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Research Article

Gastrointestinal Parasites of the Ethiopian Rock Hyrax (*Procavia capensis*, Pallas, 1766) in the North East Region of Ghana

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Wildlife may serve as potential reservoirs and intermediate or accidental hosts of zoonotic pathogens due to their interactions with human beings. For the first time in Ghana, we report extempore the gastrointestinal parasites of three Ethiopian rock hyraxes captured in September 2021. Forty adult parasites (21 nematodes and 19 tapeworms) were recovered from the gastrointestinal tracts of these three game hyraxes (*Procavia capensis,* Pallas, 1766) from the hills of Bimbagu (near the Gambaga Scarp) in the North East Region of Ghana. Adult worms comprising 16 tapeworms and 24 nematodes were identified. The intestinal faecal examination detected ova of *Trichuris* spp., tapeworms, and hookworms. The results are presented alongside the results of the molecular determination of the worm identities. Since wildlife has been identified as an important source of emerging human pathogens, including helminth parasites, there is an urgent need for sufficient literature on wildlife parasites in Ghana. As the rock hyrax is hunted for its meat, there is a potential risk of transmitting these identified helminths and other zoonotic pathogens to humans, especially involving people who handle the carcasses as the transmission is faecal-oral. A more precarious situation may arise when the eggs of cestodes are ingested by handlers of these carcasses and could result in cysticercosis/neuro-cysticercosis when these eggs cross the blood-brain barrier in the person.

1. Introduction

The rock hyrax (*Procavia capensis*, Pallas 1760; family: Procaviidae; order: Hyracoidea), also known as rock dassies or rock rabbits, are stub-tailed, rabbit-like medium-sized (3-4 kg) social terrestrial mammals native to Africa and the Middle East [1]. Rock hyraxes resemble rodents, but their closest relatives are elephants and manatees. They are the only member of the genus *Procavia*, one of only four living species in the order Hyracoidea, and the hyrax species most adapted to arid environments [2]. However, farming and rural hunters' activities threaten hyraxes' existence.

Human-wildlife conflicts, poaching, and hunting are major issues in developing countries and may contribute to the extinction of some protected species. Typically, hunting of wildlife as food is associated with zoonotic disease transmission, which originates in mammals [3, 4], or interactions between wildlife and domestic animals [5, 6]. The majority of emerging and re-emerging human infectious diseases (EIDs) have also been associated with zoonosis. The coexistence of wildlife and humans may become more common because of habitat loss; however, the greater effects of biodiversity loss may reduce the interactions. As postulated by Cable et al. [7], the negative impacts of parasitic infections can be extreme in as much as they are ubiquitous in wildlife, livestock, and the human population. The frequent contact with wildlife through the bushmeat trade may also predispose people to infection with zoonotic pathogens. Pathogens transmissible to humans through bushmeat may include monkeypox virus, Ebola and Marburg filoviruses, anthrax, herpes viruses, hepatitis viruses, and paramyxoviruses [8, 9]. Despite parasitic protozoa being the

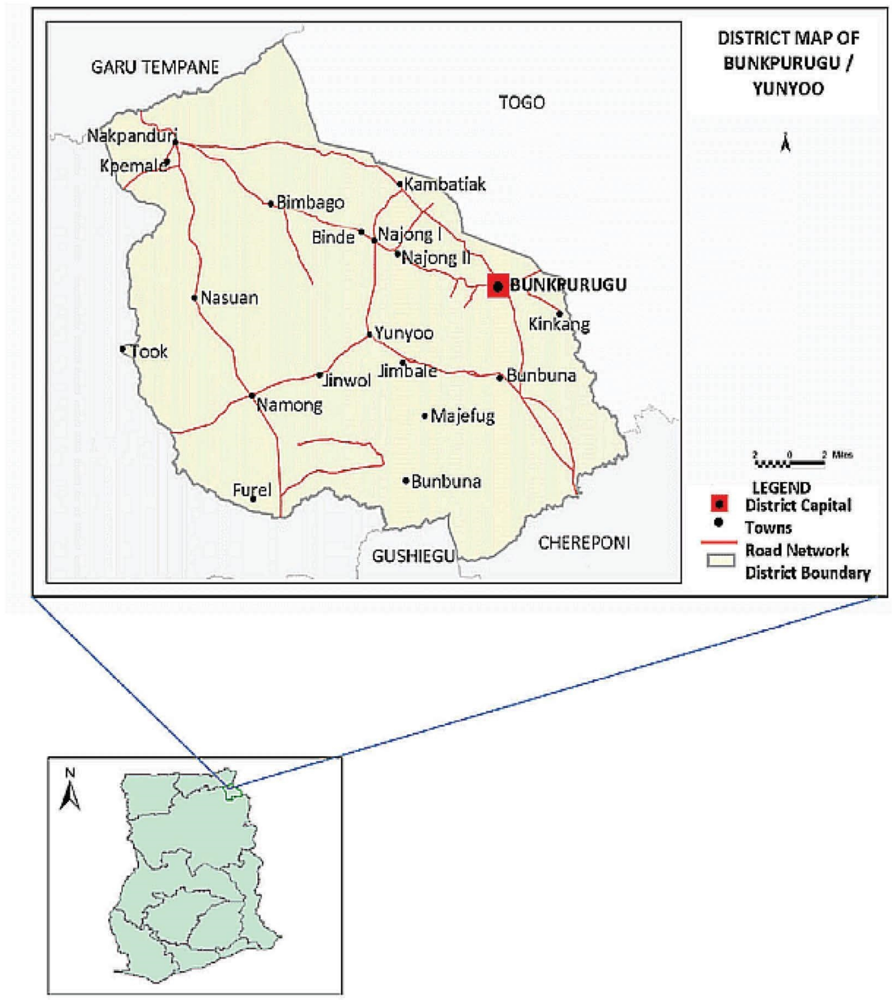


Figure 1: Map of Ghana showing the location of Bimbagu in the North East Region.

second most common cause of zoonotic diseases, behind viruses, helminths still play a significant role in disease transmission [10].

While notable external parasites such as ticks, lice, mites, and fleas have been observed in the rock hyrax, internal parasites, such as nematodes and cestodes, have also been recorded. These could also play an important role in hyrax mortality [11]. Hoeck [12] noted that rock and tree hyraxes might be an important reservoir for the leishmania parasite. Helminths have zoonotic potential in most infections, although this is rare [13, 14]. Species of the anoplocephalid cestode genus *Inermicapsifer* are very common in Africa, mainly in rodents and hyraxes [15]. Within the genus *Inermicapsifer*, *I. madagascariensis* is widespread in animals and has been reported in humans from several African countries, including Kenya, South Africa, Zambia, and Zimbabwe [16]. These helminths have adapted in different ways to the microenvironment of the vertebrate intestine since this specialised habitat affords parasites a reliable source of nutrients, a relatively homeostatic environment, and protection from predators [17]. We extemporaneously report on the gastrointestinal parasites of three hyraxes killed by a local hunter in Bimbagu, North East Region of Ghana.

2. Materials and Methods

In September 2021, we encountered a local hunter spontaneously in Bimbagu (Figure 1), a town in the Nakpanduri-Bunkpurugu District, North East Region, Ghana. The town is located at an elevation of 443 meters above sea level, and its coordinates are 10°34′60″N and 0°6′0″W. Among his day's games were two female and one male Ethiopian rock hyraxes (Figure 2), weighing 2.32 kg, 1.73 kg, and 2.05 kg, respectively. These were brought to the Department of Animal Biology and Conservation Science, University of Ghana, for autopsy and examination of the gastrointestinal tracts for parasites. A longitudinal incision using a surgical blade opened the body cavity of all three animals from the throat to vent. The gut contents were examined thoroughly with a magnifying glass for adult parasites. The various sections of the alimentary canal were first identified and cut

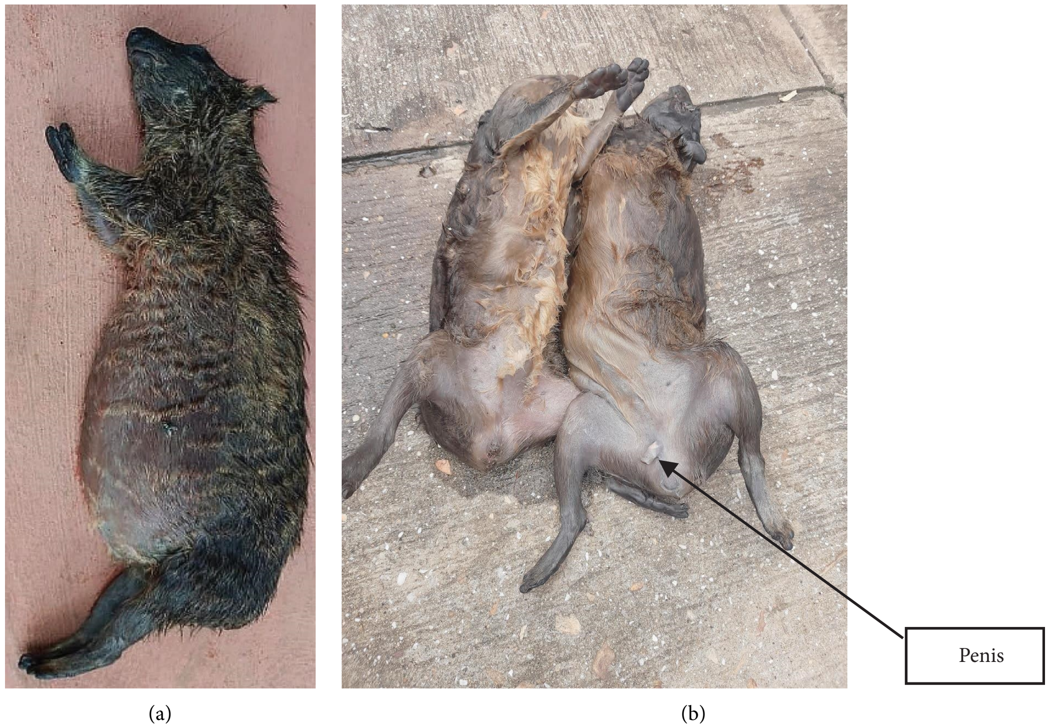


Figure 2: The specimen (Ethiopian rock hyraxes).

off. These sections were removed and opened, and the contents were washed with 0.9% saline into Petri dishes and examined thoroughly for adult worms. All the adult worms found were preserved in 70% ethanol and later identified according to the descriptions [18].

2.1. Identification of Parasite Ova and Oocysts. After carrying out the macroscopic examinations on the various segments of the gastrointestinal tracts (GITs) for adult parasites, the zinc sulphate ($ZnSO_4$) centrifugal floatation technique [19, 20] was used for the identification of parasite ova (nematodes, trematodes, and cestodes). About 3 mg of faecal samples were mixed with 15 ml of $ZnSO_4$ solution, and the resulting solutions were then strained through a nylon tea strainer to remove coarse faecal materials. The resultant solutions were then poured into the appropriate tubes and centrifuged at 1500 rpm for 5 minutes. The tubes were removed from the centrifuge, filled with the flotation solution to the top, and left for 10 minutes. Finally, a drop of the solution at the top was placed on a microscope glass slide, covered with a cover slip, and examined with a 40x light microscope objective. Identification of helminths, helminth eggs, and protozoan oocysts was done by standard parasitological criteria[21, 22].

2.2. DNA Amplification by Polymerase Chain Reaction. Direct polymerase chain reaction (PCR) was used to amplify worm DNA fragments using genus-specific primers as indicated in Table 1.

All PCR reactions were performed in final volumes of 25.0 μl, and the products were examined by electrophoresis on 2% agarose gels stained with ethidium bromide.

3. Results

3.1. Identification of Recovered Worms. Adult worms (Figures3–5) and their ova/oocysts (Figure 6) were recovered from the GIT of all three animals. While five nematodes (hookworms and Strongyles) and three tapeworms were recovered from one of the females (Figure 2(a)), the second female was observed to contain eight nematodes (six hookworms and two *Trichuris* spp.) but no tapeworms. Likewise, the male specimen had eight nematodes and 16 tapeworms from the stomach and small intestine.

While the adult nematodes were identified as hookworms and Strongyles, the tapeworms were identified as *Inermicapsifer* spp., a genus of tapeworms of the family Anoplocephalidae. Some of the worm ova/eggs and larvae recovered from the faecal contents of the animals are presented in Figure 6.

3.2. Images of Gel Electrophoresis. The images for *Strongyloides* spp. and Pinworm. are shown in Figures 7 and 8, respectively. The molecular weight marker, or the DNA ladder denoted by M (lane M), was used to detect the approximate sizes of the amplicons.

4. Discussion

We examined the gastrointestinal tract contents of three rock hyraxes captured from the hills of Bimbagu in Ghana. A total of 40 adult parasites were recovered. These included hookworms, Strongyles (tapeworms), and *Trichuris* spp., with all three hyraxes being infested with more than one

Table 1: Primer sets for the polymerase chain reaction (PCR).

Pathogen	Primers	Primer sequence	Reference
Ascaris spp.	F2662 R3214	5′-GGCAAAAGTCGTAACAAGGT-3′ 5′-CTGCAATTCGCACTATTTATCG-3′	Dorris et al. [23]
Strongyloides spp.	GS-forward GS-reverse	5′-AAAGATTAAGCCATGCATG-3′ 5′-GCCTGCTGCCTTCCTTGGA-3′	Ishiwata et al. [24], Marques et al. [25]
Nematodes	GSNC5 F GSNC2 R	5′-GTAGGTGAACCTGCGGAAGGACATT-3′ 5′-TTAGTTTCTTTTCCTCCGCT-3′	Newton et al. [26]

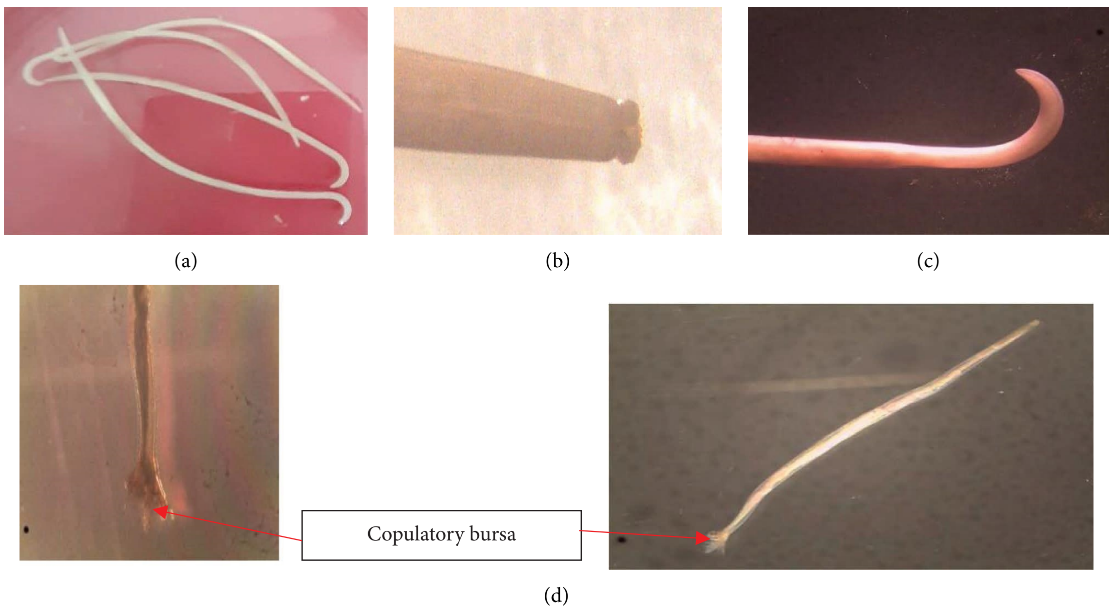


Figure 3: Adult hookworms with typical cylindrical bodies (a) and sharply curved heads (c). The buccal capsule (b) and the bursae rays (d) are also very visible. (a) Whole worms (b) anterior end (c) posterior end (d) male worm with copulatory bursa.

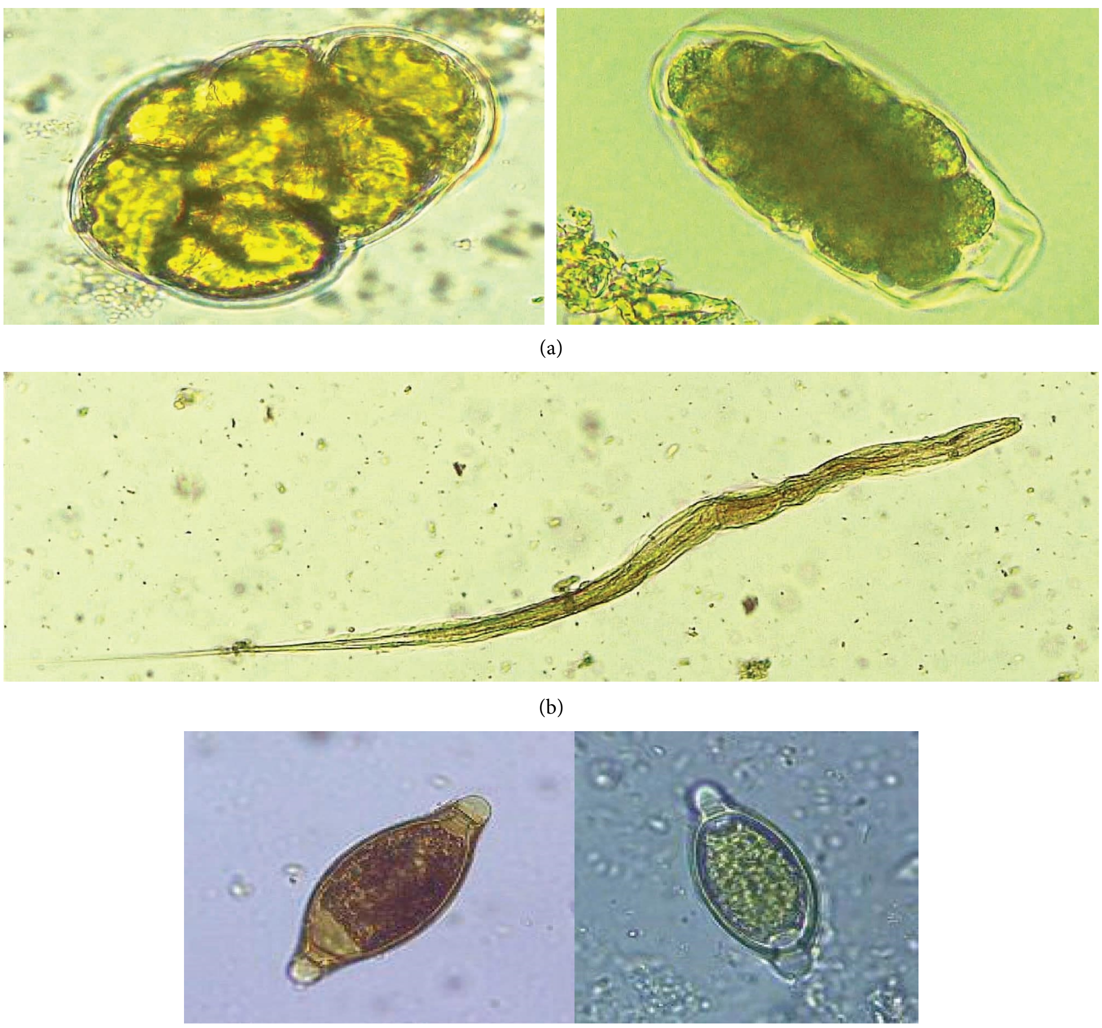
Figure 4: Adult *Trichuris* spp.

parasite species of public health importance. As indicated by Kołodziej-Sobocińska [27], the existing state of knowledge on the factors affecting parasitic diseases in wild mammals shows a need for sufficient literature on parasites in wildlife. The reason is not only for academic purposes but also for the benefit and use in managing wild mammal species and disease control in nature. The findings of our current study, where co-infections of helminth species have been observed in wild mammals, agree with earlier observations made in some developed countries [28]. Also, as explained by Bimi et al. [29], the findings of parasites in wildlife should raise concerns about the possibility of zoonotic transmission of the parasites from these animals to humans, especially if they are hunted and eaten as meat. The helminths in the hyraxes belong to the same genus that can infect people. However, we are unsure of the species present in these animals, so we cannot say with certainty whether they can survive to infect humans. Until we can establish their potential survival, we advocate that humans avoid contact with or handle these animals with caution.

Although these helminths were not identified to the species level, the additional microscopic examination of faeces from the gastrointestinal tracts of the animals made it possible to confirm their identities. Since more than 75% of human diseases are of zoonotic origin [30], significant public health consideration must be given to the game we hunt for

(a) (b)

Figure 5: Recovered adult tapeworms presenting some of their notable features. (a) Adult tapeworms. (b) Tapeworm head/scolex with suckers.

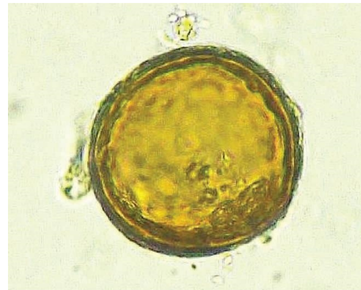


(a)

(b)

(c)

Figure 6: Continued.



(d)

Figure 6: Recovered worm ova/larva presenting some of their notable features. (a) Recovered thin-shelled eggs of hookworms, taken at 40x magnification. (b) A filariform hookworm larva with a well-developed tail and esophagus. (c) Ova of *Trichuris* spp. (d) Tapeworm ovum.

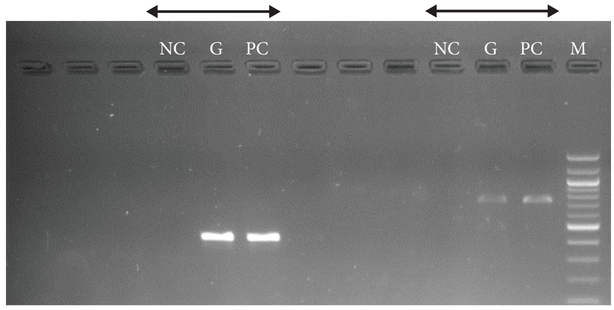


Figure 7: Amplified PCR product of *Strongyloides* spp. and *Pinworm* spp. (lane M = 100 bp, lane NC = negative control, lane PC = positive control, and lane G = positive sample).

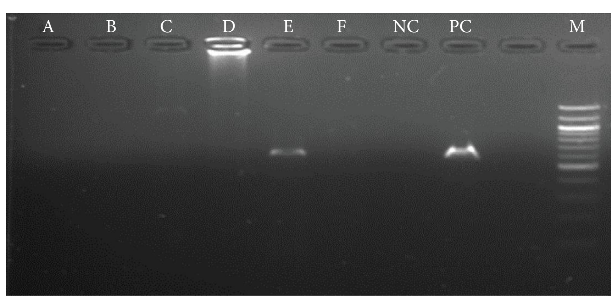


Figure 8: Amplified PCR product of *Ascaris* spp. (lane M = 100 bp, lane NC = negative control, lane PC = positive control, lane E = positive sample, and lanes A, B, C, D, and F = negative samples).

food. The recovery of these helminths in the hyraxes in this small geographic area of Ghana could be associated with environmental conditions and interaction between wildlife, domestic animals, and humans that could support the transmission of zoonotic parasites in the area.

Although the current study did not establish a direct link between infestations in wildlife and humans, observations are that zoonotic diseases are increasingly becoming an emerging public health threat [31], partly due to the risk of spillover incidents at the human-wildlife interface. There is, therefore, the possibility of these animals transmitting pathogens to humans. According to Xie et al. [32], molecular and epidemiological data support evidence for the zoonotic potential among species of hookworm transmission to humans, which is being facilitated by increased human-wildlife interactions. Our recent study on soil-transmitted helminthiasis in the study area found a prevalence of 19% hookworm infestation in humans [33].

5. Conclusions

This paper has shown that there are gastrointestinal infestations of wildlife with different parasite species in the study area. Three gastrointestinal helminths (hookworms, Strongyles, and *Trichuris* spp.) and cestodes (*Inermicapsifer* spp.) were detected in the study animals. The possibility for zoonotic helminths to establish in humans and cause disease is a potential public health problem, partly due to the risk of spillover events at the human-wildlife interface. These helminths can potentially be transmitted to humans if the necessary precautions are not taken.

Furthermore, the study has demonstrated that hyraxes could be hosts of helminths and could play a role in transmitting the same to humans. The influence of these parasites on human health cannot be overstated and should, thus, be considered in risk assessments.

6. Recommendations

These parasites detected in the hyrax (and possibly in present in other wild animals in the area) may be zoonotic, and hence future studies are needed to determine risks of cross-transmission. There is a need to carry out a comprehensive prevalence study of intestinal helminths of the rock hyrax and other wildlife used as bushmeat in Ghana, as they could pose a significant zoonotic threat. By so doing, the prevalence, diversity, burdens, and species of the wildlife parasites in the area should be established.

7. Impacts

(1) Wildlife's role in transmitting pathogens to human beings has become imminent due to the interaction between the two. Over the years, this feat has manifested itself grossly due to encroachment on their natural habitats by human dwellings and the fact that they are hunted and eaten as meat.

(2) The recovery of these helminths from the rock hyrax's intestinal tracts could indicate their ability to host and probably transmit the parasites into human populations.

(3) There is, therefore, an urgent need to unearth the zoonotic potential of the hyrax as a host of helminths and other disease-causing organisms to lessen their effects.

Data Availability

All data used to support the findings of this study are available upon request from the corresponding author.

Disclosure

This study was part of the authors' employment at the University of Ghana. The authors' sole responsibility was to write, edit, seek approval, or decide to publish this article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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