Journal of Applied & Environmental Microbiology, 2014, Vol. 2, No. 4, 198-202
Available online at http://pubs.sciepub.com/jaem/2/4/14

DOI:10.12691/jaem-2-4-14

Dual infections of Enteric *Salmonella* species with *Schistosoma mansoni* among Patients from Two Hospitals in Jos, Nigeria

A. A. Modebe[1], A. U. Nnachi[2,*], C. O. Ukaegbu[1], N. Tata[3], M. V. Agah[4], O. E. Udu-Ibiam[4], I. A. Nnachi[5]

[1]Department of Microbiology, Faculty of Natural Sciences, University of Jos, Jos, Nigeria
[2]Department of Medical Microbiology and Parasitology, Nnamdi Azikiwe University, Awka, Nigeria
[3]Department of Science Laboratory Technology, Federal Polytechnic, Oko, Nigeria
[4]Department of Applied Microbiology, Ebonyi State University, Abakaliki, Nigeria
[5]Department of Applied Biology, Ebonyi State University, Abakaliki, Nigeria
*Corresponding author: nnachiau@gmail.com

Received June 07, 2014; Revised June 20, 2014; Accepted June 25, 2014

Abstract Schistosomiasis and typhoid fever caused by blood flukes and *Salmonella* bacteria respectively are leading infectious diseases in most tropical parts of the world especially in sub-Saharan Africa. In countries where both are endemic, co-infection is a consistent reality. This study therefore investigated the incidence of dual *Schistosoma mansoni* and enteric *Salmonella* species infections in patients from Eldin Specialist and Plateau Specialist Hospitals, Jos, Plateau State, Nigeria. In this, a total of 250 each of blood and stool samples were collected from 250 patients who showed positive for widal tests and were receiving health care from the two hospitals. The samples were analyzed using standard methods which included culture, concentration and agglutination (Widal) techniques. Out of the 250 widal-positive patients used, only 34 (13.6%) were positive for typhoid fever by stool culture. The prevalence rates of the dual infections were observed to be 22 (8.8%) and 6 (2.4%) by Widal and stool culture techniques respectively. Co-infection was highest among females (28.6%) within the age bracket 40 - 49 years, followed by males (14.3%) within the age brackets 0 - 9 and 20 - 29 years. There was a stronger relationship between the two organisms by widal test ($r = 0.858$, $P<0.05$) than by stool culture ($r = 0.653$, $P>0.05$). Although culture technique is reputed as a gold standard in the diagnosis of typhoid fever, widal test is suggested in the case of co-infection with *Schistosoma* parasite provided judicious interpretations of results are made against backgrounds of pertinent information. Since both diseases share social circumstances such as poverty and hygiene, governments' involvements in the improvement of the standard of living of individuals in areas of high endemicity is hereby recommended. Also, cases of the diseases should be detected and promptly treated to avoid further transmissions. Indiscriminate droppings of faeces should be discouraged as rain can wash them into water bodies for onward transmissions. When the organisms are detected from positive samples, treatment should be concurrent with both anti-schistosomal and anti-Salmonellal drugs.

Keywords: *schistosomiasis, Schistosoma mansoni, Salmonella spp., typhoid fever, co-infection, Jos, Nigeria*

Cite This Article: A. A. Modebe, A. U. Nnachi, C. O. Ukaegbu, N. Tata, M. V. Agah, O. E. Udu-Ibiam, and I. A. Nnachi, "Dual infections of Enteric Salmonella species with Schistosoma mansoni among Patients from Two Hospitals in Jos, Nigeria." *Journal of Applied & Environmental Microbiology*, vol. 2, no. 4 (2014): 198-202. doi: 10.12691/jaem-2-4-14.

1. Introduction

Infectious diseases have remained a sustainable burden to human existence, health and longevity [1,2]. Despite the attempts to control them, the incidence of emerging, re-emerging and now neglected infectious diseases has continued to raise a global concern [3]. In sub-Saharan Africa (Nigeria inclusive), the situation is not less; the morbidity and mortality rates are well-documented worldwide. Among these infections are schistosomiasis and typhoid fever [4,5]. Schistosomiasis, classified as a Neglected Tropical Disease (NTD), is a parasitic disease of poverty caused by blood flukes or trematodes of the genus, *Schistosoma*. Schistosomes are parasitic helminthes that infect humans via invasion of the skin while in contaminated water [6]. The disease is spread by contact with water contaminated with the parasites and harboring infected freshwater snails, known as the intermediate hosts [6,7]. *Schistosoma* species that infect humans include: *Schistosoma mansoni, Schistosoma japonicum, Schistosoma intercalatum, Schistosoma haematobium* and *Schistosoma mekongi*. They show specificity in their choice of snail hosts and the prevalence of each depends on the availability of the appropriate snail host in the area [8,9]. They may infect the urinary tract or intestines;

however, genital schistosomiasis has been reported [10,11]. The infection presents with abdominal pain, diarrhea, bloody stool or urine. In chronic cases there could be liver damage, renal failure and infertility [7]. Schistosomiasis infect almost 210 million people worldwide [12] with estimated death rate of 12, 000 [13] to 300, 000 people per annum [4,14]. The disease is commonly found in Africa, Asia and South America [7]. In about 74 developing tropical countries, around 700 million people live in areas of high endemicity of this disease and about 20 million suffer from severe consequences from the disease [14,15,16]. In 2010, 238 million people were infected and 85% of these live in Africa. Schistosomiasis is second only to malaria, as a parasitic disease with the greatest economic impact [17], yet among the most neglected. The risk groups include children (playing in contaminated water), farmers, fishermen, and people using infected water for daily chores [18].

On the other hand, typhoid fever is a common worldwide bacterial disease transmitted by the ingestion of food and/or water contaminated with the faeces of an infected person, which contain the bacterium, *Salmonella enteric* serovar *typhi* [5]. It is a systemic infectious disease [6] characterized by an acute illness, the first typical manifestations of which are fever, headache, abdominal pain, relative bradycardia, splenomegaly, and leucopenia [19]. An estimated 16 to 33 million cases of typhoid fever occur annually and the incidence is highest in children and young adults between 5 and 19 years old [20]. Approximately 2 million individuals die each year from diarrheal diseases and *Salmonella* is the leading cause of this malady. Humans are the only reservoir and host for the typhoid fever bacteria [6].

Both schistosomiasis and typhoid fever are water-borne and share some symptomatology and social circumstances such as poverty imperative in their transmission. Therefore, in areas (like Nigeria) where both diseases are common, co-infection is an inevitable possibility as both can be contracted together. A relationship between persistent or recurrent *Salmonella* infections and schistosomiasis has been described in both adults and children [21-26]. The mechanism of *Salmonella-Schistosoma* relationship has been explained by the fact that the *Salmonella* bacterial pili adhere to a mannose receptor-like surface glycoprotein on the tegument of *Schistosoma mansoni* [26]. This successful adherence makes it possible for the adult worm to provide a site for intravascular persistence [21]. The consequence of this relationship is that *Salmonella* bacteria would evade the toxic effects of antibiotics mobilized against them by hiding within the parasite, making them reservoirs for persistent infection after therapy [27]. Also, when anti-schistosomiasis drugs are administered, the death of the parasite would liberate the bacterium into the bloodstream [6,22]. Further, since most of the *Salmonella* bacteria in the teguments of the *Schistosoma* parasites are continuously exposed to sub-therapeutic concentrations of antibiotics in the course of treatment of typhoid fever infections, the development of antibiotic resistance is constantly reported [6]. The co-infection can also hide *Salmonella* from the hosts' defense mechanisms [28]. Based on syndromes, the dual infections are often misdiagnosed and considered to be something else as the presentations are more of Kala-azar than typhoid fever or schistosomiasis [29].

The present study investigated the association of *Schistosoma mansoni* infection with *Salmonella* infections among patients attending Eldin Specialist and Plateau Specialist Hospitals, both in Jos, Plateau State, Nigeria.

2. Materials and Methods

2.1. The Study Area

The study was conducted in two hospitals in Jos North. Jos North is the capital city of Plateau state in Nigeria. Jos is located in an area covering about 9400km of the crystalline complex in North Central Nigeria. Its average elevation is about 1250m above mean sea level and has an average annual rainfall of about 1,400mm. There is always large influx of people including foreigners to the city due to the economic viability. The hospitals used were Plateau State Specialist Hospital and Eldin Specialist Hospital. Plateau State Specialist Hospital (PSSH), Jos (formally known as Plateau Hospital) is located at Old Bukuru road Jos, plateau state. The hospital stands on its own, serving as a referral centre for other general and cottage hospitals within the state and hence, opens to the inhabitants of Plateau State. Eldin Specialist Hospital on the other hand, is situated in Dodon Dutse Street, Jos. It is accessible to people living around the area and caters majorly for women.

2.2. Study Population

A total of 250 patients who showed positive for widal agglutination test were recruited for the study. It included individuals of all ages and sexes.

2.3. Sample Collection

Samples used in this study were blood and stool samples. A total of 500 samples were collected including 250 blood and 250 stool samples. About 5 ml of blood samples were aseptically collected by venepuncture [30] from each patient into plain tubes. Stool samples were collected into clean wide-mouthed containers. Also structured questionnaires were shared and sociodemorgraphic information of each patient obtained after informed consent was obtained from him or her.

2.4. Laboratory Analysis

2.4.1. Parasitological Examination of Stool Samples

Each stool sample was observed for the presence of *Schistosoma mansoni* eggs or ova using formol ether concentration technique described by Cheesbrough [31] noting the availability of lateral spines.

2.4.2. Widal Agglutination Test for *Salmonella* Antibodies

Widal agglutination test was performed on each blood sample using the Widal agglutination kit (Biotech lab, United States) containing somatic (O) and flagella (H) antigens of *Salmonella typhi* and *Salmonella paratyphi* A-C. A negative saline control was introduced in each batch of test. The procedure used was as described by Ochei and

Kolhatkar [32]. Drops of sera from each patient were made on a clean tile, mixed with the antigens rocked for 3 minutes and observed for agglutination. A positive Widal test was considered as one that gave a reaction titre of 1/80 or greater in a single test.

2.4.3. Bacteriological Examination of Stool Samples

A small portion of each stool sample was inoculated on previously dried surface of *Salmonella-Shigella* agar using sterile wire loop. The plates were incubated aerobically at 37°C for 24 hours after which they were observed for growth. Isolates were identified as *Salmonella* spp. using standard microbiological techniques described by Cheesbrough [30].

3. Results

Out of the 250 widal positive samples, 34(13.6%) were *Salmonella* positive by stool culture in 12(4.8%) and 22(8.8%) males and females respectively (Table 1). Out of the 250 patients who showed positive for widal test, 18(7.2%) and 4(1.6%) had co-infection with *Schistosoma mansoni* at Eldin Specialist and Plateau Specialist Hospitals respectively. The overall co-infection of *Salmonella* spp. and *Schistosoma mansoni* observed in this study was 22(8.8%) by widal test as shown in Table 2. Co-infection among male patients was highest (14.3%) within the age groups of 0 – 9 and 20 – 29, while for female patients it was highest (28.6%) among patients 40 – 49 years old. The age group with the highest prevalence rate of co-infection was 40 – 49 by widal test, while age groups 50 years and above showed no *Salmonella-Schistosoma* co-infections (Table 2).

A total of six (6) co-infections between *Salmonella* spp. and *Schistosoma mansoni* were observed by stool culture out of which one (1) was from Plateau Specialist Hospital, while five (5) were from Eldin Specialist Hospital. Of the six (6) incidence of co-infection, 2(16.7%) were male while 4(18.2%) were females. Similarly, 10(29.4%) and 18(52.9%) males and females respectively were negative from the overall total (Table 3). The age groups 10 – 19 years had the highest rate of co-infection of 33.3% by stool culture followed by the age group 30 – 39 years with the co-infection rate of 16.7%. The females had the highest prevalence rate of co-infection of 18.2% than 16.7% observed in males. Correlation analysis showed a stronger relationship between *Salmonella* spp. and *Schistosoma mansoni* by widal test ($r = 0.858$, $P<0.05$) than stool culture ($r = 0.653$, $P>0.05$). Details of the results are shown in the tables below.

Table 1. Age and Sex Distribution of *Salmonella* among Widal-positive Patients from two Hospitals in Jos by Stool Culture

Age	Male		Female		Total Examined	Total (%) Positive
	No. Examined	No. (%) Infected	No. Examined	No. (%) Infected		
0 – 9	7	-	6	2 (33.3)	13	2 (15.4)
10 – 19	31	3 (9.7)	48	6 (12.5)	79	9 (11.4)
20 – 29	35	7 (2.0)	52	6 (11.5)	87	13 (14.9)
30 – 39	16	1 (6.3)	20	5 (25.0)	36	6 (16.7)
40 – 49	9	-	14	3 (21.4)	23	3 (13.0)
50 – 59	2	1 (50.0)	7	-	9	1 (11.1)
≥60	-	-	3	-	3	-
Total	**100**	**12 (1.2)**	**150**	**22 (14.7)**	**250**	**34 (13.6)**

Table 2. Age and Sex Distribution of *Salmonella-Schistosoma mansoni* Co-infection among Patients from two Hospitals in Jos by Widal Test

Age	Male		Female		Total Examined	Total (%) Positive
	No. Examined	No. (%) Co-infected	No. Examined	No. (%) Co-infected		
0 – 9	7	1 (14.3)	6	-	13	1 (7.7)
10 – 19	31	2 (6.5)	48	3 (6.3)	79	5 (6.3)
20 – 29	35	5 (14.3)	52	2 (3.8)	87	7 (8.1)
30 – 39	16	1 (6.3)	20	3 (15.0)	36	4 (11.1)
40 – 49	9	1 (11.1)	14	4 (28.6)	23	5 (21.7)
50 – 59	2	-	7	-	9	-
≥60	-	-	3	-	3	-
Total	**100**	**10 (10.0)**	**150**	**12 (8.0)**	**250**	**22 (8.8)**

Table 3. Age and Sex Distribution of *Salmonella-Schistosoma mansoni* Co-infection among Patients from two Hospitals in Jos by Stool Culture

Age	Male		Female		Total Examined	Total (%) Positive
	No. Examined	No. (%) Co-infected	No. Examined	No. (%) Co-infected		
0 – 9	-	-	2	-	2	-
10 – 19	3	1 (33.3)	6	2 (33.3)	9	3 (33.3)
20 – 29	7	1 (14.3)	6	-	13	1 (7.7)
30 – 39	1	-	5	1 (20.0)	6	1 (16.7)
40 – 49	-	-	3	1 (33.3)	3	1 (33.3)
50 – 59	1	-	-	-	1	-
≥60	-	-	-	-	-	-
Total	**12**	**2 (16.7)**	**22**	**12 (54.6)**	**34**	**6 (17.6)**

4. Discussion

Typhoid fever, a worldwide bacterial disease and schistosomiasis, a parasitic disease are both endemic in Nigeria [33]. In such areas of high endemicity as Nigeria co-infection is an inevitable reality, as both share social and pathological circumstances that are imperative in their transmission and pathogenesis. They are both water-borne and when in the blood, *Salmonella* attach to the tegument of *Shistosoma mansoni* adult worm [23]. Schistosomes have been suggested as a source and vehicle of *Salmonella* infections [26]. The granulomatous reaction associated with schistosomiasis also can reduce antibody activity against *Salmonella* and this is crucial in the recovery from infection [34]. This study therefore, investigated the incidence of concurrent *Salmonella* and *Schistosoma* infections among widal-positive patients attending Eldin Specialist and Plateau State Specialist Hospitals, Jos, Plateau State, Nigeria.

The result revealed overall prevalence rates of *Salmonella-Schistosoma* infections of 8.8% and 2.4% by widal test and stool cultures techniques respectively. There was a relationship between *Salmonella* sp. and *Schistosoma mansoni* in this study as revealed by a correlation analysis. The observation and record of a relationship between *Salmonella* spp. and *Schistosoma mansoni* is in agreement with several other previous works though with varied rates of 6.4% in Jos and 5.4% in Kaduna [33] all by widal tests. Sample size and sampling season could have contributed to the slight variations in the results. Of the 250 patients tested who were positive for widal tests, only 34 (13.6%) had *Salmonella* presence by stool culture. This study is in agreement with the findings of Ukaegbu *et al.* [5] in Jos, Nigeria who observed 68(42%) for widal test against 9(5.6%) for stool culture and suggested that the use of widal test alone in the diagnosis of typhoid fever is unreliable, misleading and should be discouraged; and that culture technique still remains the gold standard in the diagnosis of typhoid fever and should be embraced. This is actually the first judgment that comes to mind when widal agglutination test and culture are to be compared.

However, in as much as the statement is true, it is different with *Salmonella* and *Schistosoma* co-infection. This is because a great possibility exists that *Salmonella* antigen may induce antibody production, but the organisms themselves may not be recovered from the stool since they may attach themselves to the tegument of *Schistosoma mansoni* adult worm when they are both present in the blood [23]. Therefore, widal test may be a better technique than culture in the diagnosis of typhoid fever co-infected with schistosmiasis provided judicious interpretations of the results are made against backgrounds of pertinent information [35].

5. Conclusion

The study showed a relationship between *Salmonella* and *Schistosoma mansoni* infections supporting the fact that co-infection with *Schistosoma* could complicate treatment of enteric fever caused by *Salmonella* bacteria. The worms provide a focus for multiplication of the bacteria, which are then released into the blood stream, causing septicemia. This explains why chemotherapy for salmonellal infection must be administered with antischistosomal treatment to be efficient. This association can result in early relapses of typhoid fever and probably cause septicemia [24,36].

Although culture is a gold standard in the diagnosis of typhoid fever, widal test is suggested in the case of co-infection with *Schistosoma* parasite provided judicious interpretations of results are made against backgrounds of pertinent information. Since both diseases share social circumstances such as poverty and hygiene, governments' involvements in the improvement of the standard of living of individuals in areas of high endemicity is hereby recommended. Also, cases of the disease should be detected and promptly treated to avoid further transmissions. Indiscriminate droppings of faeces should be discouraged as rain can wash them into water bodies for onward transmission. The populace should be educated on the importance of personal hygiene and discouraged from dumping faecal materials into water bodies. The intermediate snail hosts of *Schistosoma* parasites should be eradicated. Appropriate drugs should be made available by the government at reduced and affordable costs.

References

[1] Udu-Ibiam, O. E., Ogbu, O., Nworie, O., Ibiam, U.A., Agah, M. V., Nnachi, A. U. and Ogbu, K. I. "Antimicrobial Activities of Some Selected Edible Mushrooms and Spices against Clinical Isolates from Federal University Teaching Hospital Abakaliki (FETHA), Ebonyi State, Nigeria", *International Journal of Scientific and Technology Research, **3**(5).* 251-255. 2014.

[2] Cohen, M. L. "Epidemiology of drug resistance implications for a post antimicrobial era ‖ ", *Comment in Sciences, 257(1050).* 1050-1055. 1992.

[3] Prescott, L. M., Harley, J. P. and Klein, D. A., "*Microbiology*", Sixth edition, McGraw Hill Publishers, New York, USA, 2005; 832-836.

[4] Hotez, P. J. and Fenwick, A., "Schistosomiasis in Africa: An Emerging Tragedy in our New Global Health Decade", *PLoS Neglected Tropical Diseases, 3(9)*. e485. 2009.

[5] Ukaegbu, C.O., Nnachi, A.U., Mawak, J.D. and Igwe, C.C., "Incidence of concurrent malaria and typhoid fever infection in febrile patients in Jos, Plateau State Nigeria", *International Journal of Scientific and Technology Research, **3**(4).* 157-161. 2014.

[6] Barnhill, A. E., Novozhilova, E., Day, T. A. and Carlson, S. A., "Schistosoma-associated Salmonella resist antibiotics via specific fimbrial attachments to the flatworm", *Parasites and Vectors, 4*.123. 2011.

[7] World Health Organization, "Schistosomiasis Fact sheet N°115", Retrieved 15 March 2014 from http://www.who.int/mediacentre/factsheets/fs115/en/.

[8] Lawrence, P. and Robert, P., "Schistosomiasis". 2002. Available online at http://www.istm.org/publications/newshare1/200201/schistosomiasis.aspx.

[9] Greenwood, D., Slak, R. C. B. and Peuthere, J. F., "*Medical Microbiology*", Sixteenth edition, Church Hill Livingstone, London, 2002. 679.

[10] WHO, "Report of an informal working group meeting on urogenital schistosomiasis and HIV transmission", Information Resource Centre, World Health Organization, 1211 Geneva 27, Switzerland. 2010.

[11] Wikipedia, "Genital Schistosomiasis". 2013. Available online at http://en.wikipedia.org/wiki/Genital_schistosomiasis.

[12] Fenwick, A., "The global burden of neglected tropical diseases", *Public health, 126(3).* 233-6. 2012.

[13] Lozano, R., Naghavi, M., Foreman, K., Lim, S., Shibuya, K., Aboyans, V., Abraham, J. Adair, T. *et al.*, "Global and regional

mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010", *Lancet, 380(9859).* 2095-128. 2012.

[14] Thétiot-Laurent, S. A., Boissier, J., Robert, A. and Meunier, B., "Schistosomiasis Chemotherapy". *Angewandte Chemie (International ed. in English), 52(31).* 7936-56. 2013.

[15] Oliveira, G., Rodrigues N. B., Romanha, A. J., Bahia, D., "Genome and Genomics of Schistosomes". *Canadian Journal of Zoology, 82(2).* 375-90. 2004.

[16] Kheir, M. M., Eltoum, I. A., Saad, A. M., Ali, M. M., Baraka, O. Z., Homeida, M. M., "Mortality due to schistosomiasis mansoni: a field study in Sudan". *Am. J. Trop. Med. Hyg, 60(2).* 307-10. 1999.

[17] The Carter Center, "Schistosomiasis Control Program", Retrieved 2008-07-17 from http://www.cartercenter.org/health/schistosomiasis/index.html.

[18] Wikipedia, "Schistosomiasis", 2014. Available online at http://en.wikipedia.org/wiki/Schistosomiasis.

[19] Butter, T., "Typhoid fever In: J. B. Wyngaargen, L. H. Smith, J. C. Bennett, editors. ―Cecill Textbook of Medicine ‖ , XIX edition", Philadelphia, U.S.A: W.B. Saunders Co., 2002. 1690-1692.

[20] "Typhoid Fever". World Health Organization. Retrieved 2007-08-28.

[21] Gordon, M. A., Zijlstra, E. E., Naus, C. W. A., Visser, L. G. Molyneux, M. E. and van Lieshout, L., "Schistosomiasis Does Not Contribute to Death or Recurrence of Nontyphoid Salmonella Bacteremia in Human Immunodeficiency Virus–Infected Malawian Adults", *Clinical Infectious Diseases, 37.* e177-179. 2003.

[22] Gendrel, D., Kombila, M., Beaudoin-Leblevec, G. and Richard-Lenoble, D., "Nontyphoidal salmonellal septicemia in Gabonese children infected with *Schistosoma intercalatum"*, *Clin Infect Dis, 18*.103-105. 1994.

[23] Lambertucci, J. R., Rayes, A. A. M., Serufo, J. C., Gerspacher-Lara, R., Brasileiro-Filho, G., Teixeira, R., Antunes, C. M. F., Goes, A. M. and Coelho, P. M. Z., "Schistosomiasis and Associated Infections", *Mem Inst Oswaldo Cruz, Rio de Janeiro, 93(I).* 135-139. 1998.

[24] Gendrel, D., Richard-Lenoble, D., Kombila, M., Engohan, E., Nardou, M., Moussavou, A., Galliot, A. and Toure, R., "Schistosoma intercalatum and relapses of Salmonella infection in children. *Am J Trop Med Hyg, 33.* 1166-1169. 1984.

[25] Hathout, S., El-Ghaffar, Y. A. and Awny, A. Y., "Salmonellosis complicating schistosomiasis in Egypt", *Am J Trop Med Hyg, 16.* 462-72. 1967.

[26] LoVerde, P., Amento, C. and Higashi, G., "Parasite-parasite interaction of *Salmonella typhimurium* and *Schistosoma*. *Journal of Infectious Diseases, 141*. 177-185. 1980.

[27] Njunda, A. and Oyerinde, J., "*Salmonella typhi* infection in *Schistosoma mansoni* infected mice. *West African Journal of Medicine, 15*. 24-30. 1996.

[28] Young SW, Higashi G, Kamel R, et al. "Interaction of salmonellae and schistosomes in host-parasite relations", *Trans R Soc Trop Med Hyg, 67(6).*797-802. 1973.

[29] Lambertucci, J. R., Pereira, F. A. S., Marinho, R. P., Neves, J. and Ferreira, M. D., "Associação *Salmonella-S. mansoni*: análise de 104 casos", *Rev Soc Bras Med Trop, 24(I).* 76. 1991.

[30] Cheesbrough, M. "*District Laboratory Practice in Tropical Countries Part 2*, 2nd edition", Cambridge University Press, New York, 2004; 101-103, 297-298.

[31] Cheesbrough, M., "*District Laboratory Practice in Tropical Countries Part 1*, 2nd edition", Cambridge University Press, New York, 2006; 196-197.

[32] Ochei, J. O. and Kolhatkar, A. A., "*Medical Laboratory Science: Theory and Practice*", Tata McGraw-Hill, New Delhi, India, 2010; 692-693, 962.

[33] Igwe, N. N. and Agbo, E. A., "Incidence of co-infection of enteric *Salmonella* with *Schistosoma* in Kachia Local Government Area of Kaduna State, Nigeria", *Inter J Trop Med Pub Health, 3(1).* 12-17. 2014.

[34] Muniz-Junqueira, M., Tavares-Neto, J., Prata, A. and Tosta, C. E., "Antibody response to *Salmonella typhi* in human schistosomiasis mansoni", *Rev Soc Bras Med Trop, 29*: 441-445. 1996.

[35] Uneke, C. J., "Concurrent Malaria and Typhoid Fever in the Tropics: the Diagnostic Challenges and Public Health Implications", *Journal of Vector Borne Diseases, 45*. 133-142. 2008.

[36] Gendrel, D., Nardou, M., Richard-Lenoble, D., Kombila, M. and Moreno, J. L. "*Klebsiella pneumonia* septicemia and *Schistosoma* infestation", *Journal of Pediatrics, 8.* 250-251.1986.