DOI 10.26873/SVR-1716-2023
UDC 636.1:616.936:57.083.33(620)
Pages: 95–103

Original Research Article

Equine Leptospirosis in Egypt: Seroprevalence and Risk Factors

Key words

Leptospirosis;
seroprevalence;
risk factors;
horse;
Egypt

Mohamed Marzok[1,2]*, Abdelrahman M. Hereba[3,4], Abdelfattah Selim[5]*

[1]Department of Clinical Sciences, College of Veterinary Medicine, King Faisal University, Al-Hofuf, 31982, Saudi Arabia, [2]Department of Surgery, Faculty of Veterinary Medicine, Kafr El Sheikh University, Kafr El Sheikh, Egypt, [3]Department of Biomedical Physics, Medical Research Institute, Alexandria University, Egypt, [4]Department of Microbiology, College of Veterinary Medicine, King Faisal University, Al-Ahsa 31982, Saudi Arabia, [5]Department of Animal Medicine (Infectious Diseases), Faculty of Veterinary Medicine, Benha University, Toukh 13736, Egypt

***Corresponding authors:** abdelfattah.selim@fvtm.bu.edu.eg, mmarzok@kfu.edu.sa

Abstract: Most leptospiral infections in horses are asymptomatic; however, acute disease manifestations as well as reproductive failure and recurrent uveitis have been reported. Horses are considered accidental hosts. The data about equine leptospirosis in Egypt are scarce. Hence, the present study aimed to investigate presence of antibodies against *Leptospira* sp. in horse in four Egyptian governorates and determine the associated risk factors for the infection. To determine the seroprevalence in 305 serum samples, the microscopic agglutination test (MAT) was carried using eight Leptospira serovars antigens. The results revealed 104 animals were positive for at least one of the serovars (34.1%; 95%CI: 29.01-39.59). The most common reaction was reported to Icterohaemorrhagiae serovar (15.14%), followed by Canicola (14.75%), Bratislava (11.47%), Copenhageni (8.19%), Pomona (7.86%), and Hardjo (6.88%). The most prevalent was observed among females, older horses raising in pasture or in contact with ruminants or dogs and lack of rodents control. The significant seroprevalence suggests that Egyptian horses living in the studied area are at high risk of infection or exposure by *Leptospira* sp. Thus, the establishment of emergency surveillance and control program is very crucial for this zoonotic pathogen.

Received: 2 March 2023
Accepted: 18 May 2023

Introduction

Leptospirosis is one of the most common zoonoses in the world and is caused by gram-negative spirochetes from *Leptospira* genus (*Leptospiraceae* family, order *Spirochaetales*) (1, 2). It affects both human and animals, mainly in tropical regions where the organism thrives in optimal temperature and humidity circumstances (3). Infections in horses are most occurred through direct contact with urine or placenta secretions of diseased animals, or indirectly through a contaminated surroundings (4).

Leptospira sp. infection is predominantly subclinical in equines and is thought to be a significant cause for abortion, stillbirth, delivery weak foals, and neonatal mortality (5, 6). However, the main symptoms in horses are anorexia, moderate fever, jaundice and recurrent uveitis (7). Moreover, pulmonary hemorrhage and deaths due to interstitial nephritis may be occurred (8).

Leptospirosis infection in horses is one of the leading causes of significant economic loss in the equine agribusiness sector due to the numerous consequences of the disease, including the cost of treating diseases animals, the interruption of training, a decline in performance, and the exclusion of affected animals from auctions and competitions (9, 10). Moreover, the infected animals in either acute or chronic phases are thought of as reservoirs and play a significant part in the transmission of disease that poses a risk to public health (11).

Leptospirosis has traditionally been diagnosed in a laboratory using serological tests. The standard serological test

is the microscopic agglutination test (MAT), where a single detection of a high antibody titer associated with clinical symptoms and a four-fold or more shift in antibody titers in paired acute and convalescent samples are considered diagnostic. It is preferable to isolate the spirochete, however this is a challenging and time-consuming (12). Moreover, the polymerase chain reaction (PCR) have been used as a specific test for detection of *Leptospira* DNA in tissue of premature born foals (13, 14) and in the vitreous fluid of horses with recurrent uveitis. (15).

Leptospiral infection in horses is frequently detected using serology. The most common reported serovars are *L. interrogans* sv. Bratislava, *L. interrogans* sv. Pomona, *L. kirschneri* sv. Grippotyphosa and *L. interrogans* sv. Icterohaemorrhagiae (16).

In Egypt, most of previous studies on leptospirosis were focused on human or pets like dogs, cats (17) and few studies in cattle (18). Nonetheless, there is no epidemiological data about the *Leptospira* infection in horse particularly in Nile Delta of Egypt.

Therefore, the objective of the current study was to assess the prevalence of leptospirosis among horses in the four governorates of northern Egypt as well as potential risk factors for leptospiral infection.

Materials and methods

Ethical statement

The study protocol was approved by ethical committee of the Faculty of Veterinary Medicine, Benha University, Egypt, which complies with all applicable Egyptian regulations on research and publication. The Committee's Animal Ethical Rules and Guidelines were followed in the collection and handling of serum samples.

Study location

A serological survey was conducted from January 2020 to April 2021 in the northern Egyptian governorates of Cairo, Giza, Kafr ElSheikh, and Qalyubia, which situated geographically at 30°2'40"N 31°14'9"E, 29.9870°N 31.2118°E, 31.3°N 30.93°E and 30.41°N 31.21°E, Figure 1.

According to Köppen, the climate of Giza is similar to an arid, hot desert. Because of its proximity to Cairo, it has a similar climate to Cairo. The average temperature is 25 °C and highest temperature reported in August, while the rain is rare in this area with average rainfall of 100-200 mm annually. In addition, the weather in Kafr ElSheikh and Qalyubia governorates is hot, muggy, arid summers and chilly, dry, windy, mainly clear winters. The temperature falls between 15 to 30 °C throughout the year.

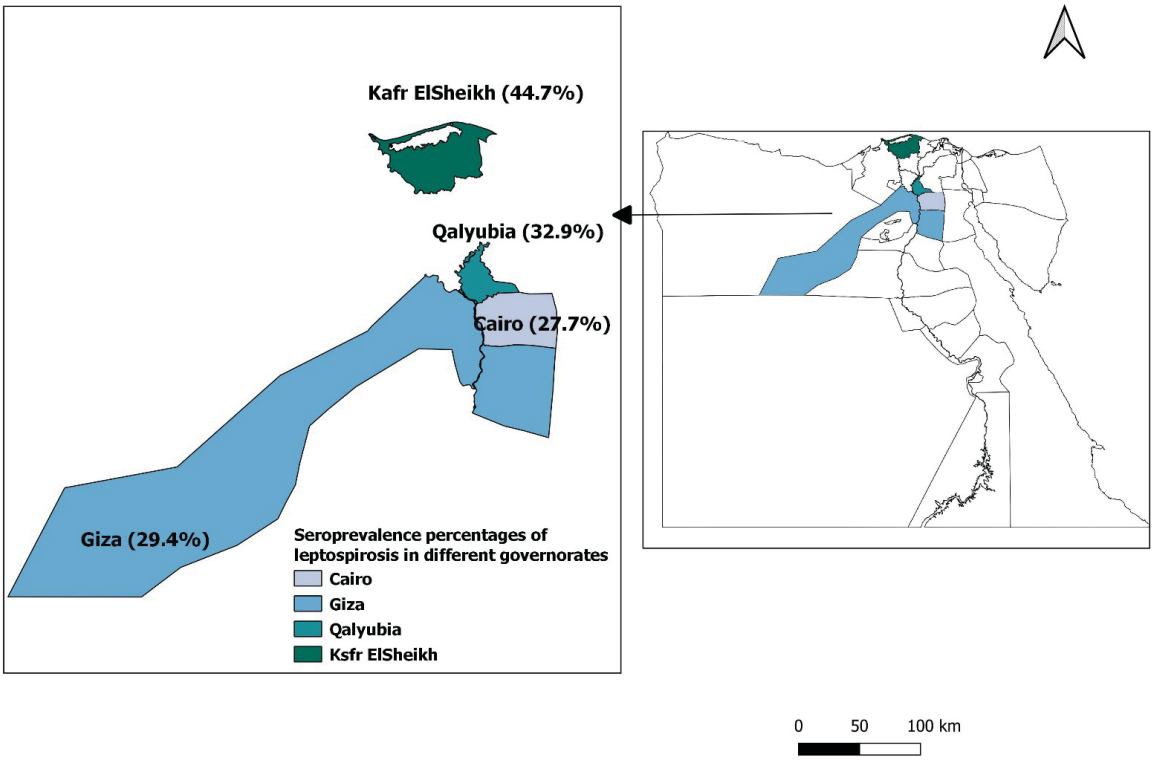

Figure 1: MAP demonstrate studied governorates and seropositivity percentages to *Leptospira* sp.

Sampling and epidemiological data

Win Epi 2.0 was used to estimate the sample size, which was 305 horses, with a predicted prevalence of 50%, a 95% confidence range, and an accepted error of 5%. Because there haven't been any epidemiological study that describe the state of horse leptospirosis in the examined region, the predicted prevalence of 50% was chosen. The examined horses had not specific signs for the disease and have not been vaccinated against leptospirosis. In the present study, no exclusion criteria or repeat sampling of the same horses were applied. The blood samples were taken after obtaining the farmer's informed consent from horse by puncturing the jugular vein with vacuum tubes without an anticoagulant. The samples were centrifuged at 3000 xg for 10 min to separate the serum, which kept at -20 °C until serological analysis.

In order to determine risk variables related with seropositive horses, a questionnaire was made accessible to the owners of the study's horses. Questionnaire was set to collect the data associated with the potential risk factors for leptospira infection. The questionnaire included the data about sex (male or female), age (<6 years, 6-10 years, and >10 years), season (winter, autumn, summer, and spring), the presence of ruminants (yes/no), the presence of dogs (yes/no), the type of housing (Stable, pasture, mixed), and control of rodents (yes/no).

Serological testing

The microscopic agglutination test (MAT) was used to screen serum samples for *Leptospira* antibodies. A variety of *Leptospira* serovars were used as antigens in the microscopic agglutination reaction, including serogroup Icterohaemorrhagiae, serovar Copenhageni and Icterohaemorrhagiae; serogroup Canicola, serovar Canicola; serogroup Grippotyphosa, serovar Grippotyphosa; serogroup Pomona, serovar Pomona; serogroup Sejroe, serovar Hardjo; serogroup Tarassovi, serovar Tarassovi and serogroup interrogans serovar Bratislava. The serum samples were tested at 1:100 dilution by mixing of 25 µL of diluted serum 1:14 in sterile saline with 150 µL of the diluted *Leptospira* suspensions. Sera that produced a positive reaction were titrated further in a series of two-fold dilutions, commencing at 1:125 and continuing until the titer endpoint. Antibody titers were calculated as the reciprocal of the highest serum dilution that resulted in a 50% or more reduction in the amount of free leptospires in the suspension when compared to a sterile saline-based negative control. A titer of ≤100 was considered positive, meaning it indicated exposure to or infection with *Leptospira*.

Statistical analysis

Data were organized and statistically analyzed using SPSS software version 24 (IBM, Chicago, USA). Chi-square test was used to evaluate the relationship between the results of the serology (positive and negative) and the factors. Findings with *P*-value less than 0.05 were regarded as statistically significant. First, the univariate binary logistic regression analysis was performed to identify important risk factors linked to *Leptospira* seropositivity. Then, all variables with $P<0.05$ in univariate regression model were passed to multivariant logistic regression model. The odds ratios (ORs) and 95% confidence intervals were calculated to evaluate the degree of risk. The model's fit was evaluated using the Hosmer and Lemeshow goodness test.

Results

At a serum dilution of 1:100, 104 horses (34.1%, 95%CI: 29.01-39.59) from four governorates showed positive MAT titers to one or more *Leptospira* serovars. The majority of

Table 1: MAT antibody titer distribution for different *Leptospira* serovars

Serovar	Number of positive horses in each titer						No of positive animals (%)
	125	250	500	1000	2000	4000	
Icterohaemorrhagiae	15	12	7	8	6	5	53/305 (15.14%)
Canicola	14	11	8	4	3	5	45/305 (14.75%)
Bratislava	13	10	6	3	1	2	35/305 (11.47%)
Copenhageni	11	9	5	0	0	0	25/305 (8.19%)
Pomona	11	8	3	1	1	0	24/305 (7.86%)
Hardjo	9	6	5	0	1	0	21/305 (6.88%)
Grippotyphosa	0	0	0	0	0	0	0/305 (0)
Tarassovi	0	0	0	0	0	0	0/305 (0)

Table 2: Number of seropositive animals to single and multiple serovars

No of serovar	Number of animals reacted positive (%)
1	59/104 (56.7%)
2	22/104 (21.1%)
3	18/104 (17.3%)
4	5/104 (4.8)
5	0/104 (0)

horses tested positive for Icterohaemorrhagiae serovar, followed by Canicola, Bratislava, Copenhageni, Pomona, and Hardjo, but no animals tested positive for Grippotyphosa or Tarassovi serovars, Table 1. The seropositive horses reacted with single serovar were 59/104 (56.7%), while 43.3% (45/104) of the seropositive horses tested positive to numerous serovars, Table 2.

In this study, it was discovered that 104 animals possessed *Leptospira* antibodies, representing a seroprevalence of 34.1%. Horses from Kafr ElSheikh had the greatest prevalence rate (44.7%), followed by those from Qalyubia (32.9%), while animals from the Giza governorate had the lowest prevalence (27.7%), as indicated in Table 3.

Considering sex as a potential risk factor among the tested animals, gelding horses and male vs female horses showed a significant difference ($P< 0.05$). Significantly, the infection rate among females was the greatest (39%), while the prevalence rate among male animals was the lowest (24.3%). In addition, age was associated with a greater seroprevalence that was statistically significant ($P=0.001$). In comparison to horses in the age groups < 6 and 6 to 10 years old, all horses over 10 years old had greater prevalence rates (49.1%), table 3. The highest prevalence rates were seen in the autumn (50.6%) and spring (33.3%), with a significant seasonal difference in *Leptospira* seropositivity ($P<0.05$). According to the findings, horses raised in close proximity to ruminants or dogs had higher seropositivity rates, which were 39.9% and 38.5%, respectively. Also, the findings show that, in comparison to horses living in stables or mixing houses, horses roaming freely in pastures had the highest prevalence rate (42%). It's interesting to note that rodent control has a substantial effect on the prevalence of *Leptospira* in horses, where the prevalence rate significantly rose in the presence of rodent control, Table 3.

The result of multivariate logistic regression analysis summarized in table 4 and showed that sex, age, season, housing, contact with ruminants or dogs and control of rodents were identified as risk factor for *Leptospira* infection. Females (OR= 1.27, 95%CI: 0.49-5.70) within age group more than 10 years old (OR=3.25, 95%CI: 1.31-8.11) was found to be a greater risk than gelding and other age groups. Moreover, horses raised in contact with ruminants (OR=2.43, 95%CI: 1.35-4.36) or dogs (OR=1.36, 95%CI: 0.66-2.78) and living freely in pasture (OR=2.30, 95%CI: 1.16-4.52) had high risk of infection than other animals. Also, autumn season (OR=2.66, 95%CI: 1.21-5.83) and presence of rodents control (OR=3.26, 95%CI: 1.55-6.85) increased risk of infection, Table 4.

Discussion

Horses are not frequently thought as a potential source of leptospirosis spread unlike other domestic and wild animals. Nevertheless, horses may have *Leptospira* in their kidneys, making them carriers and transmit the bacterium in the environment (5). In horses, the disease varies geographically in terms of prevalence and serovars involved, and its effects are still unknown (8, 19). The current study used the MAT to determine the prevalence of antibodies against eight different Leptospira serovars and related risk variables in horses living in the four Egyptian governorates.

The findings of present study revealed that 34.1% of horses had positive MAT titers for at least one *Leptospira* serovar, while 53.3% of seropositive horses had antibodies for several serovars. Several infections or cross-reactions may cause seropositivity to multiple serovars. Additionally, because none of the horses were immunized against leptospirosis, we concluded that the presence of antibodies indicated *Leptospira* exposure or illness.

The *Leptospira* sp. seroprevalence in Egyptian horses was lower than that reported in Europe. In Switzerland, Italy and the Netherlands, seroprevalences were determined to be 58.5% 67.2% and 79%, respectively (20-22). On the other hand, the seroprevalence rate in the current study was higher than those reported in Italy, which were 11.4% and 1.5%, respectively (23, 24). Additionally, in a Brazilian studies, the seropositivity rates were 71.4% (25), 28.75% (26), 45.9%, (27) and 8% (28). Furthermore, according to a recent study conducted in various States of the American Midwest, healthy horses have a 77% seroprevalence rate (29). The findings of present investigation were attributed to the type of environment (30-34). The studied horses were kept under good care conditions and in regions with little stagnant water (35).

The present fndings revealed that the most prevalent serovar was Icterohaemorrhagiae (15.14%), followed by Canicola (14.75%). These findings are consistent with earlier serological studies conducted on Brazilian horses (21, 27, 36). It's interesting that no animals tested positive for the Grippotyphosa serovar. Although this serovar very seldom affects horses, it is thought to be the one most frequently linked to equine recurrent uveitis (ERU) in Europe (20). The obtained findings were consistent with those reported by several authors, where most of seropositive or infected horses have no symptoms (7, 8).

Table 3: The risk factors associated with *Leptospira* spp. seropositivity in horse

Variable	Total tested horses	No of positive	No of negative	% of positive	95% CI	Statistic
locality						
Giza	85	25	60	29.4	20.78-39.82	x^2=6.322 df=3 *P*=0.097
Cairo	65	18	47	27.7	18.29-39.58	
Kafr ElSheikh	85	38	47	44.7	34.6-55.28	
Qalyubia	70	23	47	32.9	23-44.5	
Sex						
Male	74	18	56	24.3	15.97-35.2	x^2=7.552 df=2 *P*=0.023*
Female	210	82	128	39.0	32.7-45.79	
Gelding	21	4	17	19.0	7.67-40	
Age						
<6 years	64	11	53	17.2	9.88-28.22	x^2=13.805 df=2 *P*=0.001*
6-10	186	66	120	35.5	28.96-42.59	
>10	55	27	28	49.1	36.38-61.92	
Season						
Winter	73	17	56	23.3	15.08-34.17	x^2=15.067 df=3 *P*=0.002*
Spring	75	25	50	33.3	23.71-44.58	
Summer	76	21	55	27.6	18.84-38.57	
Autumn	81	41	40	50.6	39.95-61.23	
Contact with ruminants						
Yes	198	79	119	39.9	33.33-46.85	x^2=8.451 df=1 *P*=0.004*
No	107	25	82	23.4	16.35-32.21	
Contact with dogs						
Yes	231	89	142	38.5	32.49-44.94	x^2=7.968 df=1 *P*=0.005*
No	74	15	59	20.3	12.87-31.18	
Housing						
Stable	81	17	64	21.0	13.54-31.07	x^2=12.599 df=2 *P*=0.002*
Pasture	181	76	105	42.0	35.04-49.27	
Mixed	43	11	32	25.6	14.93-40.24	
Control of rodents						
No	76	12	64	15.8	9.27-25.6	x^2=15.100 df=1 *P*<0.0001*
Yes	229	92	137	40.2	34.03-46.63	
Total	305	104	201	34.1	29.01-39.59	

*The result is significant at $P < 0.05$

Table 4: Multivariate logistic regression analysis for variables associated with horse leptospirosis

Factors	B	S.E.	OR	95% CI for OR		P value
				Lower	Upper	
Sex						
Male	0.240	0.662	1.27	0.35	4.65	0.717
Female	0.518	0.624	1.68	0.49	5.70	0.407
Age						
6-10	0.749	0.401	2.11	0.96	4.64	0.062
>10	1.180	0.466	3.25	1.31	8.11	0.011
Season						
Spring	0.300	0.410	1.35	0.60	3.02	0.464
Summer	0.068	0.416	1.07	0.47	2.42	0.870
autumn	0.978	0.400	2.66	1.21	5.83	0.015
Contacts with ruminants						
Yes	0.886	0.299	2.43	1.35	4.36	0.003
Contacts with dogs						
Yes	0.306	0.366	1.36	0.66	2.78	0.403
Housing						
Pasture	0.831	0.346	2.30	1.16	4.52	0.016
Mixed	0.373	0.489	1.45	0.56	3.79	0.446
Control of rodents						
Yes	1.182	0.379	3.26	1.55	6.85	0.002

B: Logistic regression coefficient, SE: Standard error, OR: Odds ratio, CI: Confidence interval

According to our data, older horses are significantly more likely than young horses to be seropositive to *Leptospira* sp. This finding is consistent with results from previous studies (9, 37) and could be explained by the fact that exposure to *Leptospira* is more likely as horse get older and that seropositivity can last for a very long time. Nevertheless, other researchers did not observe significant relationship between age and seropositivity (27, 38).

The present findings are consistent with previous studies showing that females more susceptible to get *Leptospira* infection than males (27, 28). These findings confirm that females are more vulnerable than males since they are allowed to roam more freely on pasture on stud farms and are often included in batches of the most animals (39-47).

According to our findings, the seroprevalence rate of *Leptospira* was highest during autumn in comparison with other seasons, which come in accordance with findings of Trimble and colleagues (29). Since leptospires may survive and spread infection for a longer period of time in warm and humid climates. Thus, spring and fall have higher seroprevalences.

The study's findings confirmed the necessity of sanitary management when different species cohabit, with the presence of animals such as sheep, goats, or cows on nearby farms serving as risk factors for exposure to *Leptospira* sp. in study participants' animals (9). *Leptospira* infections in ovine and caprine are frequent, and these species, like bovines, can serve as significant reservoirs of the disease and

have epidemiological implications (39, 48-52). Moreover, according to findings reported by Chiareli and colleagues (53), equines that coexist with other species share communal drinking and pasture, have direct or indirect contact with contaminants of aborted materials, graze on pasture contaminated with infected urine, and have contact with animals on neighbouring properties are more likely to be exposed to *Leptospira* spp.

In the horses' indoor habitat, rats are probably the most common species of animals, and *Leptospira interrogans* prevalence was positively correlated with the density of the rat population (54). The possibility of the *Leptospira* spreading to horses was greatly decreased by the existence of pest control methods. Rodent control is seen as a key element in prevention (55) despite the fact that it can occasionally be challenging to assess the role that rodents play in the transmission of leptospiral serovars (56).

In agreement with findings of Pinna and colleagues (57), appropriate management, such as the availability of veterinary support on the property, control measures for presence of rodents, and quarantine of recently arriving animals, suggested probable circumstances of less exposure to leptospirosis. In contrast, Batista and colleagues (58), observed no significant associateion between presence of rodents and livestock farming and seropositivity for *Leptospira* sp. and they attributed this to inaccurate data, a non- conclusive epidemiological questionnaire, the presence of confounding variables, and unmeasured environmental variables.

Conclusion

The present study confirms presence of antibodies against *Leptospira* sp. among Egyptian horses and horses living in studied areas high risk exposure to pathogenic leptospires. Age, sex, season, the presence of ruminants or dogs, and the absence of rodent controls were the risk factors targeted in this investigation for the occurrence of horse leptospirosis. Thus, control of roddent is important factor to reduce the spreading of infcetion among horses and consequently for human.

Acknowledgements

The authors would like to acknowledge the Deanship of Scientific Research, Vice Presidency for Graduate Studies and Scientific Research, King Faisal University, Saudi Arabia for the financial support of this research through the Grant Number 3413.

Authors' contributions. Conceptualization, methodology, formal analysis, investigation, resources, data curation, writing-original draft preparation, A.S., A.M.H. and M.M.; writing-review and editing, A.S. and M.M.; project administration, M.M.; funding acquisition, A.S., A.M.H. and M.M. All authors have read and agreed to the published version of the manuscript.

Ethics approval and consent to participate. The study protocol was approved by ethical committee of the Faculty of Veterinary Medicine, Benha University, Egypt, which complies with all applicable Egyptian regulations on research and publication. The Committee's Animal Ethical Rules and Guidelines were followed in the collection and handling of serum samples.

Consent for publication not applicable.

Availability of data and materials. All data generated or analysed during this study are included in this published article

Competing interests. There are no conflicts of interest declared by the authors.

Funding. This work was supported through the Annual Funding track by the Deanship of Scientific Research, Vice Presidency for Graduate Studies and Scientific Research, King Faisal University, Saudi Arabia (Grant Number 3413).

References

1. Pappas G, Papadimitriou P, Siozopoulou V, Christou L, Akritidis N . The globalization of leptospirosis: worldwide incidence trends. Int J Infect Dis 2008; 12(4): 351–7.
2. Vijayachari P, Sugunan AP, Shriram AN. Leptospirosis: an emerging global public health problem. J Biosci 2008; 33(4): 557–69.
3. Bharti AR, Nally JE, Ricaldi JN, et al. Leptospirosis: a zoonotic disease of global importance. Lancet Infect Dis 2003; 3(12): 757–1.
4. Hamond C, Martins G, Lawson-Ferreira R, Medeiros MA, Lilenbaum W. The role of horses in the transmission of leptospirosis in an urban tropical area. Epidemiol Infect 2013; 141(1): 33–5.
5. Hamond C, Pinna A, Martins G, Lilenbaum W. The role of leptospirosis in reproductive disorders in horses. Trop Anim Health Prod 2014; 46(1): 1–10.
6. Whitwell K, Blunden A, Miller J, Errington J. Two cases of equine pregnancy loss associated with Leptospira infection in England. Vet Rec 2009; 165(13): 377–8.
7. Divers T, Chang YF, Irby N, Smith JL , Carter CN. Leptospirosis: an important infectious disease in North American horses. Equine Vet J 2019; 51(3): 287–92.
8. Verma A, Stevenson B, Adler B. Leptospirosis in horses. Vet Microbiol 2013; 167(1/2): 61–6.
9. Båverud V, Gunnarsson A, Engvall EO, Franzén P, Egenvall A. Leptospira seroprevalence and associations between seropositivity, clinical disease and host factors in horses. Acta Vet Scand 2009; 51(1): 1–10.
10. Pinto PS, Libonati H, Lilenbaum W. A systematic review of leptospirosis on dogs, pigs, and horses in Latin America. Trop Anim Health Prod 2017; 49(2): 231–8.
11. Daher EDF, Abreu KLS, Silva Junior GB. Insuficiência renal aguda associada à leptospirose. Braz J Nephrol 2010; 32(4): 408–15.
12. OIE. Leptospirosis. In: Manual of diagnostic tests and vaccines for terrestrial animals. 8th ed. Paris: OIE, 2018; 503–16.

13. Vemulapalli R, Langohr IM, Sanchez A, et al. Molecular detection of Leptospira kirschneri in tissues of a prematurely born foal. J Vet Diagn Invest 2005; 17(1): 67–71.

14. Selim AM, Elhaig MM, Gaede W. Development of multiplex real-time PCR assay for the detection of Brucella spp., Leptospira spp. and Campylobacter foetus. Vet Ital 2014; 50(4): 269–75.

15. Brandes K, Wollanke B, Niedermaier G, Brem S, Gerhards H. Recurrent uveitis in horses: vitreal examinations with ultrastructural detection of leptospires. J Vet Med A Physiol Pathol Clin Med 2007; 54(5): 270–5.

16. Hashimoto VY, Gonçalves DD, Silva FGd, et al. Occurrence of antibodies against Leptospira spp. in horses of the urban area of Londrina, Paraná, Brazil. Rev Inst Med Trop São Paulo 2007; 49(5): 327–30.

17. Samir A, Soliman R, El-Hariri M, Abdel-Moein K , Hatem ME . Leptospirosis in animals and human contacts in Egypt: broad range surveillance. Rev Soc Bras Med Trop 2015; 48(3): 272–7.

18. Ibrahim NA, Alrashdi BM, Elnaker YF, et al. Serological investigation and epidemiological analysis of bovine leptospirosis in Egypt. Trop Med Infect Dis 2022; 7(9): 208.

19. Martinez F. Leptospirosis in horses: a European perspective. Equine Vet J 2019; 51(3): 285–6.

20. Vera E, Taddei S, Cavirani S, et al. Leptospira Seroprevalence in bardigiano horses in northern Italy. Animals 2019; 10(1): e 23. doi: 10.3390/ani10010023

21. Houwers DJ, Goris MGA, Abdoel T, et al. Agglutinating antibodies against pathogenic Leptospira in healthy dogs and horses indicate common exposure and regular occurrence of subclinical infections. Vet Microbiol 2011; 148(2/4): 449–51.

22. Blatti S, Overesch G, Gerber V, Frey J, Hüssy D. Seroprevalence of Leptospira spp. in clinically healthy horses in Switzerland. Schweiz Arch Tierheilkd 2011; 153(10): 449–56.

23. Cerri D, Ebani V, Fratini F, Pinzauti P, Andreani E . Epidemiology of leptospirosis: observations on serological data obtained by a" diagnostic laboratory for leptospirosis" from 1995 to 2001. New Microbiol 2003; 26(4): 383–9.

24. Ebani VV, Bertelloni F, Pinzauti P, Cerri D . Seroprevalence of Leptospira spp. and Borrelia burgdorferi sensu lato in Italian horses. Ann Agric Environ Med 2012; 19(2): 237–40.

25. Hamond C, Martins G, Lilenbaum W. Subclinical leptospirosis may impair athletic performance in racing horses. Trop Anim Health Prod 2012; 44(8): 1927–30.

26. Dewes C, Fortes TP, Machado GB, et al. Prevalence and risk factors associated with equine leptospirosis in an endemic urban area in Southern Brazil. Braz J Dev 2020; 6(8): 58380–90.

27. Da Silva AS, Jaguezeski AM, Laber IF, et al. Leptospira spp. in horses in southern Brazil: seroprevalence, infection risk factors, and influence on reproduction. Comp Immunol Microbiol Infect Dis 2020; 73: e101552. doi:10.1016/j.cimid.2020.101552

28. Siqueira CC, Fraga DBM, Chagas-Junior AD, et al. Seroprevalence and risk factors associated with equine leptospirosis in the metropolitan region of Salvador and Recôncavo Baiano region, Bahia state (NE Brazil). Trop Anim Health Prod 2020; 52(1): 31–9.

29. Trimble AC, Blevins CA, Beard LA, Deforno AR, Davis EG . Seroprevalence, frequency of leptospiuria, and associated risk factors in horses in Kansas, Missouri, and Nebraska from 2016-2017. PLoS One 2018; 13(10): e0206639. doi:10.1371/journal.pone.0206639

30. Selim A, El-Haig M, Galila ES, Gaede W. Direct detection of Mycobacterium avium subsp. paratuberculosis in bovine milk by multiplex Real-time PCR. Anim Sci Pap Rep 2013; 31(4): 291–302.

31. Elhaig MM, Selim A, Mandour AS, Schulz C, Hoffmann B. Prevalence and molecular characterization of peste des petits ruminants virus from Ismailia and Suez, Northeastern Egypt, 2014–2016. Small Ruminant Res 2018; 169: 94–8.

32. Selim A, Ali A-F, Ramadan E. Prevalence and molecular epidemiology of Johne's disease in Egyptian cattle. Acta Trop 2019; 195: 1–5.

33. Abdallah M-C, Kamel M, Karima B, et al . First report of Toxoplasma gondii infection and associated risk factors in the dromedary camel (Camelus dromedarius) population in south east Algeria. Vet Parasitol Reg Stud Rep 2020; 22: e100475. doi:10.1016/j.vprsr.2020.100475

34. Selim A, Abdelhady A. The first detection of anti-West Nile virus antibody in domestic ruminants in Egypt. Trop Anim Health Prod 2020; 52(6): 3147–51.

35. Raghavan R, Brenner K, Higgins J, Shawn Hutchinson JM , Harkin KR . Evaluations of hydrologic risk factors for canine leptospirosis: 94 cases (2002–2009). Prev Vet Med 2012; 107(1/2): 105–9.

36. Coiro CJ, Langoni H, da Silva RC. Epidemiological aspects in the Leptospira spp. and Toxoplasma gondii infection in horses from Botucatu, São Paulo, Brazil. J Equine Vet Sci 2012; 32(10): 620–3.

37. Rocha T, Ellis W, Montgomery J, Gilmore C, Regalla J, Brem S. Microbiological and serological study of leptospirosis in horses at slaughter: first isolations. Res Vet Sci 2004; 76(3): 199–202.

38. Wangdi C, Picard J, Tan R, Dowling B, Gummow B . Equine leptospirosis in tropical Northern Queensland. Aust Vet J 2013; 91(5): 190–7.

39. Langoni H, Da Silva A, Pezerico S, Lima VY. . Anti-leptospirose agglutinins in equine sera, from São Paulo, Goiás, and Mato Grosso do Sul, Brazil, 1996-2001. J Venom Anim Toxins Incl Trop Dis 2004; 10(3): 207–18.

40. Selim A, Abdelhady A. Neosporosis among Egyptian camels and its associated risk factors. Trop Anim Health Prod 2020; 52(6): 3381–5.

41. Selim A, Ali A-F. Seroprevalence and risk factors for C. burentii infection in camels in Egypt. Comp Immunol Microbiol Infect Dis 2020; 68: e101402 .doi:10.1016/j.cimid.2019.101402

42. Selim A, Marawan MA, Ali A-F, Manaa E , AbouelGhaut HA . Seroprevalence of bovine leukemia virus in cattle, buffalo, and camel in Egypt. Trop Anim Health Prod 2020; 52(3): 1207–10.

43. Selim A, Megahed AA, Kandeel S, Abdelhady A. Risk factor analysis of bovine leukemia virus infection in dairy cattle in Egypt. Comp Immunol Microbiol Infect Dis 2020; 72: e101517. doi:10.1016/j.cimid.2020.101517

44. Selim A, Radwan A. Seroprevalence and molecular characterization of West Nile Virus in Egypt. Comp Immunol Microbiol Infect Dis 2020; 71: e101473. doi: 10.1016/j.cimid.2020.101473

45. Selim A, Radwan A, Arnaout F, Khater H. The recent update of the situation of West Nile fever among equids in Egypt after three decades of missing information. Pak Vet J 2020; 40(3): 390–3.

46. Marawan MA, Alouffi A, El Tokhy S, et al. Bovine Leukaemia Virus: current epidemiological circumstance and future prospective. Viruses 2021; 13(11): e2167. doi: 10.3390/v13112167

47. Selim A, Almohammed H, Abdelhady A, Alouffi A, Alshammari FA . Molecular detection and risk factors for Anaplasma platys infection in dogs from Egypt. Parasites Vector 2021; 14(1): e429. doi: 10.1186/s13071-021-04943-8

48. Martins G, Lilenbaum W. The panorama of animal leptospirosis in Rio de Janeiro, Brazil, regarding the seroepidemiology of the infection in tropical regions. BMC Vet Res 2013; 9: e237. doi:10.1186/1746-6148-9-237

49. Selim A, Manaa E, Khater H. Molecular characterization and phylogenetic analysis of lumpy skin disease in Egypt. Comp Immunol Microbiol Infect Dis 2021; 79: e101699 . doi:10.1016/j.cimid.2021.101699

50. Selim A, Manaa E, Khater H. Seroprevalence and risk factors for lumpy skin disease in cattle in Northern Egypt. Trop Anim Health Prod 2021; 53(3): e350. doi:10.1007/s11250-021-02786-0

51. Selim A, Manaa EA, Alanazi AD, Alyousif MS. Seroprevalence, risk factors and molecular identification of bovine leukemia virus in Egyptian cattle. Animals 2021; 11(2): e319. doi:10.3390/ani11020319

52. Selim A, Megahed A, Kandeel S, Alouffi A, Almutairi MA. West Nile virus seroprevalence and associated risk factors among horses in Egypt. Sci Rep 2021; 11: e20932. doi:10.1038/s41598-021-00449-6

53. Chiareli D, Moreira E, Gutiérrez H, et al. Freqüência de aglutininas anti-Leptospira interrogans em eqüídeos, em Minas Gerais, 2003 a 2004. Arq Brasil Med Vet Zootec 2008; 60(6): 1576–9.

54. Barwick RS, Mohammed HO, McDonough PL, White ME. Epidemiologic features of equine Leptospira interrogans of human significance. Prev Vet Med 1998; 36(2): 153–65.

55. Tsegay K, Potts A, Aklilu N, Lötter C, Gummow B. Circulating serovars of Leptospira in cart horses of central and southern Ethiopia and associated risk factors. Prev Vet Med 2016; 125: 106–15.

56. Simbizi V, Saulez MN, Potts A, Lötter C, Gummow B. A study of leptospirosis in South African horses and associated risk factors. Prev Vet Med 2016; 134: 6–15.

57. Pinna MH, Varges R, Lilenbaum W. Aplicação de um programa integrado de controle da leptospirose em eqüinos no Rio de Janeiro, Brasil. Rev Brasil Ciência Vet 2008; 15(2): 63–6.

58. Batista CdSA, Alves CJ, Azevedo SSd, et al. Soroprevalência e fatores de risco para a leptospirose em cães de Campina Grande, Paraíba. Arq Brasil Med Vet Zootec 2005; 57(suppl. 2): 179–85.

Leptospiroza konj v Egiptu: seroprevalenca in dejavniki tveganja

Mohamed Marzok, Abdelrahman M. Hereba, Abdelfattah Selim

Izvleček: Večina leptospiroz pri konjih je asimptomatskih, vendar obstajajo poročanja o akutnih bolezenskih znakih, reprodukcijskih motnjah in ponavljajočih se uveitisih. Konji veljajo za naključne gostitelje. Podatki o leptospirozi konj v Egiptu so pomanjkljivi. Zato je bil namen te študije raziskati prisotnost protiteles proti bakteriji *Leptospira* sp. pri konjih v štirih egiptovskih pokrajinah in določiti z njimi povezane dejavnike tveganja za okužbo. Za določitev seroprevalence v 305 vzorcih seruma je bil opravljen mikroskopski aglutinacijski test (MAT) z osmimi antigeni serovara *Leptospira*. Rezultati so pokazali, da so bile 104 živali pozitivne na vsaj enega od serovarov (34,1 %; 95-odstotni indeks: 29,01–39,59). Najpogostejša reakcija je bila na serovar Icterohaemorrhagiae (15,14 %), sledili so Canicola (14,75 %), Bratislava (11,47 %), Copenhageni (8,19 %), Pomona (7,86 %) in Hardjo (6,88 %). Najpogostejše so bile pri kobilah, starejših konjih, konjih, ki se redijo na pašnikih ali so v stiku s prežvekovalci ali psi in pri pomanjkanju nadzora nad glodavci. Velika seroprevalenca kaže, da so egiptovski konji, ki živijo na proučevanem območju, izpostavljeni velikemu tveganju za okužbo z bakterijo *Leptospira* sp. Zato je za ta zoonotski patogen zelo pomembna vzpostavitev programa nujnega nadzora in obvladovanja.

Ključne besede: Leptospirosis; seroprevalence; risk factors; horse; Egypt