

Diagnostic study of *Toxoplasma gondii* in turkey (*Meleagris gallopavo*) in some regions in Ninevah governorate, Iraq

E. T. Butty

Department of Microbiology, College of Veterinary Medicine, University of Mosul, Mosul, Iraq

Abstract

A total of 107 serum samples of turkeys from ten regions in Ninevah governorate which included (Karakosh, Bartila, Kokjali, Al-Khather, Al-Manara, Alirash, Kabarly, Khazna, Bazkertan and Kharab Sultan) were collected from January 2008 till December 2008 and tested for *Toxoplasma gondii* antibodies by using latex agglutination test. The total prevalence of toxoplasmosis among turkey was 76.63% (82 out of 107). The positive agglutination titers were distributed between 1/20 – 1/320, and the highest seropositive rate at a titer 1/160 was 66.66% in Al-Khather, while lowest seropositive test at a titer 1/20 was 9.09% in Bartila. Control measure should be taken to prevent transmission of the infection to the animals and humans by health and veterinary organizations.

Keywords: *Toxoplasma gondii*, *Meleagris gallopavo*, Toxoplasmosis.

Available online at <http://www.vetmedmosul.org/ijvs>

دراسة تشخيصية للمقوسات الكوندية في الديك الرومي *Meleagris gallopavo* في بعض مناطق محافظة نينوى، العراق

انتصار توما بطي

فرع الاحياء المجهرية، كلية الطب البيطري، جامعة الموصل، الموصل، العراق

الخلاصة

بلغ عدد المصول المأخوذة ١٠٧ من الديك الرومي من عشرة مناطق في محافظة نينوى (قرة قوش، برطلة، كوكجلي، الخضر، المنارة، علي رش، كبرلي، خزنة، بازكرتان، خراب سلطان) للفترة من كانون الثاني ٢٠٠٨ والى كانون الاول ٢٠٠٨ وذلك للكشف عن الاجسام المضادة للمقوسة الكوندية باستخدام اختبار تلازن اللاتكس. بلغت نسبة الإصابة الكلية (٨٢ من ١٠٧) بنسبة ٧٦,٦٣%. وكما أشارت الدراسة إلى معايير الاضداد في الديك الرومي والتي تراوحت ما بين ٢٠/١ إلى ٣٢٠/١ وكانت أعلى نسبة للمعايير الاضداد عند المعيار ١٦٠/١ ونسبة ٦٦,٦٦% في منطقة الحضر وقلها عند المعيار ٢٠/١ بنسبة ٩,٠٩% في منطقة برطلة. وتناولت الدراسة أهمية المرض وكيفية السيطرة عليه من خلال اخذ الاحتياطات لمنع انتشار الإصابة إلى الحيوان والانسان عن طريق المنظمات الصحية والبيطرية.

Introduction

Toxoplasma gondii is an obligate intercellular protozoan that infects human and a wide range of mammals and birds (1). The disease occurs mostly through ingestion of under cooked meat or by the oocyst excreted by infected cat as a definitive host (2). Toxoplasmosis caused parasitic disorder in mammals, birds and reptiles affecting primarily

the central nervous system but some time also the reproductive system, skeletal muscles and visceral organs (3). It is the major causes of abortion in sheep and goats in many countries (4). The clinical signs of toxoplasmosis in poultry include anorexia, emaciation, reduce eggs production, ataxia, blindness, and even mortality rate may be as high 50% (5), which is seldom observed (2). As concern with production of turkey, *Meleagris gallopavo* in

Iraq until now was depended on the house breeding, although these birds have a high production of meat. The population of these birds was considered to be in increasing rate especially in the North region of Iraq (6). In broiler chicken also *Toxoplasma gondii* was detected in Ninevah governorate by (7). Anyhow sporadic out breaks of toxoplasmosis in turkeys have been reported in Georgia (8). It is noteworthy that, more than 63 species of birds and 27 species of animals become infected from ingestion of oocysts and develop cysts in tissue without passing oocysts infeces (9). Furthermore, naturally occurring infections have been diagnosed in chicken, turkey, ducks and many wild birds (10). Ruiz and Frenkel (11) isolated *Toxoplasma gondii* from 54% of chickens and 16% from the sparrows examined in Costa Rica. Also this parasite has been isolated from Japanese quail, crows, and chickens of the experimental infection (12). Infected birds were considered as important source of *Toxoplasma gondii* world wide. The prevalence of *Toxoplasma gondii* antibodies in chicken were reported from nil to 40% by different method using different cut of points (13). The information on spontaneous toxoplasmosis in wild birds is very rare over a period of 15 years (14), which recorded several epizootics of toxoplasmosis in Capercaillie (*Tetrao urogalus*) and (15) who described toxoplasmosis in wild turkeys, whilst they have been few reports on spontaneous toxoplasmosis in pigeons despite the high sensitivity of the columbiformes to *Toxoplasma gondii* (16). Furthermore, an outbreak of fatal toxoplasmosis has been reported in passerine birds in Italy (17). While only several small out breaks of toxoplasma chorioreinits have been seen in canaries in Australasia (18). Also *toxoplasma* has been isolated from various species of wild birds from central England such as 2.4% of pheasants (*Phasianus colchicus*) and 0.7% in green finches (*Carduelis chloris*) (19). Infections and antibody titers have been documented in free-rang wild turkeys *Meleagris gallopavo* with improved isolation procedures and serological test (20). On the other hands, the rate of toxoplasmosis in turkeys as one of the intermediate host of *Toxoplasma gondii* is a good indicators of environmental contamination because of eating habits from the ground. From all above, this study was aimed to detect and estimate the antibodies titers of *Toxoplasma gondii* prevalence among turkeys (*Meleagris gallopavo*) by latex agglutination test in Ninevah governorate and we will be tried to elucidate the role of turkey in the maintenance of infection in the environment. Therefore this study was designated to deal with parasitic prevalence of *Meleagris gallopavo* in Ninevah governorate, which represent the first trial to explore toxoplasmosis in turkey, as in Iraq there is no survey of toxoplasmosis.

Materials and methods

One hundred-seven of blood samples of turkeys *Meleagris gallopavo* were collected from different regions of Ninevah governorate which include (Karakosh, Bartila, Kokjali, Al-Khather, Al-Manara, Ali Rash, Kabarly, Khazna, Bazkertan and Kharab Sultan) during January 2008 till December 2008.

Five to ten ml of blood samples were collected from each sampled of turkey bird in clean and sterilized test tubes and brought to the research laboratory in the college of veterinary medicine, University of Mosul. Blood samples were placed in refrigerator to the following day. Serum was isolated by centrifugation of blood samples at 3000 rpm for 5-10 minutes, and stored at -20°C till using for antibodies detection (7). Latex agglutination test were used toxolatex-kit from Bio kit – SA (BARCELON-SPAIN), that used for detection of *Toxoplasma gondii* antibodies invitro. A qualitative test for all the samples while quantitative test for the positive samples.

Histological examination of the liver and brain just only for the detection the presence of tissue cyst from the turkey birds that gave the positive results, the first step was performed by fixing the organ (Liver, brain) in 10% neutral buffered formalin, sectioned at 4µm and stained with Haematoxylin and Eosin stain (21). Tissue sections were then examined microscopically under oil lens.

Chi – square test (X^2) was used to compare the frequencies of positive and negative specimens to test within the different regions (22).

Results

From Table (1), it is evident that 82 positive samples out of 107 76.63%. The positive samples were covered the studied turkey birds in ten locations. In Karakosh eighteen blood samples were positive out of 22 blood samples 81.81%. In Bartila 11 positive samples were positive out of 14 78.57%. In Kokjali 7 positive samples out of 11 63.63%. Six out of seven blood samples were tested from Al-Khather 85.7% which is highest percentage. From Al-Manara 5 out of 6 83.33%, while in Ali Rash 5 samples out of 7 71.42%. Three out of 5 60.0% from Kabarly, which is the lowest percentage of the positive sample than other regions. From Khazna 12 out of 16 75.50%, while in Bazkertan 7 out of 9 77.77%, and 8 out of 10 80.0%, from Kharab Sultan. After statistical analysis, no significant difference between the different regions. The distribution of *Toxoplasma gondii* antibodies of the positive samples for turkey in different locations were elucidated in Table (2). It is evident that in Karakosh there were no positive samples at a titer 1/20, but at a titer 1/40 there were 2 samples 11.11%, and 5 samples at a titer 1/80 27.27%. Ten positive samples 55.5% were detected at a titer 1/160, while only one samples was positive 5.55% at a titer of 1/320. In Bartila the positive samples at a titer 1/20 and 1/320 was

one sample 9.09%, two positive samples were reported at a titer 1/40, 1/160 18.18%. At a titer 1/160 there were 5 samples 45.45%. In Kokjali, 1 positive at a titer 1/40, 1/320 with percentages 14.28%, while at a titer 1/80 there were 2 positive samples 28.57%, in a titer 1/160 there were three positive samples 42.85%. In Al-Khather, 2 positive samples were detected at a titer 1/80 33.33%, and 4 positive samples at a titer 1/160 66.66%, which is the high percentage from all the locations at this titer. From Al-Manara, one positive sample was detected at a titer 1/40, 1/80 with percentage 20% and three positive samples were detected at a titer 1/160 60.0%. In Ali Rash, there was one positive sample at a titer 1/20, 1/40, 1/320 with percentage 20%. Only 2 positive samples at a titer 1/80 40.0%. In Kabarly, there was one positive sample only at a titer 1/40, 1/80, 1/160 33.33%. From Khazna, there was one positive sample at a titer 1/40, 1/320 8.33%. Two positive samples were detected at a titer 1/20 16.6%, three positive samples at a titer 1/80 25.0% while five positive samples were detected at a titer 1/160 41.66%. In Bazkertan, one positive samples at a titer 1/40 14.28%, two positive samples were detected 28.57% at a titer 1/80, four positive samples at a titer 1/160 57.14%. The last studied location, Kharab Sultan, there was one positive sample at a titer 1/20, 1/320 12.5% and two positive samples at a titer 1/80 25% were determined. At a titer 1/160 four positive samples were detected 50.0% the results revealed high percentage of antibody titers against *Toxoplasma gondii* in turkey which was reached 76.63%.

Figure (1) show the higher percentage of titer of antibody *Toxoplasma gondii* at 1/160 was 49.19%, while the lower percentage of antibody was 4.975% at a titer 1/320. Figures (2, 3) show the presence of tissue cyst of *Toxoplasma gondii* in brain and liver from the birds that were given the positive result for latex agglutination test. Table (1) Locations, number of blood samples, number of positive samples of *Toxoplasma gondii* and their

percentages in turkey in different locations in Ninevah governorate.

Location	No. of examined samples	No. of positive samples	% of infection
Karakosh	22	18	81.81
Bartila	14	11	78.57
Kokjali	11	7	63.63
Al-Khather	7	6	85.71
Al-Manara	6	5	83.33
Alirash	7	5	71.42
Kabarly	5	3	60.00
Khazna	16	12	75.50
Bazkertan	9	7	77.77
Kharab sultan	10	8	80.00
Total	107	82	76.63

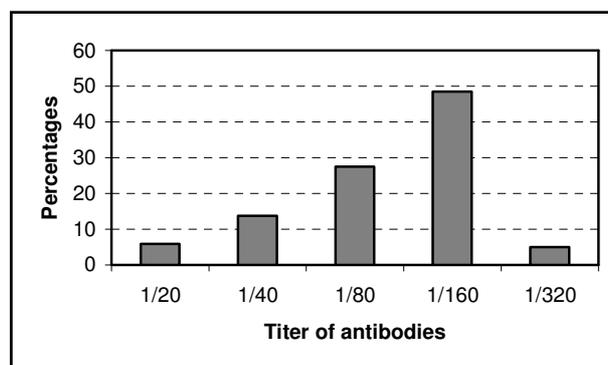


Figure (1) Percentages of *Toxoplasma gondii* antibody titer of turkey, *Meleagris gallopavo* in Ninevah governorate.

Table (2) *Toxoplasma gondii* antibody titers and their percentages in turkey, *Meleagris gallopavo*, in different locations in Ninevah governorate.

Locations	Positive Samples	Antibody titer									
		1/20		1/40		1/80		1/160		1/320	
		No.	%	No.	%	No.	%	No.	%	No.	%
Karakosh	18	-	-	2	11.11	5	27.78	10	55.5	1	5.56
Bartila	11	1	9.09	2	18.18	2	18.18	5	45.45	1	9.09
Kokjali	7	-	-	1	14.28	2	28.57	3	42.85	1	14.28
Al-Khather	6	-	-	-	-	2	33.33	4	66.66	-	-
Al-Manara	5	-	-	1	20.0	1	20.0	3	60.0	-	-
Alirash	5	1	20.0	1	20.0	2	40.0	1	20.0	-	-
Kabarly	3	-	-	1	33.33	1	33.33	1	33.33	-	-
Khazna	12	2	16.6	1	8.33	3	25	5	41.66	1	8.33
Bazkertan	7	-	-	1	14.28	2	28.57	4	57.14	-	-
Kharab sultan	8	1	12.5	-	-	2	25.0	4	50.0	1	12.5

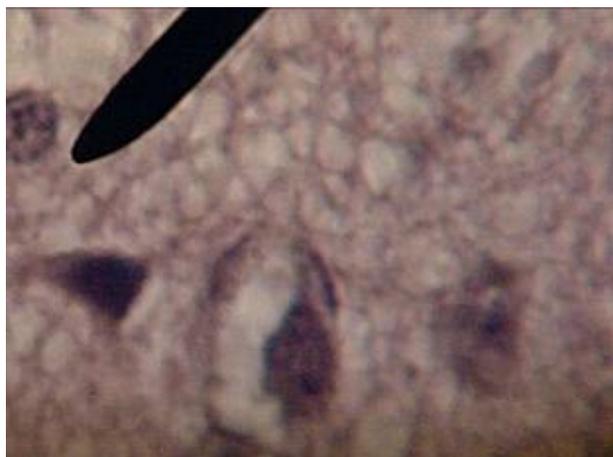


Figure (2) Tissue cyst of *Toxoplasma gondii* in brain of infected turkey, *Meleagris gallopavo*, in Ninevah governorate stained by Haematoxylin and Eosin. 100X (oil lens).

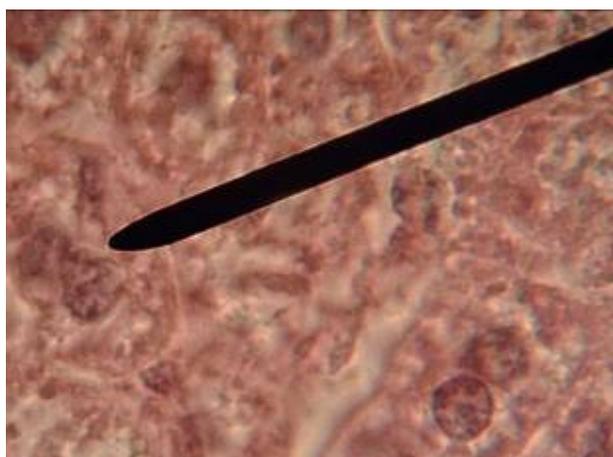


Figure (3) Tissue cyst of *Toxoplasma gondii* in liver of infected turkey, *Meleagris gallopavo*, in Ninevah governorate stained by Haematoxylin and Eosin. 100X (oil lens).

Discussion

Toxoplasma gondii detected by serological test such as reported from different animal species in Ninevah governorate, among those are aborted ewes in Ninevah province by (23) who reported 11.44% while in sheep 29.1% that reported by (24). The prevalence of *Toxoplasma gondii* in chickens 81.81% were documented by (7) in Ninevah governorate. In Baghdad area, by Rasheed (25), 80% found as detected antibodies by serological test in goats.

Anyhow, although there was a valid researches carried on turkey *Meleagris gallopavo* in Mosul area by (6), but has no report on *Toxoplasma gondii* as such this is the first record of this parasite in our local breed of turkey. It is noteworthy that *Toxoplasma gondii* has been reported from wild turkey. The results in this study revealed high percentage of antibody titer against *Toxoplasma gondii* in turkey which was reached 76.63%, this was higher than those reported in Egypt in turkey 47.2% and 50% in chickens and ducks respectively by (26).

In Maryland also the results of this study were higher than reported in our locality which reach to 14% (27). In Georgia, Louisiana and North Carolina the prevalence of *Toxoplasma gondii* in wild turkey was 40% (28), while in other types of poultry especially in chickens (Broiler chickens) in Ninevah governorate was higher 81.81%, this results were higher than that revealed by Mahmood (7), but in free-ranging chickens (*Gallus domesticus*) in Shiraz city Iran was reached to 36.1% (29). In southern Iran the prevalence of toxoplasmosis in chickens was as low as to 10.04% (30). In India percentage varies from 33%, 36.3%, 39.5% in chickens (*Gallus gallus*) (31). Toxoplasmosis prevalence in middle east countries was reached 40.4% in free range chicken (32). In Japan the percentage of the infection in the water fowl was 22.17% (33). In the other types of birds have been reported toxoplasmosis by (34), in which to the incidence of *Toxoplasma gondii* was 18% in Rooks (*Orvus fungilegus*). In American crow, *Toxoplasma gondii*, prevalence was 18% in creek republic (35). In Brazil (36) united state (37) 10.3%, 17.1% rates were reported respectively in chicken. In south America the prevalence of *Toxoplasma gondii* in free – ranging chicken was 55.39%, while in Venezuela was 32% (38). In Colombia also in chickens was 55.39% (39). Also *Toxoplasma gondii* in Brazil have been reported a high percentage in chickens 84.92% (40).

The percentage of antibody against *Toxoplasma gondii* in turkey at a titer 1/160 was 66.66%, this lower than that reported by (30) in chickens, while it is close to the result reported by (29) which 63.90%. In free-ranging chicken, it is lower than that reported by (20) who reported 45.45% that was at a titer 1/160 in Broiler chickens. Furthermore, investigation especially determining cats population and local social habits in both villages (Al-Manara, Kabrli), is required also the presence of oocysts in soil because most of the birds were feed from the ground is result of high infection on these regions.

There are many factors such as management and hygienic standards in breeding and environmental condition are effect on the acquisition of *Toxoplasma gondii* oocysts by animal, also humidity and temperate temperature favor of oocysts survival. Although no registration of the disease was made by veterinarians here in Ninevah province, this may be attributed to the silent clinical signs of the disease

and to the sporadic occurrence of the toxoplasmosis in poultry farms (9). Anyhow the presence of circulating antibodies to *Toxoplasma gondii* in several population of turkeys is evidence as such wild turkeys often are susceptible on infection; however, the diagnostic case accession on data is evidence that turkeys rarely develop systemic clinical toxoplasmosis possibly because of innate resistance (28). The mode of transmission of toxoplasmosis to birds are carnivorous and fecal contamination, tachyzoites and bradyzoites may be spread by carnivorous ingestion and sporulated oocyst are spread by cat feces. The serologic tests for *Toxoplasma gondii* are not adequate for detecting the presence of the carrier state in most turkey, the latex agglutination test may give an answer for detecting carrier state that is considered as difficult diagnosing zoonotic disease of human health concern.

Finally, the important method for destroyed tissue cysts of *Toxoplasma gondii* is by heat treatment of infected meat up to 66°C and through washing the hands after meat treatment to prevent transmission of parasite to the consumer and excluded the cats that have an important role as a definitive host for this parasite, in order to protect the farm animals.

References

1. Smith J E, and Reduck, N R.. *Toxoplasma gondii* strain variation and pathogenicity. In: Cary, J. W., Linz, Bhatnagar, B. CEDs, Microbial food borne diseases: Mechanisms of pathogenesis and toxin synthesis. Technomic publishing, Lancaster, PA, 2000; pp. 405-431.
2. Dubey JP and Beattie C P Taxoplasmosis of animal and man. CRC Press, Boca Raton, FL, 1988; pp: 1-220.
3. Calnek B W, Barnes H J B, Eard C W, Medoughlad L P, Saif Y M. Diseases of poultry 10th ed Editioal board for Amme Association Avian Pathologist. 1977, pp. 907-911.
4. Jenson R, Swift B I. Disease of Sheep. 2th ed London. Bailliere Tindall. 1982, pp. 52-54.
5. Kaufmann, J. Parasit of poultry. In: Parasitic infections of domestic animals (A Diagnostic Manual). Birkhauser Verlag. Basel, 1996, pp. 367.
6. Al-Alousi TI, Daoud M S, Al-Bayati M M. A study of endoparasites of turkeys in Mosul-IRAQ. Iraqi J Vet Med. 1993;7:123-129.
7. Mahmood, A F, Nashwan AA, Waked H M, Bashar M J, Yaser Y H. Detection of *Toxoplasma gondii* antibodies in Broiler chickens in Ninevah governorate. Journal of Dohuk University 2006; 9:145-148.
8. Guist CF, Dubey J P, Luttrell M P, Davidson W R. Taxoplasmosis in wild turkeys a case report and serological survey. J. Wild Dis. Apr; 1995; 31(2): 255-8.
9. Siim, J.C., Bierin, U., Sorenson and Moller, T. Toxoplasmosis in domestic animals. Adv Vet Sci. 1963; 8: 329-335.
10. Burrige, M J, Birgler D J, Henneman, J M. Serologic Survey for *Toxoplasma gondii* in wild animals in Florida. J Amer Med Assoc. 1979; 175: 964-967.
11. Ruiz A, Frenkel J K. Intermediat and transport hosts of *Toxoplasma gondii* in Costa Rica. Am J Trop Med Hyg. 1980;29:1161-1166.
12. Miller, NL, Frenkel J K, Dubey JP. Oral infections with *Toxoplasma* cysts and oocysts in felines, other mammals and in birds. J Parasitol 1972;58:928-937.
13. Tontler, A.M., Heckerroth, A. R. and Weiss L. M. *Toxoplasma gondii* from animal to human. Int J Parasita. 2000; 30: 1217-58.
14. Borg K. Toxoplasmosis in wild life in Sweden transactions of the 26th Nord American wild life and nature resources conference, Washington D C. 1961; 219-229.
15. Howerth, E W, Rodenrth N. Fatal systematic toxoplasmosis in a wild turkey. J Wild life Disease. 1985;21:446-449.
16. Berger JC Zur Epidemiologie der Toxoplasrose. I. Die toxoplasrose der ver wilderten stadtauben. Ziet Schrift fur medizinische mikrobiologie. Und Immunologie 1966; 153: 68-82.
17. Parent E. Sola SC, Turilli C. Spontaneous toxoplasmosis in canaries (*Serinus canaria*) and other small passerine cage birds. Avian Pathol. 1986; 15: 193-197.
18. Hartley W J, Dubey J P. Fatal toxoplsmosis in some native Australian birds. J Vet Diagn Invest. 1991 3:167-169.
19. Peach W, Fowler J, Hay J. Incidence of *Toxoplasma* infection in a population of European starlings *Sturnus vulgaris* from central England. Annals of Tropical Med Parasitol. 1989;83,173-177.
20. Lindsay D S, Smith P C, Bलगurn B L. Prevalence and isolation of *Toxoplasma gondii* from wild turkey in Alabam. J Helmintholo Society Washington 1994;61:115-117.
21. Drury RAB, Wallington E A. Carleton's histological technique. 5th ed. Oxford University Press, Oxford. 1980.
22. Braning L J, Kintz B .L. Computational hand book statistics, 2nd ed, Scot Foresman and company, England, 1977, pp. 233-237.
23. Al-Tae A F M. Survey on presence to *Toxoplasma gondii* antibodies in the borted ewes in Ninevah province. J Vet Sci. 2002; 16:9-16.
24. Al-Tae A F, Gorgees R G. Prevalence study of *Toxoplasma gondii* in sheep in Ninevah province. J Iraq Vet Sci. 2004;18:68-61.
25. Rasheed R N. Isolation of *Toxoplasma gondii* and serological diagnosis of toxoplasmosis in sheep in goats in Baghdad province. MSc thesis, College of Veterinary medicine University of Baghdad, Iraq. 1984.
26. El-Massry A, Mahdy O A, El-Ghaysh A, Dubey J P. Prevalence of *Toxoplasma gondii* antibodies in sera of turkeys chickens and ducks from Egypt. Journal of parasitology 2000; 86:627-628.
27. Dubey JP, Camrgo M E, Ruff M D, Wilkins G C, Shen S K, Kwok O CH, Thulliez. Experimental toxoplasmosis in turkeys. J Parasitology 1993;79: 949-952.
28. Chariotte F. Guist Dubey J P, Pageluttrell M, Davidson W R. Toxoplasmosis in wild turkeys, A case report and serological survey. Journal of wild life disease. 1995;31: 255-258.
29. Asgari Q, Farzaneh A., Kalantari, M. Mohajeri, F.A., Moazeni M., Zarif M., Esmailzadeh B, Motazedian M H. Seroprevalence of free-ranging chicken toxoplasmosis in sub-Urban Regions of Shiraz, Iran. Inter J Poultry Sci. 2006;5(3):262-264.
30. Asgari G, Mohajeri F A, Kalatari M, Esmailzadeh B, Moazeni M, Ghalebi SR, Saremi F, Kalyani M Z, Motazedian M H. Chicken toxoplasmosis indifferent types of breeding: A Seroprevalence Survey in Southern Iran. International J Poultry Sci. 2008;7(12):1247-1250.
31. Devadak A R., Dubey J.P. Serologic prevalence of *Toxoplasma gondii* in chicken in Madras, India. J. Parasitol. 1998; 84(3): 621-622.
32. Dubey J P, Graham D H, Dahl DH, Hilali M, El-Ghaysh A, Sreekumar O C H, Shen S K, Lehmann S K. Isolation and molecular characterization of *Toxoplasma gondii* from chickens and ducks from Egypt Vet Parasitol. 2003;114:89-95.
33. Takehiro Murao, Omata Yoshitaka, Kano Rika, Muratashiro Okada Tsukasa Okada, Konnai Satoru, Asakawa Mitsuhiro, Kazuhiko Ohashi, and Misao Onuma Serological survey of *Toxoplasma gondii* in wild water fowl in chukotka kamehatka, Russia and Hokkaido, Japan. J parasitol 2008;94(4): 830-833.
34. Literak H, Nezral J, Folk C. Incidence of *Toxoplasma gondii* in populations of wild birds in Czech Republic. Arian Pathology 1992; 21:659-665.
35. Thierry M. Work, Massey J.G., Rideont B.A., Gardiner C.H., Ledig D.B., Kwok, O.C.H. and Dubey J.P. Fatal toxoplasmosis in free-ranging endangered ALALA from Hawaii. J Wild Life Dis. 2000; 36(2): 205-212.

36. Garcia, J.L., Navarro I.T., Ogawal L. and Maranat R.M. Seroprevalencia do *Toxoplasma gondii* em galinhas *Gallus gallus domesticus* decriacoes domesticas, oriundas de propriedades rurais do norte do parana, Brazil, Cienc Rural (Santa Maria) 2000; 30:123-7.
37. Dubey J.P., Ventarini M.C., Ventarini L., Piscopo M., Graham D.H., Dahl, E. Screckumar C., Vianna MC and T. Lehmann. Isolation and genotyping of *Toxoplasma gondii* from free-ranging chickens from Argentina. J. Parasitol., 2003; 89:1063-1064.
38. Dubey T.P., Patitua A.N., Suc, Sundar N., Kwok O.C. Shensk. Characterization of *Toxoplasma gondii* isolates in free range chicken from Chile, South America. J. Vet. Parasitol 2006; 140 (1-2): 76-82.
39. Dubey J.P., Lenhart A., Castillo CE, Alvarez L., Marcet p., Sreekumar C., Lehmann. *Toxoplasma gondii* infections in chickens from Venezuela isolation, tissue distribution and molecular characterization. J. parasitol. 2005; 91(6): 1332-4.
40. Leite A.S., Alres LC., Faustion M.A.G. Serological survey of toxoplasmosis in birds from Cracidae family in a wild bird center facility at Pernambuco state, North East of Brazil. Medicina Veterina, Recife. 2007; Vol. 1, No.1 pp55-57.