

***Figure S1. PCR Gel picture of Salmonella enterica isolated from North-Central Nigeria.***

Loading arrangement from 1-15 represents 56 A1CI L3 BI L2 CH2 CH1 LI A2 B2 CH3 W3 N2 W1 respectively.

Presence of a 230bp in samples 56, CI and L3 confirms the presence of typhoid causing *Salmonella enterica*.

**Table S1. Molecular identification of NTS**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **S/N** | **sample ID** | **Description** | **Max Score** | **Total Score** | **Query Cover** | **E value** | **Per. Ident** | **Accession** |
| 1  | 56 | Salmonella enterica subsp. enterica serovar Enteritidis strain SSYN001 16S ribosomal RNA gene, partial sequence | 2676 | 2676 | 99% | 0 | 99.66% | MT500568.1 |
| 2 | CI | Salmonella enterica subsp. enterica serovar Enteritidis strain SSYN001 16S ribosomal RNA gene, partial sequence | 2750 | 2750 | 100% | 0 | 100.00% | MT500568.1 |
| 3 | L3 | Salmonella enterica subsp. enterica serovar Enteritidis strain SSYN001 16S ribosomal RNA gene, partial sequence | 2700 | 2700 | 99% | 0 | 99.93% | MT500568.1 |

*Details of sequence data are found below.*

**Sequence data**

>56 *Salmonella enterica*

TTTTGATCCCGGCCCAGATTGAAAGCTGGCGGCAGGCCTAACACATGCAAGTCGAACGGTAACAGGAAGCAGCTTGCTGCTTCGCTGACGAGTGGCGGACGGGTGAGTAATGTCTGGGAAACTGCCTGATGGAGGGGGATAACTACTGGAAACGGTGGCTAATACCGCATAACGTCGCAAGACCAAAGAGGGGGACCTTCGGGCCTCTTGCCATCAGATGTGCCCAGATGGGATTAGCTTGTTGGTGAGGTAACGGCTCACCAAGGCGACGATCCCTAGCCGGTCTGAGAGGATGACCAGCCACACTGGAACTGAGACACGGTCCAGACTCCTACGGGAGGCAGCAGTGGGGAATATTGCACAATGGGCGCAAGCCTGATGCAGCCATGCCGCGTGTATGAAGAAGGCCTTCGGGTTGTAAAGTCCTTTCAGCGGGGAGGAAGGTGTTGTGGTTAATAACCGCAGCAATTGACGTTACCCGCAGAAGAAGCACCGGCTAACTCCGTGCCAGCAGCCGCGGTAATACGGAGGGTGCAAGCGTTAATCGGAATTACTGGGCGTAAAGCGCACGCAGGCGGTCTGTCAAGTCGGATGTGAAATCCCCGGGCTCAACCTGGGAACTGCATTCGAAACTGGCAGGCTTGAGTCTTGTAGAGGGGGGTAGAATTCCAGGTGTAGCGGTGAAATGCGTAGAGATCTGGAGGAATACCGGTGGCGAAGGCGGCCCCCTGGACAAAGACTGACGCTCAGGTGCGAAAGCGTGGGGAGCAAACAGGATTAGATACCCTGGTAGTCCACGCCGTAAACGATGTCTACTTGGAGGTTGTGCCCTTGAGGCGTGGCTTCCGGAGCTAACGCGTTAAGTAGACCGCCTGGGGAGTACGGCCGCAAGGTTAAAACTCAAATGAATTGACGGGGGCCCGCACAAGCGGTGGAGCATGTGGTTTAATTCGATGCAACGCGAAGAACCTTACCTGGTCTTGACATCCACAGAAGAATCCAGAGATGGATTTGTGCCTTCGGGAACTGTGAGACAGGTGCTGCATGGCTGTCGTCAGCTCGTGTTGTGAAATGTTGGGTTAAGTCCCGCAACGAGCGCAACCCTTATCCTTTGTTGCCAGCGGTTAGGCCGGGAACTCAAAGGAGACTGCCAGTGATAAACTGGAGGAAGGTGGGGATGACGTCAAGTCATCATGGCCCTTACGACCAGGGCTACACACGTGCTACAATGGCGCATACAAAGAGAAGCGACCTCGCGAGAGCAAGCGGACCTCATAAAGTGCGTCGTAGTCCGGATTGGAGTCTGCAACTCGACTCCATGAAGTCGGAATCGCTAGTAATCGTGGATCAGAATGCCACGGTGAATACGTTCCCGGGCCTTGTACACACCGCCCGTCACACCATGGGAGTGGGTTGCAAAAGAAGTAGGTAGCTTAACCTTCGGGAGGGCGCTTACCACTTTGTGGG

>CI *Salmonella enterica*

TGATCCTGGCTCAGATTGAACGCTGGCGGCAGGCCTAACACATGCAAGTCGAACGGTAACAGGAAGCAGCTTGCTGCTTCGCTGACGAGTGGCGGACGGGTGAGTAATGTCTGGGAAACTGCCTGATGGAGGGGGATAACTACTGGAAACGGTGGCTAATACCGCATAACGTCGCAAGACCAAAGAGGGGGACCTTCGGGCCTCTTGCCATCAGATGTGCCCAGATGGGATTAGCTTGTTGGTGAGGTAACGGCTCACCAAGGCGACGATCCCTAGCTGGTCTGAGAGGATGACCAGCCACACTGGAACTGAGACACGGTCCAGACTCCTACGGGAGGCAGCAGTGGGGAATATTGCACAATGGGCGCAAGCCTGATGCAGCCATGCCGCGTGTATGAAGAAGGCCTTCGGGTTGTAAAGTACTTTCAGCGGGGAGGAAGGTGTTGTGGTTAATAACCGCAGCAATTGACGTTACCCGCAGAAGAAGCACCGGCTAACTCCGTGCCAGCAGCCGCGGTAATACGGAGGGTGCAAGCGTTAATCGGAATTACTGGGCGTAAAGCGCACGCAGGCGGTCTGTCAAGTCGGATGTGAAATCCCCGGGCTCAACCTGGGAACTGCATTCGAAACTGGCAGGCTTGAGTCTTGTAGAGGGGGGTAGAATTCCAGGTGTAGCGGTGAAATGCGTAGAGATCTGGAGGAATACCGGTGGCGAAGGCGGCCCCCTGGACAAAGACTGACGCTCAGGTGCGAAAGCGTGGGGAGCAAACAGGATTAGATACCCTGGTAGTCCACGCCGTAAACGATGTCTACTTGGAGGTTGTGCCCTTGAGGCGTGGCTTCCGGAGCTAACGCGTTAAGTAGACCGCCTGGGGAGTACGGCCGCAAGGTTAAAACTCAAATGAATTGACGGGGGCCCGCACAAGCGGTGGAGCATGTGGTTTAATTCGATGCAACGCGAAGAACCTTACCTGGTCTTGACATCCACAGAAGAATCCAGAGATGGATTTGTGCCTTCGGGAACTGTGAGACAGGTGCTGCATGGCTGTCGTCAGCTCGTGTTGTGAAATGTTGGGTTAAGTCCCGCAACGAGCGCAACCCTTATCCTTTGTTGCCAGCGGTTAGGCCGGGAACTCAAAGGAGACTGCCAGTGATAAACTGGAGGAAGGTGGGGATGACGTCAAGTCATCATGGCCCTTACGACCAGGGCTACACACGTGCTACAATGGCGCATACAAAGAGAAGCGACCTCGCGAGAGCAAGCGGACCTCATAAAGTGCGTCGTAGTCCGGATTGGAGTCTGCAACTCGACTCCATGAAGTCGGAATCGCTAGTAATCGTGGATCAGAATGCCACGGTGAATACGTTCCCGGGCCTTGTACACACCGCCCGTCACACCATGGGAGTGGGTTGCAAAAGAAGTAGGTAGCTTAACCTTCGGGAGGGCGCTTACCACTTTGTGATTCATGACTGGGGTGAAGTCGTAACA

>L3 *Salmonella enterica*

ATTTGATCCTGGCTCAGATTGAACGCTGGCGGCAGGCCTAACACATGCAAGTCGAACGGTACAGGAAGCAGCTTGCTGCTTCGCTGACGAGTGGCGGACGGGTGAGTAATGTCTGGGAAACTGCCTGATGGAGGGGGATAACTACTGGAAACGGTGGCTAATACCGCATAACGTCGCAAGACCAAAGAGGGGGACCTTCGGGCCTCTTGCCATCAGATGTGCCCAGATGGGATTAGCTTGTTGGTGAGGTAACGGCTCACCAAGGCGACGATCCCTAGCTGGTCTGAGAGGATGACCAGCCACACTGGAACTGAGACACGGTCCAGACTCCTACGGGAGGCAGCAGTGGGGAATATTGCACAATGGGCGCAAGCCTGATGCAGCCATGCCGCGTGTATGAAGAAGGCCTTCGGGTTGTAAAGTACTTTCAGCGGGGAGGAAGGTGTTGTGGTTAATAACCGCAGCAATTGACGTTACCCGCAGAAGAAGCACCGGCTAACTCCGTGCCAGCAGCCGCGGTAATACGGAGGGTGCAAGCGTTAATCGGAATTACTGGGCGTAAAGCGCACGCAGGCGGTCTGTCAAGTCGGATGTGAAATCCCCGGGCTCAACCTGGGAACTGCATTCGAAACTGGCAGGCTTGAGTCTTGTAGAGGGGGGTAGAATTCCAGGTGTAGCGGTGAAATGCGTAGAGATCTGGAGGAATACCGGTGGCGAAGGCGGCCCCCTGGACAAAGACTGACGCTCAGGTGCGAAAGCGTGGGGAGCAAACAGGATTAGATACCCTGGTAGTCCACGCCGTAAACGATGTCTACTTGGAGGTTGTGCCCTTGAGGCGTGGCTTCCGGAGCTAACGCGTTAAGTAGACCGCCTGGGGAGTACGGCCGCAAGGTTAAAACTCAAATGAATTGACGGGGGCCCGCACAAGCGGTGGAGCATGTGGTTTAATTCGATGCAACGCGAAGAACCTTACCTGGTCTTGACATCCACAGAAGAATCCAGAGATGGATTTGTGCCTTCGGGAACTGTGAGACAGGTGCTGCATGGCTGTCGTCAGCTCGTGTTGTGAAATGTTGGGTTAAGTCCCGCAACGAGCGCAACCCTTATCCTTTGTTGCCAGCGGTTAGGCCGGGAACTCAAAGGAGACTGCCAGTGATAAACTGGAGGAAGGTGGGGATGACGTCAAGTCATCATGGCCCTTACGACCAGGGCTACACACGTGCTACAATGGCGCATACAAAGAGAAGCGACCTCGCGAGAGCAAGCGGACCTCATAAAGTGCGTCGTAGTCCGGATTGGAGTCTGCAACTCGACTCCATGAAGTCGGAATCGCTAGTAATCGTGGATCAGAATGCCACGGTGAATACGTTCCCGGGCCTTGTACACACCGCCCGTCACACCATGGGAGTGGGTTGCAAAAGAAGTAGGTAGCTTAACCTTCGGGAGGGCGCTTACCACTTTGTGAT

***Table S2. Categorization of Variables based on selected industry standards and peer-reviewed literature.***

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Question | Decision | Category | Reference | Reclassification | Notes | Reference |
| Serial number | - | - | No |  | - | - |
| State |  | State by state | No |  | - | - |
| Serial number  |  | - | No |  | - | - |
| L .G. A |  | L. G. A by L. G. A | No |  | - | - |
| Gender |  | 0 vs 1 | Y | M=1F=0 | There 57% of women and 51% of men with a gender gap of 7.2% are involved in poultry. | The World Bank Nigeria development report (2021) (<https://www.worldbank.org/en/country/nigeria/publication/nigeria-development-update-ndu>).  |
| Age |  | 0 vs 1 | Y | 41 and above = 11-40 = 0 | The mean age of poultry farmers is 40 years  | Gender participation in commercial poultry production (<http://www.lrrd.org/lrrd22/9/okoh22160> ) |
| Length of farming |  | 0 vs 1 | Y | 6 and above =11-5 = 0 | 65% of farmers have mean farming experience of 6 years  | Differentials in technical efficiency among broiler farmers in Imo state Nigeria ( <https://www.ajol.infor/index.php/naj/article/view/196166/185183> ) |
| Level of education |  | 0 vs 1 | Y | Primary &secondary =0Tertiary & others higher qualifications =1 | 40% of poultry farm owners hold secondary school cert, 35% a university degree and 8.3% a primary school certificate.  | Socio-economic factors as determinants of farm management skills ([www.resarchgate.net/publication/321650666](http://www.resarchgate.net/publication/321650666) )  |
| Type of poultry |  | 0 vs 1 | Y | Broiler = 0Layer & others =1 |  | Short cycle and long cycle |
| Number of chickens |  | 0 vs 1 | Y | 500 and above = 01-499 = 1 |  | - |
| Source of feed |  | 0 vs 1 | Y | Self-compounded = 1Commercial = 0 | Poultry farmers prefer to use self-compounded feeds than commercial feeds  | Poultry farmers preference and use of commercial and self-formulated feeds ( <https://www.researchgate.net/publication/223151006> ) |
| Source of water |  | 0 vs 1 | Y | Borehole/tap borne = 0Stream/well/ others = 1 | 27% of poultry farmers depend on borehole, tap water combined and 3% on depended solely well, stream or river.  | quality of different water sources used in poultry and piggery farms in southeastern Nigeria (<https://www.researchgate.net/publication/349180707> ) |
| Pen type |  | 0 vs 1 | Y | Standard block= 0Others = 1 | In commercial and semi commercial setting in developing countries, chickens are normally housed in naturally ventilated pen with additional lightning provided in form of electricity  | Poultry development review (<https://wwwfao.org/3/i3531e/i3531e.pdf> ) |
| System of mgt |  | 0 vs 1 | Y | Deep litter = 1Battery cage = 0 | There are three primary intensive control: deep litter, battery case and wire floor system.  | Types of poultry management systems (<https://fabioclass.com/poultry-management-systems/>) |
| Litre material |  | 0 vs 1 | Y | Saw dust/wood shavings/sand=0Cement floor= 1 |  | Beddings and no beddings |
| Litre mgt |  | 0 vs 1 | Y | Good=0Poor/fair=1 | Daily grading of litter should be done.it is advisable to also use dry lime in order to keep litre dry. | Poultry litter management for better performance and production (<https://www.pashudhanpraharee.com/poultry-litter-management-for-better-performance-and-production/> ) |
| Pen odour |  | 0 vs 1 | Y | Yes =1No =0 | Ammonia is the cause of pen odor and the most environmentally significant aerial pollution associated with poultry production  | Poultry development review (<https://wwwfao.org/3/i3531e/i3531e.pdf> ) |
| Stocking density |  | 0 vs 1 | Y | 1-16 =017 & above = 1 |  | Code of practice 2012, broiler production South Africa<http://www.sapoultry.co.za/pdf-docs/code-practice-broilers.pdf>  |
| Adherence to Vaccination |  | 0 vs 1 | Y | Yes=1No/partial=0 | 87% of poultry farmers vaccinate their chickens  | An appraisal of the use of vaccination for disease prevention in poultry in Ibadan, Nigeria. ( [www.ajol.info/index.php/bahpa/article/view/76526](http://www.ajol.info/index.php/bahpa/article/view/76526) ) |
| Practice biosecurity |  | 0 vs 1 | Y | Yes = 1No/partial = 0 | Practice of biosecurity in the study area was high  | Adoption of biosecurity for disease prevention and control by poultry farmers in Imo state, Nigeria ( [www.ajol.info/index.php/jafs/article/view/204206](http://www.ajol.info/index.php/jafs/article/view/204206) )  |
| Fowl typhoid & cholera vaccine |  | 0 vs 1 | Y | Yes = 1No = 0 | 4% of farmers vaccinate chickens against fowl typhoid and fowl cholera  | An appraisal of the use of vaccination for disease prevention in poultry in Ibadan, Nigeria. ( [www.ajol.info/index.php/bahpa/article/view/76526](http://www.ajol.info/index.php/bahpa/article/view/76526) ) |
| Ever heard of Salmonella Infection in poultry |  | 0 vs 1 | Y | Yes = 1No = 0 | - | - |
| Ever experienced Salmonellosis |  | 0 vs 1 | Y | Yes=1No=0 | Large scale farms had experienced more salmonella prevalence at 33% prevalence rate  | Prevalence of salmonella in chicken , farm attendants and beddings ( [www.researchgat.net/figure/prevalence-of-salmonella-in-chickens-farm-attendants-and-bediing -in-hawassa-and-bonga-\_tbi2\_317032593](http://www.researchgat.net/figure/prevalence-of-salmonella-in-chickens-farm-attendants-and-bediing%2520-in-hawassa-and-bonga-_tbi2_317032593) ) |
| Salmonella management |  | 0 vs 1 | Y | Antibiotic/Vaccination = 1Others = 0 | - | Survey |
| Knowledge of Salmonellosis as zoonotic |  | 0 vs 1 | Y | No knowledge = 0Knowledge = 1 | Majority of respondent have good knowledge about poultry diseases but not poultry zoonotic diseases  | Understanding attitude, practices and knowledge of zoonotic infectious disease risks among poultry farmers in Ghana (<https://onlinelibrary.wiley.com/doi/10.1002/vms3.257> ) |
| Source of knowledge of Sal as major zoonotic |  | 0 vs 1 | Y | Media = 1Others = 0 | Farmers with higher education level and longer experience have improved knowledge of zoonotic poultry diseases  | Understanding attitude, practices and knowledge of zoonotic infectious disease risks among poultry farmers in Ghana (<https://onlinelibrary.wiley.com/doi/10.1002/vms3.257> ) |
| Ever encounter mortality of chickens |  | 0 vs 1 | Y | No = 0 Yes = 1 | A mortality rate of 1.5% or less is normal however zero mortality is the aim. | Mortality in poultry ( <https://agreenerworld.org/wp-content/uploads/2018/05/TAFS-8-Mortality-in-poultry-v3.pdf> )  |
| Type of mortality |  | 0 vs 1 | Y | High & moderate = 1Low/normal = 0 |  | Survey |
| Ever taken sample to Lab. |  | 0 vs 1 | Y | No = 0 Yes = 1 | - | - |
| Type of Sample |  | - | No |  |  | Survey |
| Result |  | 0 vs 1 | Y | Salmonella / Salmonella + others=1No Salmonella = 0 | - | - |
| What did you do after the result |  | 0 vs 1 | Y | Sell = 1Others = 0 | - | Survey |
| Cost of treatment |  | 0 vs 1 | Y | High = 1Others = 1 | - | Survey |
| Cost of mortality |  | 0 vs 1 | Y | High= 1Others= 0 | - | Survey |
| Did Salmonella affect your production | - | - | No |  | - | Survey |
| Nature of effect on production | - | - | No |  | - | Survey |
| Profit after sales | - | - | No |  | - | Survey |
| Access to professional support |  | 0 vs 1 | Y | Yes= 1Others= 0 | Shortage of professional affects availability of support.  | Challenges and prospect of poultry industry ( <https://www.grin.com/document/296347> ) |

LGA = Local Government Authority; Y = Yes.

***Table S3. Sample Questionnaire for risk factor data collection in the field***

1. State -
2. Serial Number -
3. LGA -
4. Gender - A. Male, B. Female
5. Age of respondents – A. >60, B. 41-60, C. 21-40, D.<20
6. Length in Poultry Farming - <2years, B. 2-4years, C. 4-6years, D. >6years
7. Educational level – A. primary B. Secondary C. Tertiary D. others
8. Farm location -
9. Name of farm -
10. Type of poultry (commercial or backyard) – A. broilers B. Layers C. mixed D. others
11. Number of birds – A. <200 B. 201-500 C. 501-1000 D. >1000
12. Source of feed- A. commercial feed B. concentrate mix C. self-compounded
13. Source of water for birds – A. borehole B. tap borne C. Well D. Stream E. others (describe)
14. Pen type – A. standard block B. dwarf block C. zinc type D. others
15. System of management – A. deep litter B. battery cage C. others
16. Litter material – A. Sawdust B. wood shavings C. Sand D. cement floor E. others
17. Litter management – A. Good B. Poor C. Fair
18. Pen odor – A. Yes B. No
19. Stocking density – A. 12-14/M2 B. 14-16/M2 C. 16-18/M2 D. 18-20/M2 E. >20/M2 F. not known
20. Adherence to vaccination - A. Yes B. No C. Partial
21. Practice biosecurity - A. Yes B. No C. Partial
22. Ever administered fowl typhoid/ cholera vaccine - A. Yes B. No
23. Ever heard of salmonella infections in poultry - A. Yes B. No
24. Ever experienced salmonella infection on farm - A. Yes B. No C. Don’t Know
25. If salmonella ever encountered how was it managed/controlled – A. antibiotics B. Vaccination C. antibiotics and vaccination D. culling and sale E. others
26. Knowledge of salmonella as a zoonotic agent - A. Yes B. No
27. Source of knowledge of Salmonella as a zoonotic agent A. electronic media B. print media C. extension agent D. vet/animal health officer E. other farmers F. hospital
28. Ever encountered mortality of birds - A. Yes B. No
29. Type of mortality A. high B. Moderate C. Low D. normal occurrence
30. Ever taken samples to a veterinarian/animal health lab - A. Yes B. No
31. What type of samples – A. feces B. Egg C. whole bird D. all E. others
32. What was the result – A. salmonella B. salmonella and another infection C. other
33. What did you do after the result? A. Treat B. Sell C. others
34. What is the cost of treatment – A. high B. Moderate C. Low D. others
35. Estimated cost of mortality from salmonella – A. high B. Moderate C. Low D. others
36. Did salmonella affect your production - A. Yes B. No
37. Nature of effect on production: A. high B. Moderate C. Low D. others
38. Profit after sales - A. Yes B. No
39. Access to professional support - A. Yes B. No C. Not always D. others