

SEROPREVALENCE OF SALMONELLA GALLINARUM INFECTION IN FREE-RANGE CHICKENS REARED IN NASARAWA STATE, NIGERIA.

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ABSTRACT: The study determined the seroprevalence of *S. gallinarum* infection in free-range chickens in Nasarawa State, Nigeria. A total of 2772 serum samples collected from free-range chickens in 12 selected villages/towns in Nasarawa State were screened for specific antibodies against *S. gallinarum* by the rapid serum agglutination method. Overall, 236 (8.5%) of the chickens had detectable antibodies against *S. gallinarum*. Nasarawa South Senatorial Zone had a significantly higher ($p < 0.05$) antibody prevalence of 109 (9.5%) when compared with Nasarawa North, 59 (8.5%) and Nasarawa West, 68 (7.2%). There was significant difference ($p < 0.05$) in *S. gallinarum* antibody prevalence in chickens sampled from individual villages/towns, with Assakio, Keana and Wamba having significantly higher antibody prevalence rates of 17 (21.3%), 21 (21.0%) and 16 (20.0%), respectively. A significant difference ($p < 0.05$) was observed in the prevalence of *S. gallinarum* antibody in the sampled chickens in relation to age, and prevalence was found to be higher ($p < 0.05$) in the older birds. Thus chickens of age greater than 34 weeks and 28-34 weeks had antibody prevalence of 47 (13.4%) and 57 (10.0%), respectively. *S. gallinarum* antibody prevalence was significantly higher ($p < 0.05$) in the rainy season (June to October) 126 (10.5%) with the highest infection peak in September, when compared with the dry season (December to May), 110 (7.0%). The layer chickens had a significantly higher ($p < 0.05$) antibody prevalence of 138 (19.1%) compared with cockerel, 60 (5.3%) and pullets, 38 (4.1%). The detection of *S. gallinarum* antibody in these unvaccinated apparently healthy chickens confirms the presence of fowl typhoid. Since these birds are

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usually managed under the extensive system, they could contribute to further spread of the infection in the environments. This could threaten the development of poultry industry in Nasarawa State, Nigeria.

INTRODUCTION

Salmonella gallinarum (*S. gallinarum*) is an avian adapted bacterial pathogen and the causative agent of fowl typhoid (Abdul, 2007; OIE Manual, 2008); a severe systemic disease which affects primarily chickens and turkeys (Lee et al., 2005) with geographical distribution in Mexico, Central and South America, Africa, and Asia and the Indian subcontinent (OIE, 2005).

Fowl typhoid is principally associated with an acute septicaemic illness of high morbidity and mortality in birds during the later growing period and in adult (AHVLA, 2012), but it may occur in young chickens where it is indistinguishable clinically from pullorum disease (OIE Manual, 2000).

In Nigeria, the incidence of *S. gallinarum* was first reported in 1930. Since then it has been reported in different parts of the country (Data on livestock disease diagnosis, National Veterinary Research Institute (NVRI), Vom). The disease has affected both government and private farms and has also been found in birds in the chicken markets (Nwobu et al., 1990). According to the Annual Animal Health Report on the Notification of the Absence or Presence of All Diseases in Nigeria (FLDPCS, 2010) and data on the diagnosis of animal diseases obtained from the Central Diagnostic Division of National Veterinary Research Institute, Vom, Nigeria, fowl typhoid ranks higher among the bacterial diseases of poultry, causing huge economic losses to commercial poultry farmers.

The demand for poultry products in Nigeria has increased in recent past, especially as more people have realized the nutritional and economic values of

chicken and their products. Consequently, many poultry farms have sprung up particularly in and around the urban centres. This is now a commercial enterprise involving thousands of chickens estimated at 203.4 million. Of this population, Nasarawa State has an estimated poultry population of 863,647.7, comprising 777,282.9 local breeds and 86,364.8 exotic breeds (FLPCS, 2011). This has become a diverse industry with variety of business interests such as egg production, meat production, hatchery and poultry equipment marketing

The free range poultry otherwise known as rural poultry in Nigeria is made up mostly of chickens, ducks, and guinea fowls, which are domesticated for the purpose of egg and meat production. These are managed under the extensive systems (Emikpe et al, 2005), and are usually not vaccinated (Adu et al, 1986). It is widely believed that they act as reservoirs of most important poultry diseases, including fowl typhoid. (Bouzoubaa et al, 1992) Chickens (*Gallus gallus domesticus*) are the most important of the free range poultry species in terms of number and development (Oluyemi and Roberts, 1979). They are kept by over 90 % of rural households, especially women, as assets (Ajala et al., 2007), providing an important source of high quality protein as well as a source of income for the families (Abubakar et al, 2008).

In Nigeria, the local chickens form the bed-rock of the poultry industry, contributing over 80% of poultry products (NAERLS, 2000). They represent a significant part of the rural economy in particular and of the national economy as a whole (Ajala et al., 2007). For example, in 1988 the rural poultry constituted 43% and 89% of the national egg and meat

production respectively, with an annual output of 67,000 metric tons of meat and 82,000 metric tons of eggs (Adegeye et al, 1988). This category of birds is however faced with all kinds of hardships, such as poor management, lack of external input for production, and disease. Of these constraints, disease remains a major limiting factor in their production. The diseases that cause significant morbidity and mortality in poultry include bacterial, viral and parasitic diseases. Among the bacterial diseases affecting chickens, fowl typhoid is significant because its causal agent is transmitted vertically from parent to offspring (Akter et al., 2007).

Prevention of *Salmonella* infection is important for the profitable expansion of poultry industry in Nigeria. This is necessitated by the fact that, with the continuous expansion of poultry farming in Nigeria, avian salmonellosis caused by *S. gallinarum* has also gained ground as a major disease of poultry (Agbaje et al, 2010), resulting into heavy economic loss through mortality and reduced egg production. Effective prevention and control measures of the disease cannot be undertaken unless its status and epidemiology are well elucidated.

A definite diagnosis of fowl typhoid requires the isolation and identification of *S. gallinarum*. However, a tentative diagnosis can be made based on the flock history, clinical signs, mortality and lesions. Positive serological findings are of great value in detecting infection (Barrow et al, 1992).

The aim of this study was to determine the seroprevalence of *S. gallinarum* infection in free range chickens in Nasarawa State, Nigeria.

MATERIALS AND METHODS

Study Area:

Nasarawa State is located in the North Central Nigeria otherwise known as the Middle-Belt region, with Lafia as its

capital. The state is divided into 13 Local Government Areas (LGA) for administrative purposes, which are further grouped into three senatorial zones. Nasarawa State is bounded in the north by Kaduna State, in the west by the Federal Capital Territory, in the south by Kogi and Benue States and in the east by Taraba and Plateau States. The state has agriculture as the mainstay of its economy and is located between latitude 8°35'N and longitude 8°32'E, with mean temperature of 32°C (Hassan et al, 2013). Nasarawa State has a total area of 27, 117 Km² and population of 2, 040, 097 with density of 75/ km² (190/sq mi), according to 2005 Nigerian National Census.

Identification and selection of study areas:

A preliminary field investigation was carried out in Nasarawa state to identify the study sites. Three villages and a local government headquarter were randomly selected from each senatorial zone of the state. A total of 12 villages /towns were selected, which included Lafia, Keana, Agbashi and Asakkio from Nasarawa South Senatorial Zone; Akwanga, Andaha, Nasarawa Eggon and Wamba from Nasarawa North Senatorial Zone, and Keffi, Garaku, Gadabuke and Gunduma from Nasarawa West Senatorial Zone. They selected villages/towns are located in 10 (76.9%) out of the 13 LGAs of the State.

Sampling procedure:

A stratified random sampling technique was employed in selecting the flocks. A total of 83 households were randomly selected from the selected villages and, all chickens in a selected household were considered as one flock (Mdegela et al, 2000). The number of flocks selected per area ranged from eight to ten and, from each of these households 10% of the total flock population was sampled (Mdegela et al, 2000; Peter et al, 2006). In the local government

headquarters, samples were collected from chicken markets, and one chicken market was selected from each local government to represent the senatorial zone.

Sample collection and processing:

Blood samples were collected between January and December 2006 from unvaccinated apparently healthy free range chickens of various types (pullets, cockerels and layers) and ages through the wing vein using sterile 5 ml syringe and 21 G needles. Three millilitres of blood was collected from each bird. Blood was kept in a standing position in syringe until clot formation and serum was harvested by decanting (Mozaffar et al, 2010). The harvested sera were transferred to 1.5 ml micro centrifuge tubes and kept in cold box before shipping to the laboratory. Sera were stored at -20°C until use for the Rapid Serum Agglutination Test (Selvan et al, 2010). A total of 2,772 blood samples comprising 927 from Nasarawa South Senatorial Zone, 907 from Nasarawa North Senatorial Zone and 938 from Nasarawa West Senatorial Zone were collected. From the total number of samples collected, 1,942 were from chicken markets, which comprised 864 from Lafia, 430 from Akwanga and 648 from Keffi markets

Salmonella. gallinarum antigen:

The method described by Mona et al (2012) was used to prepare the antigen. Samples from visceral organs (spleen and liver) collected at postmortem from chickens experimentally infected with field strain of *S. gallinarum* obtained from Central Diagnostic Department of N.V.R.I, Vom were cultured for the isolation of *S. gallinarum*. The organism was identified according to Quinn et al (2002) and subsequently subcultured onto nutrient agar containing 1/800 phenol. This was heated to inactivate Vi antigen (if present) and to obtain much growth of *S. gallinarum*. The culture was incubated at

37°C for 24 hours, and bacterial growth on agar surface was harvested into 10 ml nutrient broth by scraping using sterile wire loop. The pure culture of *S. gallinarum* in nutrient broth was shaken overnight at 37°C. Thereafter, broth culture was centrifuged at 5000 xg for 60 minutes and the pellets was resuspended and washed three times in 10 ml phosphate buffered saline. The pellets were broken using a sonicator (Fisher Model 300, UK) at power 6 % and centrifuged again at 5000 xg for 60 minutes. The suspension was checked for purity and sterility (test for absence of bacterial and fungal contaminants) using nutrient agar and Sabourad dextrose agar. Pure *S. gallinarum* culture suspension was stored at -20°C until used for Rapid Serum Agglutination Test (RSAT).

Salmonella gallinarum positive control serum:

The sera were prepared according to procedure described by Okwori et al (2007). Three adult chickens with no sign of clinical salmonellosis, which were obtained from the poultry department of the National Veterinary Research Institute (NVRI), Vom, were used. Each of the chickens was intramuscularly inoculated with 0.5ml of inactivated cultures of *S. gallinarum* containing 10⁶cfu/ml obtained from the Bacterial Vaccine Production Department, NVRI, Vom. Chickens were kept for 28 days and observed for immunological response typical of *S. gallinarum* infection. Sera were thereafter collected at 1st 2nd 3rd and 4th weeks post infection and standardized with *S. gallinarum* reference antigen obtained from NVRI, Vom, after each collection. Avid sera were pooled and dispensed in one ml aliquots as positive control serum. Serum was preserved at -20°C until required.

Salmonella gallinarum negative control serum:

Negative control serum was prepared in the same manner, but

chickens were injected with sterile distilled water obtained from Bacterial Vaccine Production Department, NVRI, Vom. Sera obtained were standardized with a reference *S. gallinarum* antigen also obtained from the Bacterial Vaccine Production Department, NVRI, Vom. Sera were pooled and stored at -20°C as negative control serum.

Rapid serum agglutination test:

The test was performed as described in OIE Manual (2008) to detect *S. gallinarum* antibody in the field serum samples. The locally prepared *S. gallinarum* antigen was allowed to warm up to room temperature prior to test. With the aid of a sterile disposable plastic Pasteur pipette, a drop (0.02ml) of the antigen was placed on the centre of each square of ruled clean white ceramic tile. An equal volume of serum was placed next to the antigen, and the reagents were mixed using fine glass rod, which was wiped clean between samples. The mixture was agitated using gentle rocking for up to 2 minutes. A positive reaction was indicated by easily visible clumping of the antigen within 2

minutes, while negative reaction was indicated by absence of clumping of antigen within 2 minutes. The previously prepared positive and negative control sera were included on each testing occasion, treated in the same manner as test samples. On completion of a set of tests, the tile was washed and dried, ready for further use.

Statistical analysis:

The data generated were statistically analysed by Chi-square method using the Statistical Package for the Social Sciences (SPSS) software version 17.0.

RESULTS

The overall seroprevalent rate is shown in table 1. Eight and half percent of the sampled chickens had detectable antibody to *S. gallinarum*. The proportion of serologically positive chickens in the individual villages/towns ranged from 5.6% in Nasarawa Eggon in Nasarawa North Senatorial Zone to 21.3% in Assakio in Nasarawa South Senatorial Zone (Table 1)

Table (1): Prevalence of *S. gallinarum* Antibody in Free Range Chickens in Nasarawa State, Nigeria in Relation to Study Locations

Location	No. of Flocks	No. of Sera Tested	No. Positive	% Positive.
Lafia	-	864	60	6.9
Keana	10	100	21	21.0
Agbashi	10	100	11	11.0
Assakio	8	80	17	21.3
Akwanga	-	430	29	6.7
Andaha	9	90	9	10.0
Wamba	8	80	16	20.0
N/Eggon	9	90	5	5.6
Keffi	-	648	42	6.5
Garaku	10	100	11	11.0
Gadabuke	10	100	9	9.0
Gunduma	9	90	6	6.7
Total	83	2772	236	8.5

Significant (p<0.05)

Table 2 presents the distribution of *S. gallinarum* antibody in the senatorial zones of the Nasarawa State. It showed that Nasarawa South Senatorial Zone had the

highest antibody prevalence of 9.5%, followed by the Nasarawa North, 8.5% and Nasarawa West 7.2% ($p < 0.05$).

Table (2): Prevalence of *S. gallinarum* Antibody in Free Range Chickens in Nasarawa State, Nigeria in Relation to Senatorial Zones

Senatorial Zone	No. of Sera Tested	No. Positive	% Positive
Nasarawa South	1144	109	9.5
Nasarawa North	690	59	8.5
Nasarawa West	938	68	7.2
Total	2772	236	8.5

Not significant ($p > 0.05$)

The percentage detectable *S. gallinarum* antibody in relation to age of chickens as presented in table 3 shows that antibody prevalence increased with advancement in age. Thus antibody prevalence increased in this order: 6.0% for

8-12 week-old, 6.9% for 13-16 week-old, 7.7% for 17-19 week-old, 8.1% for 21-27 week-old, 10.0% for 28-34 week-old and 13.4% for chickens greater than 34 week of age ($p > 0.05$).

Table (3): Prevalence of *S. gallinarum* Antibody in Free Range Chickens in Nasarawa State, Nigeria in Different Ages

Ages (Weeks)	No. of Sera Tested	No. Positive	% Positive
8-12	544	33	6.0
13-16	489	34	6.9
17-19	414	32	7.7
21-27	405	33	8.1
28-34	570	57	10.0
>34	350	47	13.4
Total	2772	236	8.5

Significant ($p < 0.05$)

Seroprevalence, *S. gallinarum*, Infection, Free-range chickens, Nigeria

Table 4 shows the monthly distribution of *S. gallinarum* antibody. Antibody prevalence was highest in September (18.5%) and lowest in February (2.3%). Two peaks of *S. gallinarum* infection were observed, one in July and the other in September (Figure 1), which

are months of rainy season in the study areas. Thus a significantly high ($p < 0.05$) seroprevalence of *S. gallinarum* infection was observed during the rainy season (10.5%) when compared with dry season (7.0%). (Table 5)

Table (4): Monthly Distribution of *S. gallinarum* Antibody in Free Range Chickens in Nasarawa State, Nigeria.

Month	No. of Sera Tested	No. Positive	% Positive
January	264	15	5.7
February	297	8	2.3
March	278	7	2.5
April	200	11	5.5
May	202	13	6.4
June	200	19	9.5
July	191	23	12.0
August	203	23	11.3
September	200	37	18.5
October	233	24	10.3
November	243	26	10.7
December	261	30	11.5
Total	2772	236	8.5

Significant ($p < 0.05$)

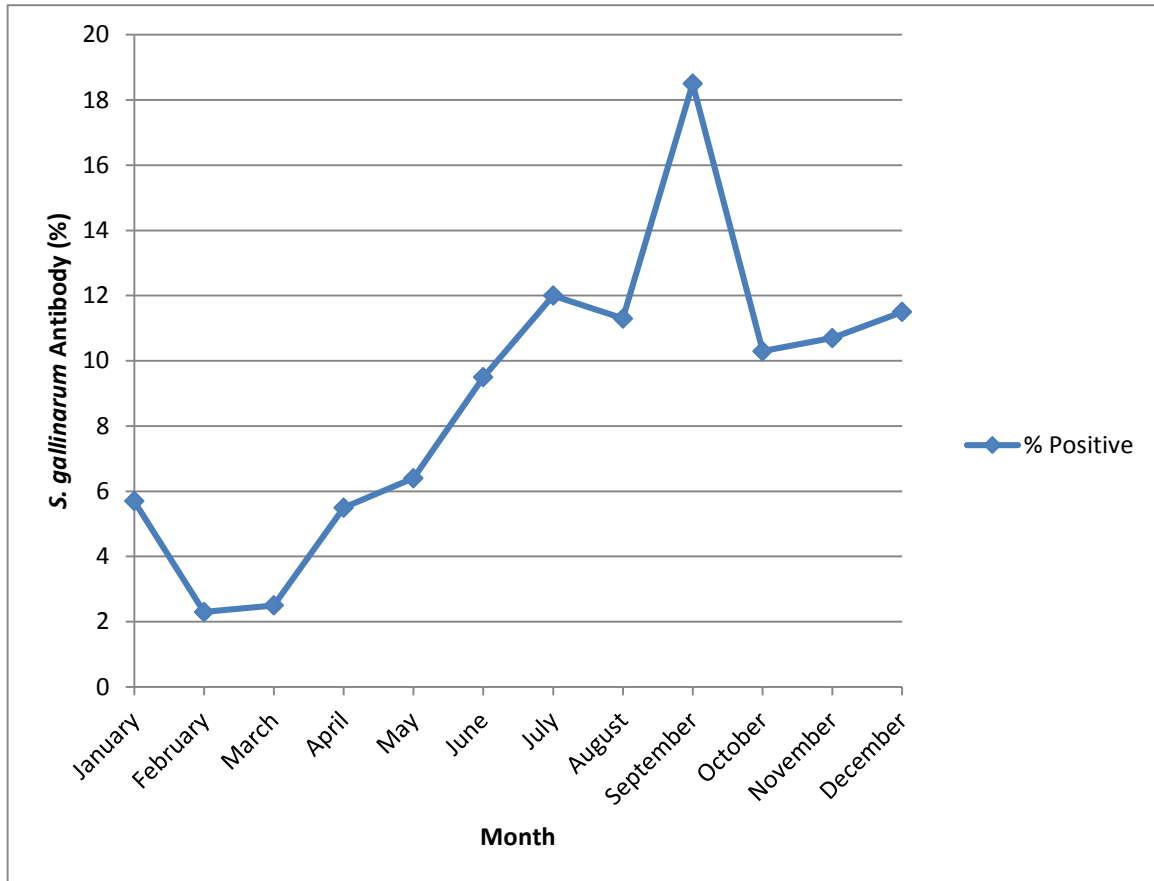


Figure (1): Peak Periods for Seroprevalence of *S. gallinarum* Infection in Free Range Chickens in Nasarawa State, Nigeria

Table (5): Prevalence of *S. gallinarum* Antibody in Free Range Chickens in Nasarawa State, Nigeria in Relation to Season

Season	No. of Sera Tested	No. Positive	% Positive
Dry	1576	110	7.0
Rainy	1196	126	10.5
Total	2772	236	8.5

Significant (p<0.05)

The seroprevalence of *S. gallinarum* infection for the different types of chickens sampled is shown in table 6. The layer chicken had a seroprevalence of 19.1%,

which was significantly higher (p<0.05) than the 5.3 % and 4.1 % recorded for cockerels and pullets, respectively.

Table (6): Prevalence of *S. gallinarum* Antibody in Free Range Chickens in Nasarawa State, Nigeria in Relation to Type of Chicken

Type of Chicken	No. of Sera Tested	No. Positive	% Positive
Pullet	923	38	4.1
Layer	721	138	19.1
Cockerel	1128	60	5.3
Total	2772	236	8.5

Significant ($p < 0.05$)

DISCUSSION

In this study, *S. gallinarum* antibody was detected in unvaccinated apparently healthy free range chickens sampled in Nasarawa State., although, the role of other group D *Salmonellae*, which cross-reacts with *S. gallinarum* (Kim et al, 1991), can not be ruled out. However, epidemiological studies show that *S.gallinarum* infection is endemic in Nigeria (Agbaje et al, 2010; Fasure et al; 2012). The non detection of antibody in the remaining samples may however be due to delayed appearance of agglutinating antibodies in the sampled birds, which takes 3-10 or more days after infection (OIE, 2005).

The presence of antibody in these birds is indicative of bacterial activity, and a serological evidence of fowl typhoid infection in these birds (Mdegela et al, 2000; Peter et al, 2006; Okwori et al, 2007; Ahmed et al, 2008; Mozaffor et al, 2010). This suggests that the birds were previously infected by *S. gallinarum* but have produced antibodies against the organism, hence presumed to be protected.

The free range chickens might have been exposed to the organism probably through contact with infected wild birds, rodents and flies especially mites, which according to valiente et al (2009) may be important mechanical spreaders of *S. gallinarum*. It is also probable that under poor biosecurity systems in commercial poultry houses, the organism may spread to free-range chickens through commercial

poultry workers, most of who also keep these birds and to which they often attend before resuming work at the commercial poultry farms (Ibu, 2008). Further spread of the organism in the study environments probably occurred as a result of inhalation of *Salmonella* by birds in close contact when pecking at contaminated surface of infected birds (Field Manual of Wildlife Diseases, 2001). Also, infected faeces contribute to contaminating the feeds and drinking water of birds, which could result to further spread of the organism. Once infected, birds remain carrier for very long; over 40 weeks, and shed the organism in faeces (Peter et al, 2006). This could promote the continuous circulation of the organism in the environments and thus exposes the seronegative chickens, and other domestic birds sharing the same environments with the infected chickens at risk of being infected by *S. gallinarum*.

This seroprevalence of *S.gallinarum* infection in free range chickens observed in this investigation is low and similar to the levels reported in Nigeria by previous authors (Salami et al, 1989; Ohore et al, 2002; Okwori et al, 2007). A similar level has also been reported from Mauritania (Bell et al, 1990), Morocco (Bouzoubaa et al, 1992), Benin (Chrysostome et al 1995) and Senegal (Arbelot et al, 1997) and Tanzania (Mdegela et al, 2000), and it shows that infection rate in free-range chickens is normally low. This is probably because, although fowl typhoid is transmitted both horizontally and vertically

(Peter et al, 2006), in cases where the disease is transmitted horizontally, contaminated feed and drinking water are the main sources of infection and, under the extensive systems of management, as in village poultry production, the chances of chickens eating and drinking contaminated materials is minimal, hence infection rate is usually low in scavenging local chickens when compared with commercial chickens which are reared under intensive management systems, of which the environmental condition favours the survival and multiplication of *S. gallinarum*, and the chances of chickens eating and drinking contaminated materials is high.

Although there is paucity of published information on the seroprevalence of *S. gallinarum* infection in free range chickens in Nasarawa State, seroprevalence of this organism has been reported in the neighbouring states of Plateau (Onunkwo & Onoviran 1978 and Okwori et al 2007) and Kaduna (Salami et al, 1989 and Mbuko et al, 2009). These authors documented prevalence of 3.2% and 9.3% in Plateau State and 8.4% and 18.4% in Kaduna State, respectively. It is important to note that Nasarawa, Plateau and Kaduna States are located in north central Nigeria. It is therefore evident that fowl typhoid is endemic in the region. Also in support of the present finding are the reports of Adesiyun et al (1984); Falade & Ehizokhale (1981); Adamu et al (2009) who reported seroprevalence of fowl typhoid in free range poultry in some parts of Nigeria. The present finding is further buttressed by the reports on seroprevalence of this organism in free-range poultry from other developing countries of Asia and Africa such as Bangladesh (Rahman et al, 2011), Tanzania (Mdegela et al, 2000) Uganda (Peter et al, 2006), Morocco (Bauzoubaa et al 1992). Evidence of *S. gallinarum* infection in scavenging chickens have also been reported by Jha et al (1995), Arsenault et al (2007), Islam et

al. (2006), Jai Sunder et al. (2007) and Habib-ur-Rahman et al. (2003), who documented 18.4%, 21.3%, 61.68%, and 63.5%, seroprevalence, respectively, which were higher than the rate observed in the present study. The variation in infection rate may be a reflection of difference in geographical distribution of the disease.

In this study, *S. gallinarum* infection was detected in chickens sampled from all the study sites. Even though statistically significant variation ($p < 0.05$) was observed in the disease prevalence, with Assakio, Keana and Wamba having significantly higher infection rates compared with the relatively low rates in Nasarawa Eggon, Keffi and Akwanga, it is evident that fowl typhoid is widespread in Nasarawa State. The variation in seroprevalence may however be a reflection of differences in rates of *S. gallinarum* activity in the infected chicken and their immune status, exposure rate of chickens to the organism, the impact of environment on the survival and multiplication of *S. gallinarum* and its epidemiology, and geographical distribution of the bacteria.

Seroprevalence was significantly higher ($p < 0.05$) in the southern senatorial zone of Nasarawa State, the zone observed to have the highest population of commercial poultry farms and where the state capital is located. This is expected to result to high business activities involving buying and selling of poultry and poultry products. Exchange of egg trays and movement of birds during buying and selling may contribute to spread of the organism in the area. It is also expected that vaccination activities, which is fundamental in commercial poultry production, will be routinely carried out. The vaccine strain of *S. gallinarum* could spread to free-range birds through commercial poultry attendants (Peter et al, 2006), most of who hail from households where scavenging local chickens are kept. The 9R vaccine strain of *S. gallinarum* causes mild systemic salmonellosis in

chicken with pathology in the liver and spleen, and bacterial persistence for several weeks at these sites (Wingley et al, 2005 and Silva et al, 1981). This may have probably contributed to the higher seroprevalence of the diseases in Assakio, Keana and Agbashi, which are the closest study villages to the state capital. *S. gallinarum* infection also observed in chickens from other villages might have resulted from contact with infected domestic birds, wild birds, rodents and flies, which are reservoirs of *S. gallinarum*. Besides, in these rural communities poor hygienic conditions were observed. This might have contributed to spread of bacterial diseases in the environments. The application of coordinated policy on hygienic measures has contributed to the eradication of *S. gallinarum* in many developed countries (Barrow, 1993).

The serological evidence of *S. gallinarum* infection observed in chickens from chicken markets is supported by the report of Nwobu, (1990), who reported fowl typhoid infection rate of 2% in local chickens at chicken markets in Jos, Nigeria. The chicken markets serve as centre for purchase and slaughter of chickens and other birds. In some of these markets, it was observed that free range chickens, commercial chickens and other domestic birds were kept in close contact in cages for sale, sharing the same feed and drinking water. In such situation, horizontal spread of the organism can not be ruled out. Also, poultry slaughter men who had direct contact with infected birds may serve as vehicle of spread of the bacteria to birds in the markets and in their homes.

In this study, seroprevalence occurred all year round but was observed to occur mostly from June to November, with the highest infection peak in September. This is similar to the finding of Mbuko et al, (2009) who reported high prevalence of fowl typhoid from July to December in Zaria. A similar observation was also reported by Roa (2000) in whose

report showed that outbreaks of fowl typhoid were mostly seen in summer particularly when the weather is wet and moisture is persistent in the air. The ISO (1993) showed that the disease has three peaks; one continues peak from June to July followed by July to August and another one from October to December. It is important to note that these months fall within the rainy season in most parts of Nigeria, including the study areas. These months are characterized by wet weather and it is the period of high egg production (Calnek, 1995). The consequence of this is increase in production of infected eggs, which results to increase chick infection. This probably caused the significantly higher ($p < 0.05$) seroprevalence of *S. gallinarum* in the wet season as observed in the present study.

It was observed in this study that *S. gallinarum* infection rate increased with advancement in age of the chicken. Thus chickens greater than 34 weeks of age had significantly higher ($p < 0.05$) infection rate of 13.4%, followed by the 28-34 week-old chickens 10.0%, then the 21-27 week-old 8.1% and the least rate of 6.0% in the 8-12 week-old chickens, which were the youngest of the chickens sampled. This also shows that chickens of all ages are susceptible to *S. gallinarum* infection. This corroborates the findings of Jordan and Pattison (1996); Calnek (1995); OIE (2008); Field Manual of Wildlife Diseases (2001), who reported that fowl typhoid generally infects growing and adult birds as well as young birds.

The high infection rate observed among chickens above the age of 21 weeks is expected since at this age, under normal conditions, chickens would commence laying eggs, which continues as the chicken advance in age. The stress of egg production contributes to their inability to resist infection (Saidu et al, 1994). Also, keeping layers for longer time than other types of flocks expose them to risk of long time exposure to *S. gallinarum* as a result

of natural infection (Peter et al, 2006). Once infected, the layer chickens will continue to produce infected eggs to perpetuate the circle of infection (Shiraprasad, 2003). Infection rates of up to 33% of eggs laid by an infected hen have been documented (Shiraprasad, 1997; Wigley et al, 2001).

CONCLUSIONS

Although *S. gallinarum* isolation was not attempted, detection of antibody to this organism suggests infection. A further study to include bacterial isolation in the entire poultry stock in the state

is recommended. This will provide information on the status of fowl typhoid in village chickens in Nasarawa State. Such information will be useful for the development of control strategies against fowl typhoid in the state.

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