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Effects of Host Demography, Season and Rainfall on the Prevalence and Parasitic Load of Gastrointestinal Parasites of Free-Living Elephants (*Loxodonta africana*) of the Chad Basin National Park, Nigeria

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Abstract: The effects of host demography, rainfall and season on the prevalence and parasitic load of gastrointestinal parasites of African elephants (*Loxodonta africana*) of the Chad Basin National Park were determined for the first time. Out of the 274 elephants examined, 36.86% were infected. Of the 178 males examined, 35.96% harboured *Strongyloides*, *Coccidia* and *Strongyles* with worm burdens of 75.6±0.3, 125.2±1.4 and 420.2±0.1, respectively. Among the males, the larvae of *Strongyloides papillosus* were recovered from those infected with *Strongyloides* while *Haemonchus contortus*, *Trichostrongylus colubriformis*, *Murshidia* species and *Oesophagostomum columbianum* were recovered from those infected with *Strongyles.* Those infected with *Coccidia* yielded *Eimeria bovis*. Of the 96 females examined, 38.54% were infected with *Coccidia* and *Strongyles* with 102.2±0.7 Oocysts per Gram of faeces (OPG) and 360.2±0.1 Eggs per Gram of faeces (EPG), respectively. The helminth larvae recovered from the females infected with *Strongyles* were; *H. contortus*, *O. columbianum* and *Murshidia* species, while those infected with *Coccidia* yielded *E. bovis*. Out of the 213 adults examined, 27.23% were infected with *Strongyloides* and *Strongyles* with 187.3±0.4 and 208.4±0.1 EPG, respectively. The larvae of *S. papillosus* were recovered from those infected with *Strongyloides*, while the larvae of *H. contortus*, *O. columbianum*, *T. colubriformis* and *Murshidia* were recovered from those infected with *Strongyles*. Of the 61 young examined, 70.49% were infected with *Coccidia* and *Strongyloides* with OPG of 88.4±0.2 and EPG of 624.4±0.2. The elephants were mostly infected in the rainy season. The worm burden and prevalence according to sex and age were highest in August. The males and young were more infected than their counterparts. In conclusion, intrinsic and extrinsic factors played a role on the prevalence and worm burden of gastrointestinal parasites of elephants of the Chad Basin National Park.

Key words: Demography, season, rainfall, gastro intestinal parasites, free-living elephants, Chad Basin

INTRODUCTION

Strongyles have been reported as the major nematodes of the African elephant (*Loxodonta africana*) (Soulsby, 1982). The genera *Choniangium, Decrusia* and *Eqinurbia* are morphometrically classified as large *Strongyles* while *Khalilia*, *Murshidia* and *Quilonia* are the small ones (Condy, 1974; Thurber *et al*., 2011). The biology and life cycle of these nematodes are similar to those of horses and cattle (Soulsby, 1982; Fowler, 2001). Several species of strongyline nematodes common to cattle such as *Haemonchus contortus*, *Trichostrongylus colubriformis* and *Oesophagostomum columbianum* have been reported among African elephants (*L. africana*) living in captivity in the semi-arid region of Northeastern, Nigeria (Nwosu, 1995; Mbaya *et al*., 2006; Ibrahim *et al*., 2007). They have also been reported among Asian elephants (*Elaphus maximus*) found in captivity (Gaur *et al*., 1979), among free roaming African elephants (*L. africana*) in the Republics of Congo and Central Africa (Kinsella *et al*., 2005) and in Burkina Faso (Jost *et al*., 2005).

Intrinsic (host demography) and extrinsic factors (environment and population density) often affect prevalence and worm burden in elephants (Krecek *et al*., 1989; Gulland, 1995; Masangane *et al*., 2004; Thurber *et al*., 2011). Despite the large concentrations of free-living African elephants (*L. africana*) in the Chad Basin National Park, Nigeria, coupled with the fact that they often share the same pasture with nomadic cattle in the area, there is a lack of information regarding the

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intrinsic and extrinsic factors that might affect the prevalence and worm burden of gastrointestinal parasites in the park. In view of these, the effects of rainfall, season and host demography (sex and age) on the prevalence and worm burden of gastrointestinal parasites of free-living African elephants (*L. africana*) were studied for the first time in the Chad Basin National Park located in the semi-arid region of northeastern, Nigeria.

MATERIALS AND METHODS

Study area: This study was conducted in the Chungurmi-Duguma sector of the Chad Basin National Park, Nigeria: An area covering 1228 sq. km. It extends between latitude 12 and 14°N and longitude 13 and 15°E. The reserve has a variety of animals such as giraffes (*Camelus pardellus*), spotted hyeana (*Crocuta crocuta*), jackals (*Canis aureaus*) and red fronted gazelles (*Gazella rufifrons*), among others. Birds such as ostrich (*Struthio camelus*), helmeted guinea fowl (*Numidia meleagris*), bustard (*Otis tarda*) and grey francolin (*Francolinus pandicerianus*) are also found in the park. The vegetation is simple and mainly dominated by the elephant grass (*Pennisetum purpureum*). The rainy season lasts for a short period (3-4 months) from June to September. This is followed by a prolonged dry season (7-8 months) from October-May (Udoh, 1981). Meteorological data regarding the pattern of rainfall in the area for the period of study was obtained from weather stations at the Department of Geography, University of Maiduguri and from the Maiduguri International Airport.

Sample collection: The study was conducted between January 2004 and December 2011. During several visits to the park, conveniently deposited fresh dung samples from 274 free-living elephants (*L. africana*) were randomly collected. The desired sample size was calculated at 95% confidence interval with 5% absolute precision using the formula of Thrusfield (1995). The samples were labelled demographically according to sex and age. High powered binoculars were used to identify the sexes of the elephants from observation towers located close to the water hole. This was based on a huge photo data previously generated to identify each elephant based on natural body markings, scar tissues or special defects such as tusklessness, one-tuskedness, broken tusks, large holes or tears on ears, missing trunk tip or absence of tail. Sexual dimorphism was also established based on the methods of Poole (1989a) where male elephants were distinguished from the females by their larger and heavier stature; characteristics curved foreheads and thick tusks. The females on the other hand were slender, having angular foreheads, pointed tusks and mammary glands hanging between their forelimbs. The adult males (>18 years) were distinguished from the young (<18 years) based on sexual maturity characterized by visible temporal gland secretions during "musth". In addition, the adult females (>18 years) were distinguished from the young females (<18 years) by the occurrence of oestrus and developed mammary glands (Poole, 1989a). The coordinates of the dung collections were obtained using the Global Positioning System (GPS) portable hand-held receiver. Each dung sample was divided into two: a set was collected and preserved in 10% formalin and the other without formalin. All the tests were carried out in the Parasitology Laboratory of the Faculty of Veterinary Medicine, University of Maiduguri, Nigeria.

Laboratory investigations: The dung samples collected and preserved in 10% formalin were examined for helminth ova by the direct smear, sedimentation and floatation methods. While faecal eggs per gram of faeces (EPG) or oocysts per gram of faeces (OPG) were used to determine the worm burden or parasitic load by the modified McMaster technique using saturated sodium chloride solution as the floating medium (MAFF, 1977). However, the dung samples not preserved in formalin were subjected to larval culture and the larvae were recovered using the modified Baerman's technique while *Coccidia* oocysts were sporulated using potassium dichromate ($K_2Cr_2O_7$) to identify the species involved (Joyner *et al*., 1966; Soulsby, 1982; Hansen and Perry, 1990). The identification of the helminth ova/oocysts and infective larvae were done using standard keys (Condy, 1974; Sloss and Kemp, 1978; Soulsby, 1982).

Statistical analysis: The data obtained were either summarized as Means±SD or percentages and the differences between the means were determined using the χ^2 ICC test adjusted for intra-cluster correlation (Donald and Donner, 1988).

RESULTS

The host demography, species of gastrointestinal parasites and associated parasitic load of African elephants (*L. africana*) of the Chad Basin National Park are presented in Table 1. Out of a total of 274 elephants (*L. africana*) examined, 101 (36.86%) were infected. Out of the 178 males examined, 64 (35.96%) of them harboured *Strongyloides* species 10 (15.63%), *Coccidia* spp. 5 (7.81%) and *Strongyles* 49 (76.56%) having 75.6±0.3 (EPG), 125.2±1.4 (OPG) and 420.2±0.1 (EPG), respectively. Out of

Table 1: Effect of host demography on the prevalence and worm burden of gastrointestinal parasites of African elephants (*L. Africana*) of the Chad Basin National Park, Nigeria

Parameters	No. examined	No. infected (%)	Parasites encountered (%)	EPG/OPG	Mean larvae recovered±SD
Sex Males	178	64 (35.96)^{a}	(i) *Strongyloides* spp. 10 (15.6)^{a} (ii) *Coccidia* 5 (7.81) spp.^{b} (iii) *Strongyle* spp.49 (76.56)^{c}	75.6±0.3^{a} 125.2±1.4^{b} 420.2±0.1^{c}	(i) *S. papillosus* 102.2±0.4^{a} (i) *E. bovis* 216.2±1.3^{b} (i) *H. contortus* 322.4±0.1^{c} (ii) *T. colubriformis* 106.2±0.3^{a} (iii) *Murshidia* species 78.2±0.3^{d} (iv) *O. columbianum* 100.8±0.3^{a}
Females	96	37 (38.54)^{a}	(i) *Coccidia* spp. 7 (18.92)^{d} (ii) *Strongyle* spp. 30 (81.08)^{e}	102.2±0.7^{d} 360.2±0.1^{e}	(i) *E. bovis* 98.2±0.7^{e} (ii) *H. contortus* 284.4±0.3^{b} (iii) *O. columbianum* 98.8±0.6^{e} (iv) *Murshidia* spp. 78.8±0.6^{d}
Total	274	101 (36.86)			
Age					
Adults	213	58 (27.23)^{b}	(i) *Strongyloides* spp. 11 (18.9)^{d} (ii) *Strongyle* spp. 47 (81.03)^{e}	187.3±0.4^{e} 208.4±0.1^{f}	(i) *S. papillosus* 102.0±0.4^{a} (i) *H. contortus* 402.0±0.6^{b} (ii) *O. columbianum* 136.2±0.4^{a} (iii) *T. colubriformis* 76.2±0.3^{d} (iv) *Murshidia* spp. 157±0.4^{a}
Young	61	43 (70.49)^{d}	(i) *Coccidia* spp. 13 (30.23)^{f} (ii) *Strongyle* spp. 30 (69.77)^{g}	88.4±0.2^{g} 624.4±0.2^{h}	(i) *E. bovis* 314.4±0.4^{c} (i) *H. contortus* 204.8±0.9^{b} (ii) *G. pachyscelis* 124.0±0.7^{a} (iii) *O. columbianum* 63.4±0.5^{d} (iv) *T. colubriformis* 30.0±0.4^{f}
Total	274	101 (36.86)		2,191.9±0.5	

Values with different superscripts in columns regarding prevalence, parasite species, EPG/OPG and larvae differed significantly (p<0.05)

the 96 females examined, 37 (38.54%) of them harboured *Coccidia* spp. 7 (18.92%) and *Strongyle* spp. 30 (81.08%) with 102.2±0.7 (OPG) and 360.2±0.1 (EPG), respectively. Out of the 213 adults (>18 years) examined, 58 (27.23%) harboured *Strongyloides* spp. 11(18.97%) and *Strongyle* spp. 47 (81.03%) with 187.3±0.4 and 208.4±0.1 EPG, respectively. Out of the 61 young (<18 years) examined, 43 (70.49%) of them were infected with *Coccidia* spp. 13 (30.23%) and *Strongyle* spp. 30 (69.77%) with OPG of 88.4±0.2 and EPG of 624.4±0.2, respectively.

Among the males infected with *Strongyloides*, the larvae of *Strongyloides papillosus* (102.0±0.4) were recovered while *Haemonchus contortus* (322.4±0.1), *Trichostrongylus colubriformis* (106.2±0.3), *Murshidia* species (78.2±0.3) and *Oesophagostomum columbianum* (100.8±0.3) larvae were recovered from those infected with *Strongyles* (Table 1). From those infected with *Coccidia* spp. *Eimeria bovis* (216.2±1.3) were encountered after sporulation. Among the females, the various species of helminth larvae recovered from those infected with *Strongyles* were, *H. contortus* (284.4±0.3), *O. columbianum* (98.8±0.6), *Murshidia* spp. (78.8±0.6) and from those infected with *Coccidia* spp. *Eimeria bovis* (98.2±0.8) were encountered after sporulation. Among the adults, the larvae of *S. papillosus* (102.0±0.4) were recovered from those infected with *Strongyloides* while, *H. contortus* (402.0±0.6), *O. columbianum* (136.2±0.4), *T. colubriformis* (76.2±0.3) and *Murshidia* spp. (157.0±0.4) were recovered from those infected with *Strongyles*. Among the young, the larvae of *H. contortus* (204.8±0.9), *G. pachyscelis* (124.0±0.7), *O. columbianum* (63.4±0.5) and

Table 2: Seasonal prevalence of gastrointestinal parasitic infections of African elephants (*L. africana*) of the Chad Basin National Park, Nigeria

Seasons	No. of examined	No. of infected (%)
All seasons	274.101	(36.86)
Dry season (October-April)	101.140	(13.86)^{a}
Rainy season (May-September)	173.870	(50.29)^{b}

Prevalence values according to seasons below the different superscripts in the 3rd column differed significantly (p<0.05)

T. colubriformis (30.0±0.4) were recovered from those infected with *Strongyles* while *Eimeria bovis* (314.4±0.4) were encountered among those infected with *Coccidia* spp.

The seasonal prevalence of gastrointestinal parasitic infections of the African elephant (*L. africana*) of the Chad Basin National Park is presented in Table 2. Out of the 173 elephants examined during the rainy season (May-September), 87 (50.29%) were significantly (p<0.05) infected than 14 (13.86%) out of the 101 elephants examined during the dry season (October-April).

The mean monthly worm burden expressed as eggs (EPG) and oocysts (OPG) per gram of faeces of the African elephant (*L. africana*) of the Chad Basin National Park in relation to rainfall are presented in Fig. 1. For *H. contortus*, *S. papillosus*, *E. bovis*, *T. colubriformis*, *G. pachyscelis* and *Murshidia* spp., the mean worm burdens were significantly (p<0.05) low and ranged from 2.0±0.9-7.0±0.2, 0-1.2±0.1, 0-4.4±0.3, 0-3.0±0.1, 0-10.0±0.1, 0-16.2±0.3 and 0-4.0±0.1,, respectively during the dry months (January-April and November-December). These values however,

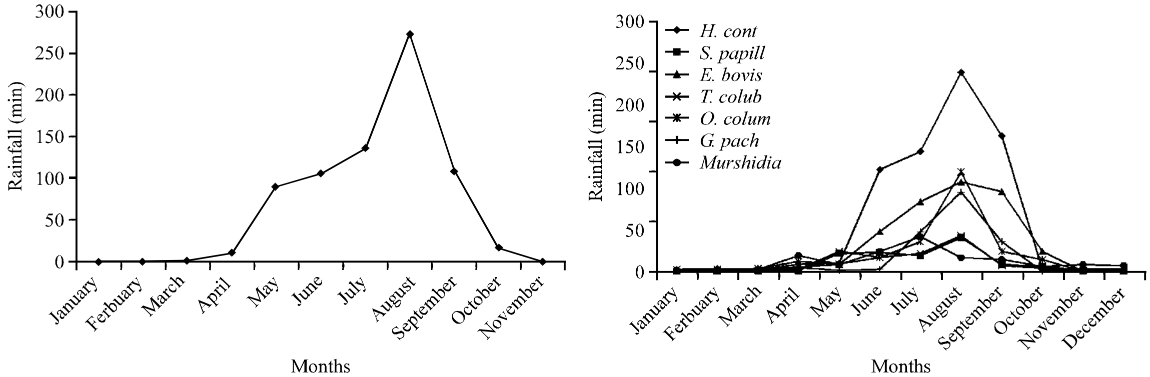


Fig. 1(a-b): Mean monthly burden (Epg/Opg) of various species of gastrointestinal parasites of free-living elephants (*L. africana*) of the Chad Basin National Park, Nigeria in relation to rainfall (mm) Keys: *H. cont.*: *Haemonchus contortus*, *T. colub.*: *Trichostrongylus colubriformis S. papillosus*: *Strongyloides papillosus*, *E. bovis*: *Eimeria bovis G. pach.*: *Gaigeria pachyscelis*, *Murshidia*: *Murshidia* species

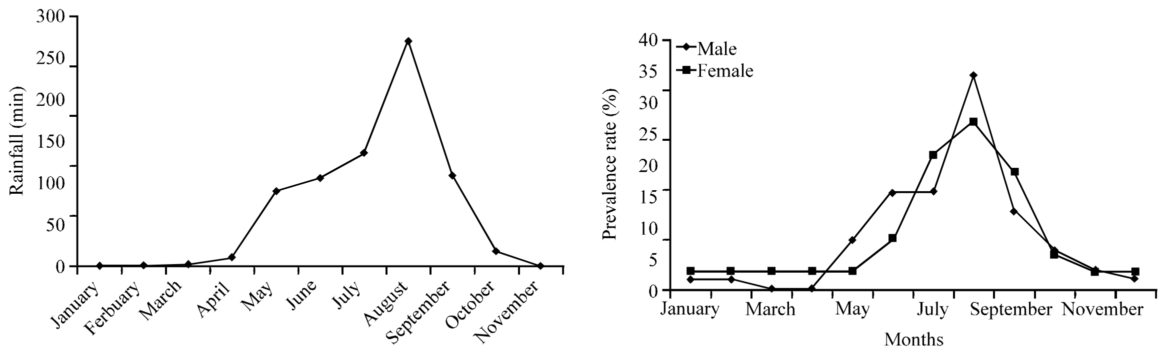
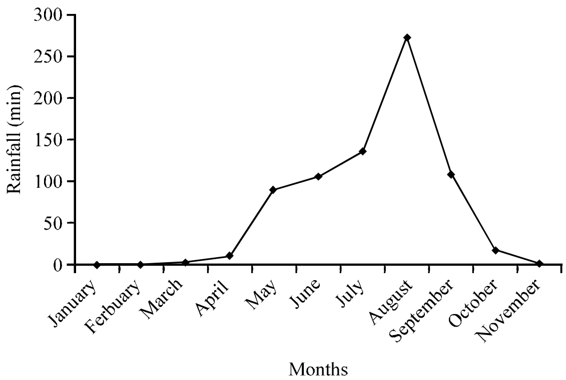


Fig. 2(a-b): Monthly prevalence (%) of gastrointestinal parasitic infections of African elephants (*L. africana*) of the Chad Basin National Park according to sex in relation to rainfall

increased significantly (p<0.05) at the onset of rains (May) and reached peak values of 200.0±0.9, 34.0±0.5, 90.0±0.7, 36.2±0.5, 100.4±0.4, 14.0±0.2 and 80.0±0.5, respectively in the month of August which was the peak of rainfall.

The monthly prevalence of gastrointestinal parasitic infections of African elephants (*L. africana*) of the Chad Basin National Park according to sex in relation to rainfall is presented in Fig. 2. For the males (bulls), low prevalence rates (1.56%) for January, February and December (0%) for March and April, 3.13% for December and 6.26% for October were encountered. However from March, the prevalence of 7.81% increased significantly (p<0.05) thereby attaining a peak value of 34.38% in the month of August which was the peak of rainfall (255 mm) commonly encountered in the semi-arid region and declined between October-December as the rains abated. Among the females, a low prevalence of 2.7% was also observed from the months of January-May and November-December. However, from June the prevalence of 8.11% increased significantly (p<0.05) to 27.0% in August which was the peak of rainfall but declined from September as the rains abated. Between the sexes, the males were more infected than the females. The monthly prevalence based on age is presented in Fig. 3. Among the young, 0% prevalence was encountered from January-August and from November-December. However, from May, the low prevalence of 2.33% increased, thereby attaining a peak value of 51.16% in the month of August and declined to 2.33% by October. Among the adults, prevalence rate of 6.92% occurred in January and February and declined to 1.72% between May-March and between November-December. However, from June it appreciated to a peak value of 34.48% by August and declined again to 5.17% in October. Between ages, the young were more infected than the adults.



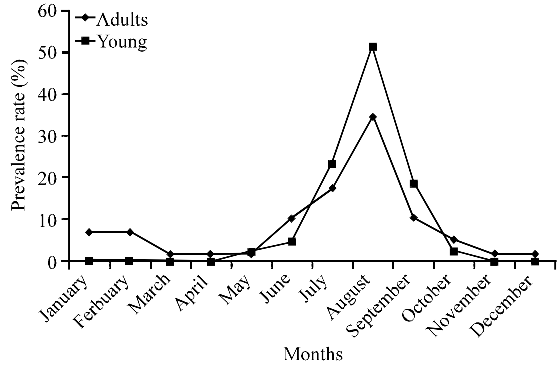


Fig. 3(a-b): Monthly prevalence (%) of gastrointestinal parasitic infections of African elephants (*L. africana*) of the Chad Basin National Park according to age in relation to rainfall

DISCUSSION

In this study, the prevalence of gastrointestinal parasitic infections of the African elephants (*L. africana*) among the males (34.38%), females (27.0%), adults (34.48%) and young (51.16%) were significantly ($p<0.05$) higher at the peak of rainfall (August) and lower during the dry months (January-April and October-December). This pattern is in consonance with several reports where temperature and rainfall played significant roles on the prevalence and development of pre-parasitic stages of *Haemonchus contortus* in open pasture (Soulsby, 1982; Chiejina, 1986). Similarly, in the Guinea savannah (Ogunsusi, 1978; Onyali *et al*., 1990) and in the semi-arid region of north-eastern, Nigeria (Nwosu, 1995; Mbaya *et al*., 2006), the development and survival of strongyline nematode larvae occur throughout the year but decreased during the months of the dry season. In the arid region of northeastern, Nigeria, where the Chad Basin National Park is located, high ambient temperature range of 40-45°C and prolonged dry season (7-8 months) have been reported to cause some degree of pasture sterilization leading to low incidences of gastrointestinal parasitism (Nwosu, 1995; Mbaya *et al*., 2006).

This study also revealed that the prevalence of infection was slightly higher among the males (bull) elephants than the females (matriarchs). Similarly, the young (calves) were slightly more infected than the adults. These findings however, disagreed with that of Thurber *et al*. (2011) in which females and adults elephants in Etosha National Park Namibia were more infected than their counterparts. It is however known that young animals are more susceptible to infections than their adult counterparts due to their lack of well developed and functional immune system (Soulsby, 1982). Generally, young animals show clinical gastrointestinal parasitism during their early challenges while adults already exposed to repeated challenges show high degree of resistance to re-infection (Soulsby, 1982). The reason why the males were slightly more infected than their female counterparts is probably associated with the fact that bull elephants in contrast to the matriarchal family groups at sexual maturity (>18) years of age live in loose association with other bulls (Poole, 1989b) and tend to roam from one matriarchal (female) group to the other in search of females in oestrus. During such period the matured bulls try to know the female's readiness to mate by wetting its trunk on the ground where the female had urinated and taking the wet trunk to its mouth. When this happens the "Jacobs organ" often picks out pheromones. This habit might possibly enhance the chances of contamination of the trunk with helminth eggs or the acquisition of infective larval stages of the parasites. Secondly, bull elephants enter a physiological state of sexual maturity called "musth" which is characterized by increased blood testosterone level, dribbling of urine, temporal gland secretions and heightened sexual aggression (Poole, 1999; Ganswindt *et al*., 2005). During such a physiological state, bulls in "musth" become restless and eat and drink less than the females. This creates a negative energy balance leading to immense stress (Poole, 1999). Stress has been reported to cause increased blood cortisol levels which is primarily responsible for immunosuppression, leading to high prevalence of gastrointestinal parasitic infections among wildlife (Mbaya *et al*., 2008).

The strongyline nematodes such as *H. contortus*, *T. colububriformis*, *S. papillosus*, *O. columbianum* which were encountered among the elephants, have been reported as the major causes of parasitic gastroenteritis complex (PGE) of domestic (Nwosu *et al*., 2006) and wild (Mbaya and Aliyu, 2007) ruminants in the semi-arid region of Northeastern, Nigeria. They have also been reported among free-living African elephants (*L. africana*) in the Democratic Republic of Congo and Central Africa (Kinsella *et al*., 2004.) and Burkina Faso (Jost *et al*., 2005). However, the description of *Murshidia* species for the first time, among the elephants of the Chad Basin National Park is worthy of note. It has been reported as a common *Strongyle* nematode of African elephants by several researchers in other parts of the world (Condy, 1974; Thurber *et al*., 2011).

The worm burden or parasitic load expressed either as mean Eggs per Gram (EPG) for the helminths and oocysts per gram of faeces (OPG) for the coccidian parasites, appreciated significantly during the wet months (May-September) and reaching its highest value at the peak of rainfall (August) and its lowest value during the dry months (October-December) and (January-April). Rainfall and relative humidity have been reported as major extrinsic factors affecting the survivability, translocation and acquisitions of pre-parasitic stages of gastrointestinal parasites on pastures in Nigeria (Chiejina, 1986; Onyali *et al*., 1990; Nwosu, 1995; Nwosu *et al*., 2006). Rainfall has been reported to greatly enhance faecal egg output or worm burden of gastrointestinal nematodes in red Sokoto goats (Nwosu *et al*., 2006) and red fronted (*Gazella rufifrons*) and dorcas (*Gazella dorcas*) gazelles in the semi-arid region of Northeastern, Nigeria (Mbaya and Aliyu, 2007). In this study, in as much as the rainy season greatly enhanced the worm burden among the elephants, the mean EPG/OPG range (0-16.2±0.003) were considered low as compared to a higher range (500±0.00-2, 237.50±1, 255.11) encountered among African elephants (*L. africana*) of Etosha National Park, Namibia. The reason for such a high worm burden among the elephants in Etosha National Park might be associated with unknown extrinsic factors. This is because the Etosha National Park and the Chad Basin National Park are both located in semi-arid ecosystems where, worm burdens ought to be low due to high ambient temperatures (>40°C). High ambient temperatures in arid ecosystems hardly support the development and translocation of pre-parasitic stages of helminths in the environment (Nwosu, 1995; Mbaya *et al*., 2006; Nwosu *et al*., 2006). In some cases however, certain degrees of pasture sterilization has been reported (Nwosu *et al*., 2006).

Based on the findings described above, it is concluded that the African elephants (*L. africana*) of the Chad Basin National Park, Nigeria harboured various species of gastrointestinal parasites that are potentially pathogenic to livestock in the area. On the other hand, livestock that often shared the same grazing reserve might have transmitted the infection to the elephants. It was therefore advised, that regular patrols by game wardens to prevent livestock from encroaching into the national park could go along way in curbing cross transmission of helminthosis between livestock and the elephants. This might also help in conserving the already dwindling elephant population in the national park.

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