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Screening for antibodies against zoonotic infections among employees of the Tripoli Zoo in Libya

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ABSTRACT

Background: Animal handlers in zoological settings are at an increased risk of zoonotic disease transmission due to close contact with animals, waste, and parasites. Research on occupational zoonotic infections in zoos, however, remains limited. This is particularly relevant in the context of the Tripoli Zoo, which has been closed since 2013 and is planned to reopen under new management.

Aim: This study investigated the seroprevalence of *Echinococcus*, *Toxoplasma*, and *Rickettsia* infections among zoo employees in Tripoli, Libya, in 2013.

Methods: Blood samples were collected from 93 zoo employees and tested for IgG antibodies against the target pathogens using serological methods. Associations between seropositivity and various demographic and occupational factors were also examined.

Results: In this study, 87.1% of the employees tested positive for at least one zoonotic pathogen IgG antibody, with *Toxoplasma* being the most prevalent. Several factors, including gender, age, marital status, occupational status, travel history, and animal husbandry practices, were associated with the prevalence of these infections. A significant proportion of participants exhibited multiple infections.

Conclusion: The high seroprevalence of zoonotic infections among zoo employees underscores the urgent need for implementing effective preventive measures to protect staff health and minimize the risk of zoonotic disease transmission, especially in light of the zoo's planned reopening.

Keywords: Zoological settings, Animal handlers, Zoonotic, Antibodies, Libya.

Introduction

Animal handlers in zoological settings are at risk of exposure to a variety of diseases that can be transmitted from animals. This risk primarily arises from close interactions with animal waste, bodily fluids, parasites, and other potential sources of infection. As a result, the probability of these handlers contacting zoonotic diseases is expected to be considerably higher than that of zoo visitors or staff members who do not engage in direct contact with the animals (Forsyth et al., 2012; Esposito et al., 2023). Despite the known dangers, there is a significant lack of published research on occupational zoonotic infections associated with zoos. However, existing studies indicate a troubling trend. For instance, a survey conducted by Adjemian et al. revealed that 77% of employees from the US National Park Service who had direct contact with animals reported experiencing zoonotic infections

(Adjemian et al., 2012). Similarly, Juncker-Voss et al. (2004) indicated that 97% of zoo staff in Vienna had antibodies against at least one zoonotic pathogen (Juncker-Voss et al., 2004). Additional studies focusing on specific pathogens have also provided important insights. Parkar et al. (2010) reported a high prevalence of Blastocystis among both zookeepers and animals in regions of Western Australia (Parkar et al., 2010). Raso et al. (2010) found that 4.7% of animal handlers and veterinarians in Brazilian zoos tested positive for antibodies to Chlamydophila psittaci (Raso et al., 2010). Furthermore, Van der Westhuizen et al. (2023) identified Brucella sp., Leptospira sp., and hantavirus in veterinarians (Van der Westhuizen et al., 2023). Research on the carriage of zoonotic pathogens within zoo animal populations is limited. Luechtefeld et al., 1981 detected Campylobacter fetus subspecies jejuni in animal samples from the Denver Zoo, indicating the

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potential for use in animal reservoirs. Although not all studies have yielded positive findings, such as those involving penguins and seals in South Georgia and the Antarctic Peninsula, the detection of zoonotic agents in various animal species emphasizes the necessity for further research (Luechtefeld *et al.*, 1981). This study aimed to screen zoo employees in Tripoli for the presence of antibodies against zoonotic pathogens, which is a key component for identifying workplace hazard exposure related to occupational health screening.

Materials and Methods

Study area

Tarabulus Zoo Park is located in Al Nasr Forest Tripoli, Libya, which is located south of Tripoli city center. Tripoli Zoo is located in the southwest corner of the park, and the Rixos Al Nasr Hotel is located in its southeast corner. The Al Nasr Forest Park is estimated to cover 416.17 square kilometers with a variety of plants and animals species (Naish, 2023).

Mammals, birds, and reptiles of 60 species were documented in the park, including the flamingos *Phoenicopterus roseus*, White stork *Ciconia ciconia*, Muscovy *Cairina moschata*, Black swan *Cygnus atratus*, and Emu *Dromaius novaehollandiae*, Greenwinged macaw, Golden eagle, and many other species (Naish, 2023).

Blood collection

In 2013, 93 blood samples were collected from each zoo employee who participated in the screening. Blood samples were collected by venipuncture in clean tubes without coagulant; sera were separated by centrifugation and stored at -20° C until testing. Each participant filled out a questionnaire in which the following variables were registered: age, gender, occupation, area of residence, blood transfusion, history of contact with domestic animals, and traveling history. No data on race were obtained. In addition, All the participants signed an informed consent form.

Serological technique

Sera were sent to the Parasitology and Vector-Borne Disease Research Laboratory at the National Center for Disease Control (NCDC), Tripoli, Libya, where they were tested by the serological method with enzyme-linked immunosorbent assays to detect the presence of Echinococcus IgG, *Toxoplasma* IgG, and *Rickettsia* IgG antibodies using a commercial enzyme immunoassay kit, (AXIOM Diagnostic, Worms, Germany), according to the manufacturer's instructions.

Statistical analysis

The seroprevalence of antibodies against *Echinococcus*, *Toxoplasma*, and *Rickettsia* was calculated as the ratio between the positive sera and all tested sera. All collected data were statistically analyzed using Jamovi software version 2.3. The data analysis was performed using the same software, and the significance threshold of the qualitative and quantitative variables studied

was considered for a value of p < 0.05 (Jamovi Project, 2022).

Ethical approval

The study was approved and confirmed under the rules and regulations of research in the National Center for Disease Control Libya. Therefore, at commencing the research point, ethical approval and authorization were issued while referring to the NCDC.

Results

A total of 93 sera samples were examined, among which 76 (82%) were male and 17 (18%) were female, with a sex ratio of 4.4. The median age was 41.9 years (range: 25–67). Table 1 shows the demographic characteristics of the sample collected (n = 93). In total, 87.1% (n = 81) were positive for the zoonotic pathogen IgG antibody; the highest seroprevalence rate was *Toxoplasma* (57%), followed by *Rickettsia* (16%) and *Echinococcus* (14%).

Factors associated with zoonotic disease prevalence

This study revealed several factors associated with the prevalence of zoonotic diseases among the participants. Gender played a role, with females having a higher prevalence of Toxoplasma than males. Age was also a factor, with the highest prevalence of Toxoplasma observed in the 30-39 years age group and the highest prevalence of *Rickettsia* in the 20–29 years age group. Marital status influenced the prevalence of Toxoplasma and Rickettsia, with married participants having higher rates than single participants. Occupational factors were also significant (p < 0.0001), as individuals in emergency medical services and janitors had higher rates of Toxoplasma and Rickettsia infections. Traveling history was associated with an increased prevalence of all three zoonotic diseases. Animal husbandry practices, particularly owning ruminants or birds, were linked to higher rates of Toxoplasma and Rickettsia. However, insecticide use, blood transfusion, and knowledge about zoonotic diseases did not appear to significantly affect the prevalence of these infections (p > 0.0001). A significant number of participants experienced multiple zoonotic infections. Sixteen individuals tested positive for more than one pathogen, while 65 individuals were infected with a single zoonotic agent. These findings highlight the complex nature of zoonotic disease transmission and the potential for coinfection in the study population.

Discussion

The results of this research highlight the considerable risk of zoonotic infections that zoo employees face. The notable presence of antibodies against *Toxoplasma*, *Rickettsia*, and *Echinococcus* among the study participants underscores the urgent need for the implementation of comprehensive occupational health measures. These findings are particularly concerning given the increasing number of open farms and petting
 Table 1. Demographic characteristics of the participants.

Characteristics	No. investigated	No. of IgG antibodies (%)		
		Echinococcus	Toxoplasma	Rickettsia
Total participants	93	13 (14)	53 (57)	15 (16)
Gender				
Male	76	10 (13)	47 (62)	17 (20)
Female	17	3 (18)	6 (35)	0
Age (years)				
20–29	8	1 (13)	5 (62.5)	0
30–39	29	3 (10.3)	15 (52)	4 (14)
40–49	33	7 (21)	25 (76)	4 (12)
50–59	18	1 (6)	8 (44)	6 (33)
>59	5	1 (20)	0 (0)	1 (20)
Marital status				
Single	25	2 (8)	12 (48)	2 (8)
Married	68	11 (16)	41 (60)	13 (19)
Primary job duties				
Employee	64	10(16)	35(55)	12(19)
Emergency medical	4	1 (25)	3 (75)	0
Janitor	12	1 (8)	6(50)	2(17)
Guard	13	1 (8)	9 (69)	1 (8)
Traveling history				
Yes	58	8 (14)	32 (55)	8 (14)
No	35	5 (14)	22 (63)	7 (20)
Using insecticide				
Yes	47	7 (15)	26 (55)	7 (15)
No	46	6 (13)	27 (59)	8 (17)
Animal husbandry at home				
Yes	24	0	11 (46)	5 (21)
No	69	11 (16)	39 (57)	9 (13)
Type of animals at home				
Birds	21	0	10 (48)	4 (19)
Cats	4	0	2 ()	0
Dogs	1	0	0	0
Ruminant	2	0	1 (50)	1 (50)
Gazelle	4	0	1 (25)	1 (25)
Contact only with working animals	68	12 (18)	39 (57)	9 (13)
Blood transfusion				
Yes	3	1 (33)	2 (66)	0
No	90	11 (12)	48 (53)	14 (15)

(Continued)

Characteristics	No. investigated -	No. of IgG antibodies (%)		
		Echinococcus	Toxoplasma	Rickettsia
Knowledge about these zoonotic				
diseases: Rickettsia, Q fever,	5			
fever	88	1 (20)	3 (60)	1 (20)
Yes		12 (14)	50 (57)	14 (16)
No				
Infection status				
Single infection	65	15 (23)	42 (64)	8 (12)
Multiple infections	16	5 (31)	11 (69)	8 (50)

zoos in Libya, which may further contribute to zoonotic disease transmission.

Our study revealed a high prevalence of toxoplasmosis (57%), which is consistent with findings reported by Juncker-Voss et al. (2004), where similar antibody screenings among employees at the Vienna Zoo indicated a high prevalence of Toxoplasma exposure. The study also showed a greater prevalence of Toxoplasma among male participants, suggesting potential gender-specific risk factors or behaviors that may contribute to heightened exposure. The previous research has linked Toxoplasma infection with changes in testosterone levels and behavioral modifications in men, with correlations not observed in women (Abdoli et al., 2024). Additionally, studies indicate that the interaction between toxoplasmosis and sex can significantly influence behavioral traits such as self-control, tidiness, interpersonal relationships, and levels of mistrust, with infected men exhibiting notable differences compared with their uninfected counterparts (Lindová et al., 2006).

Age-related patterns of infection were also observed. The highest prevalence of *Toxoplasma* was recorded among participants aged 30–39 years, consistent with prior research by (Almeida *et al.*, 2022). Similarly, *Rickettsia* infections were most prevalent in the 20–29 years age group, a finding consistent with that of (Mansoor *et al.*, 2021). These variations may be associated with differences in exposure patterns and immune responses among different age groups.

In addition to toxoplasmosis, the study also identified cases of *Rickettsia* infection (16%), highlighting the risk associated with vector-borne pathogens. *Rickettsia* infections are often associated with occupational exposure to arthropod vectors, such as ticks and fleas, which are commonly found in zoo environments. The increased prevalence of *Rickettsia* among younger individuals may reflect occupational exposure during early career stages, in which job duties involve direct contact with animals or contaminated environments.

Additionally, hydatid cysts caused by *Echinococcus* (14%) were detected among the study participants. *Echinococcus* is transmitted through contact with infected canines or contaminated environments, and its presence in zoo employees indicates possible occupational exposure. Given the severe health implications of hydatid cysts, including organ damage and potential surgical intervention, preventive measures such as deworming programs for animals, strict hygiene practices, and regular health screenings for employees are crucial. The study found that individuals engaged in animal husbandry at home exhibited a higher risk of *Echinococcus* infection, reinforcing the role of domestic animal exposure in zoonotic disease transmission (Barimah *et al.*, 2023).

The analysis of marital status revealed that married individuals exhibited elevated rates of *Toxoplasma* and *Rickettsia* infections, potentially due to greater exposure to domestic animals or agricultural activities (Morand *et al.*, 2014; Onduru *et al.*, 2021). Additionally, employees in emergency medical services and janitorial roles faced an increased risk of zoonotic infections, likely due to their frequent interactions with animals and contaminated materials in their work environments (Barimah *et al.*, 2023, Esposito *et al.*, 2023).

Travel history has also emerged as a significant factor in the spread of zoonotic diseases. Participants who had traveled to various regions demonstrated a higher risk of being infected with *Toxoplasma*, *Rickettsia*, and *Echinococcus*. This suggests that exposure to diverse animal populations and environmental conditions during travel may increase infection risk (Wilson, 1995). Furthermore, individuals who kept animals at home, particularly ruminants and birds, showed a higher prevalence of *Toxoplasma* and *Rickettsia*, emphasizing the need for proper hygiene and biosecurity measures to reduce transmission risks (Stelzer *et al.*, 2019).

Finally, this study revealed that a significant number of participants were infected with multiple zoonotic agents, highlighting the complex nature of zoonotic disease transmission. Sixteen individuals tested positive for more than one pathogen, highlighting the importance of considering coinfection when diagnosing and treating zoonotic diseases. These findings are consistent with those reported by Wood *et al.* 2014; Rahman *et al.* 2020; van der Westhuizen *et al.* 2023, reinforcing the need for multifaceted diagnostic approaches and targeted preventive strategies to mitigate the impact of zoonotic diseases on both occupational and public health.

Limitations

This study has some limitations that should be considered. The sample size was relatively small, limiting the generalizability of the findings. Additionally, the study did not investigate the clinical manifestations of zoonotic infections among the participants. Future studies with larger sample sizes and clinical assessments are needed to further elucidate the impact of zoonotic diseases on zoo staff.

Conclusion

In conclusion, this study provides valuable insights into the prevalence of zoonotic infections among zoo employees in Tripoli, Libya. The findings highlight the importance of implementing comprehensive prevention measures to protect the health of zoo staff and prevent the spread of zoonotic diseases.

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Conflict of interest

The author declares no conflict of interest.

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Authors' contributions

The authors have equal participation in conceptualization, preparation of the original draft, review, and editing.

Data availability

All analyzed data are included in this study.

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