickettsiae*. Medical Microbiology, 4th edition. Baron, S., editor. Galveston (TX), University of Texas Medical Branch at Galveston.

- Walter, G. (1996).** *Zum Ektoparasitenbefall der Fledermäuse und den potentiellen Auswirkungen.* Myotis 34:85-92.
- Watt, G. and Parola, P. (2003).** *Scrub typhus and tropical rickettsioses.* Curr. Opin. Infect. Dis. 16:429–436.
- Webb, C. E., Doggett, S. L. and Russell, R. C. (2012).** *Arthropod pests of public health significance in Australia.* enHealth Australia, pp 72
- Weber, N. and Fahr, J. (2006).** *Survey of endemic and globally threatened bat species in the Fouta Djallon Plateau for conservation priorities in Guinea.* Preliminary project report – Van Tienhoven Foundation: 7 pp.
- Weese, S. (2010).** *Ear mites and the strange pursuit of knowledge.* Worms and Germs Blog. University of Guelph.
- Wenzel, R. L, Tipton, V. J. and Kiewlicz, A. (1966).** *The streblid bat flies of Panama (Diptera: Calyptera: Streblidae),* In Wenzel, R. L. and Tipton, V. J. (eds.), *Ectoparasites of Panama,* Field Museum of Natural History, Chicago, pp. 405-675.
- Whitaker Jr, J. O. (1988).** *Collecting and preserving ectoparasites for ecological study.* In: Kunz, T. H. (ed.) *Ecological and behavioral methods for the study of bats.* Smithsonian, Washington D.C.
- Whitaker, J. O. Jr., Dannelly, H. K. and Prentice, D. A. (2004).** *Chitinase in insectivorous bats.* Journal of Mammalogy, pp 15-18.
- Whiteman, N. K. and Parker, P. G. (2004).** *Body condition and parasite load predict territory ownership in the Galapagos hawk.* Condor 106: 915-921.
- Wilkinson, G. S. (1986).** *Social Grooming in the Common Vampire Bat, Desmodus rotundus.* Animal Behaviour 34:1880–1889.

- William, D. J., Timothy, G. B. and Dirk, M. E. (2006).** *Andrews' Diseases of the Skin: Clinical Dermatology*. Saunders Elsevier (10): 466-469.
- Wilson, N. A, and Galloway, T. D. (2002).** *The occurrence of the bat bug, Cimex pilosellus (Horváth) (Hemiptera: Cimicidae), in Manitoba, Canada*. Proceedings of the Entomological Society of Manitoba, 58: 5–7.
- Wong, S., Lau, S., Woo, P. and Yuen, K.Y. (2007).** *Bats as a continuing source of emerging infections in humans*. Reviews in Medical Virology, 17: 67-91.
- Wood, S. (2012).** *Geographic distribution and composition of the parasite assemblage of the insectivorous bat, Miniopterus natalensis (Chiroptera: Miniopteridae) in South Africa*. Department of Zoology, University of Cape Town.
- Wooden, J., Kyes, S. and Sibley, C. (1993).** *PCR and strain identification in Plasmodium falciparum*. Parasitol Today 9:303-305.
- Woolhouse, M. E. and Gowtage-Sequeria, S. (2005).** *Host range and emerging and reemerging pathogens*. Emerg. Infect. Dis. 11: 1842–1847.
- World Health Organization (1989).** *Geographical distribution of arthropod-borne diseases and their principal vectors*. Report No. WHO/VBC/89.967. Geneva; WHO.
- World Health Organization (2013).** *Nipah Virus*. Accessed from <http://www.who.int/mediacentre/factsheets/fs262/en/2013>. Retrieved on 19/08/14
- World Health Organization (2014a).** *Ebola virus disease Fact sheet N°103''*. Retrieved 19/08/14
- World Health Organization (2014b).** *Infection prevention and control guidance for care of patients in health-care settings, with focus on Ebola*. Retrieved 15/12/14

- World Health Organization (2014c).** *World Malaria Report*. WHO Global Malaria Programme, pp 16.
- Wund, M. and Myers, P. (2005).** *Mammals*. Accessed from Animal Diversity Web on March 20, 2014 at <http://animaldiversity.ummz.umich.edu/accounts/Chiroptera/>
- Yeboah T. (2014).** *Empowering residents to participate in Ghana's ecotourism projects: A study of some communities in the Brong-Ahafo region*. Herald Journal of Geography and Regional Planning Vol. 3 (1): 35 – 044.
- Yunker, C. E. and Eleanor, K. J. (1961).** *Endoparasitic chiggers: I. chiroptera, a new host order for intranasal chiggers, with descriptions of two new genera and species (acarina: trombiculidae)*. The Journal of Parasitology, 47 (6): 995-1000.
- Zahn, A. and Rupp, D. (2004).** Ectoparasite load in European vespertilionid bats. Journal of Zoology (London), 262: 383-391.
- Zenon, J. C. and Hugh, G. B. (2011).** *Ectoparasite Community Structure of Two Bats (Myotis lucifugus and M. septentrionalis) from the Maritimes of Canada*. Department of Biology, Saint Mary's University, 923 Robie Street, Halifax, NS, Canada B3H 3C3.
Editor: D. D. Chadee.
- Zhang, L., Parsons, S., Daszak, P., Wei, L., Zhu, G. and Shuyi, Z. (2010).** *Variation in the abundance of ectoparasitic mites of flat-headed bats*. Journal of Mammalogy 91(1): 136-143.