Factors for production growth at poultry enterprises in Russia

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Abstract. The article presents the results of a study of antibiotic resistance and antibiotic susceptibility of 96 isolates of bacteria of the genus Salmonella, which were isolated from various poultry enterprises of the Russian Federation during 2020, to various antibacterial drugs. Thus, 100% of the examined Salmonella cultures turned out to be completely resistant to cefixime, fusidic acid, lincomycin, linezolid, metronidazole, nafcillin, oleandomycinum, oxacillin, benzylpenicillin, pristinamycine, rifampicin, tylosin, bacitracin, erythromycin, ceftazidime. Most Salmonella isolates showed resistance against clarithromycin, spiramycin, ceftazidime, cefopirazeone, doripenem, sulfadiazine and cefpirome - 90.6%; cefotaxime - 87.5%; pefloxacin, cefdinir, clindamycin, clindamycin, neomycin, piperacillin, lomefloxacin, moxifloxacin, streptomycin, cefazolin, kanamycin, azithromycin, sisomicin, furadonin, doxycycline, cefaclor, furagin, tetracycline, oxytetracycline, polymyxin-B, spectinomycin, gentamicin and other types of drugs. At the same time, salmonella showed high susceptibility to: amoxiclav (88.8%); fosfomycin and trimetroprim (80.2%); ofloxacin (76.0%); cephalexin and enrofloxacin (71.9%); co-trimoxazole (67.7%); cefotaxime / clavulanic acid, sulfafurazole, sulfametizole (59.4%); ciprofloxacin (58.3%) and others. Thus, the study established a wide spread of multi-resistant Salmonella cultures in poultry enterprises of the Russian Federation.

1. Introduction
The state policy in the sphere of the agriculture industry is aimed mainly at meeting the constantly growing needs of the population for food. To meet these goals, it is necessary to ensure the growth of production in the livestock sector. In its turn, the basis for the development of livestock breeding is the safety of the livestock of animals and birds, the birth and raising of healthy young animals, getting livestock products (meat, milk, eggs, etc.). It is impossible to increase the growth of production in livestock enterprises, farms and factories without reliable protection against infectious diseases [1, 2, 3]. Salmonellosis is a vivid example of a disease causing great economic harm to agricultural producers [4, 5].

Diseases caused by salmonella have been known since the time of Hippocrates. In our country, salmonellosis was first found in the late 1920s in calves, pigs, sheep and other animals. Salmonellosis is widespread throughout the world, occupies a large proportion among infectious diseases and is a major veterinary and public health problem. Salmonellosis belongs to a large group of zoonotic diseases of farm animals and humans, manifested by fever, toxicosis, septicemia and diarrhea, pneumonia, arthritis, abortion and asymptomatic carriage, possible generalization and varying severity of symptoms [6]. The harm caused by the disease consists not only of reduced productivity, mortality, and costs of veterinary treatment, but also in the fact that asymptomatic carriers become a constant source of the
Salmonella, isolated on the territory of poultry enterprises in various regions of Russia during 2020.

2. Materials and methods

The study was carried out in the Federal State Budgetary Scientific Institution "Federal Scientific Centre Russian Research Institute of Experimental Veterinary Medicine named after K.I. Scriabin and Y.R. Kovalenko of the Russian Academy of Sciences", during 2020, within the framework of the state assignment FGUG-2019-0001 “Obtaining new knowledge about the prevalence of pathogens of animal diseases and developing methods of fighting antibiotic resistance through the use of modern diagnostic tools, treatment and specific prevention in order to prevent the risks of outbreaks of infectious diseases that hinder the maintenance of food security and independence, as well as increase the country's export potential”.

We used 96 field isolates of Salmonella isolated from raw materials of animal origin, washes from equipment, hatchers, litter, egg incubation waste and sectional material taken from clinically healthy, sick and dead birds of different species (chickens, turkeys, ducks, geese). Salmonella belonged to the following serotypes S. enterica serovar S. london – 34.38% (33), S. nohanga – 9.38% (9), S. infantis – 8.33% (8), S. takoradi – 7.29 % (7), S. riggil – 5.21% (5), S. enteritis and S. suberu in 4.17% (4), S. typhimurium, S. dublin and S. Lomita in 3.13% (3), S. goerlitz, S. Lagos, S. sinstorfa and S. Fyris in 2.08% (2), S. concord, S. ohmarschen, S. heidelberg, S. oritamerin, S. kimberley, S. ngor, S. islington, S. irumu and S. virchow 1.04% (1). All designated Salmonella strains are preserved and maintained in the collection of the Federal State Budgetary Scientific Institution FSC Riev RAS for further study.

Determination of antibiotic susceptibility was carried out according to MUK (Methodological guidelines) 4.2.1890-04 “Determination of the susceptibility of microorganisms to antibacterial drugs” by the disk-diffusion method on Mueller-Hinton agar (Hi-Media, India). For the test, a standard suspension was prepared from a daily culture at a concentration of 1.5 * 10^8 CFU / ml, conforming to the McFarland standard of 0.5 [20]. The data were interpreted in accordance with the recommendations of Eucast, CLSI.

Antibiotic susceptibility was determined to the following antibacterial drugs: carbapenems - doripenem (10 mcg / disc); monobactams - aztreonam (30 mcg/disc); 1st generation cephalosporins - cephalexin (30 mcg/disc), cefazolin (30 mcg/disc); 2nd generation cephalosporins - ceftriaxone (30 mcg/disc), cefaclor (30 mcg/disc); 3rd generation cephalosporins - cefixime (5 mcg/disc 30), cefotaxime (30 mcg/disc), cefdinir (5 mcg/disc), ceftazidime (30 mcg/disc), cefoperazone (75 mcg/disc),
The results of studying the antibiotic susceptibility of 96 epizootic Salmonella cultures - Salmonella spp. n=96 (%)

### 3. Results and discussion

When studying antibiotic susceptibility of Salmonella, the data shown in Table 1 were obtained.

| Antibiotics | Salmonella spp. n=96 (%) | Antibiotics | Salmonella spp. n=96 (%) |
|-------------|--------------------------|-------------|--------------------------|
|             | R (%) 1 (%) S (%)        |             | R (%) 1 (%) S (%)        |
| **Aminoglycosides** |                      |             |             |
| Kanamycin   | 62 (64.6) 26 (27.1) 8 (8.3) | Piperacillin | 69 (71.9) 20 (20.8) 7 (7.3) |
| Streptomycin| 65 (67.7) 26 (27.1) 5 (5.2) | Amoxicillin | 15 (15.6) 41 (42.7) 40 (41.7) |
| Spectinomycin| 48 (50.0) 28 (29.2) 20 (20.8) | Amoxiclav | 70 (72.9) 23 (24.0) 3 (3.1) |
| Gentamicin  | 46 (47.9) 29 (30.2) 21 (21.9) | Amoxiclav | 1 (1.0) 10 (10.4) 85 (88.5) |
| Neomycin    | 70 (72.9) 12 (12.5) 14 (14.6) | Carbenicillin | 40 (41.7) 49 (51.0) 7 (7.3) |
| Sisomycin   | 57 (59.4) 31 (32.3) 8 (8.3) | Co-trimoxazole | 7 (7.3) 24 (25.0) 65 (67.7) |
| **Tetracyclines** |                      |             |             |
| Chlortetracycline | 42 (43.8) 23 (24.0) 31 (32.3) | Sulfafurazole | 21 (21.9) 18 (18.8) 57 (59.4) |
| Oxytetracycline | 49 (51.0) 25 (26.0) 22 (22.9) | Sulfamethisole | 19 (19.8) 20 (20.8) 57 (59.4) |
| Tetracycline  | 49 (51.0) 14 (14.6) 33 (34.4) | Sulfadiazine | 87 (90.6) 8 (8.3) 1 (1.0) |
| Doxycycline  | 51 (53.1) 15 (15.6) 30 (31.3) | Trimethoprim | 12 (12.5) 7 (7.3) 77 (80.2) |
| **1st gen. Fluoroquinolones** |                      |             |             |
| Lomefloxacin | 68 (70.8) 18 (18.8) 10 (10.4) | Fosfomycin | 19 (19.8) 0 (0.0) 77 (80.2) |
| **Carbenemems** |                      |             |             |
| Doripenem   | 89 (92.7) 3 (3.1) 4 (4.2) | Clindamycin | 75 (78.1) 20 (20.8) 1 (1.0) |
| **2nd gen. Fluoroquinolones** |                      |             |             |
| Ciprofloxacin| 10 (10.4) 30 (31.3) 56 (58.3) | Spiramycin | 90 (93.8) 6 (6.3) 0 (0.0) |
| Gatifloxacin | 22 (22.9) 25 (26.0) 49 (51.0) | Azithromycin | 57 (59.4) 26 (27.1) 13 (13.5) |
| Norfloxacin  | 16 (16.7) 29 (30.2) 51 (53.1) | Clarithromycin | 92 (95.8) 3 (3.1) 1 (1.0) |
| Ofloxacin   | 10 (10.4) 13 (13.5) 73 (76.0) | Aztreonam | 27 (28.1) 44 (45.8) 25 (26.0) |
| Pefloxacin  | 83 (86.5) 0 (0.0) 13 (13.5) | Nitrofurans | 36 (38.1) 6 (6.3) 29 (30.4) |
| **Nitrofurans** |                      |             |             |
| Furadonin   | 53 (55.2) 29 (30.2) 14 (14.6) | Cefazolin | 19 (19.8) 8 (8.3) 69 (71.9) |
| Furbin      | 49 (51.0) 39 (40.6) 8 (8.3) | Cephalexin | 75 (78.1) 18 (18.8) 3 (3.1) |
| **2nd gen. Cephalosporins** |                      |             |             |
| Cefaclor    | 49 (51.0) 26 (27.1) 21 (21.9) | Cefdinir | 10 (10.4) 29 (30.2) 57 (59.4) |
| Ceftriaxone  | 18 (18.8) 42 (43.8) 36 (37.5) | Cefotaxime/ clavulanic acid | 48 (50.0) 43 (44.8) 5 (5.2) |
| **3rd gen. Cephalosporins** |                      |             |             |
| Cefoperazone| 90 (93.8) 6 (6.3) 0 (0.0) | Polymyxin-B | 75 (78.1) 18 (18.8) 3 (3.1) |
To visualize the results obtained, the data from the table are additionally presented in the form of figure №1.

**Figure 1.** The structure of antibiotic resistance of strains of Salmonella spp. (n=96).

The data presented in the table and graph No. 1, high antibacterial activity against field Salmonella isolates was observed in amoxiclav, to which 88.8% of isolates were susceptible; fosfomycin and trimetroprim - 80.2%; ofloxacin - 76.0%; cephalexin and enrofloxacin - 71.9%; co-trimoxazole - 67.7%; cefotaxime / clavulanic acid, sulfafurazole, sulfametizole - 59.4%; ciprofloxacin - 58.3%; norfloxacin - 53.1%; gatifloxacin - 51.0%; amoxicillin 41.7%; ceftriaxone - 37.5%; tetracycline - 34.4%;
chlortetracycline - 32.3%; doxycycline - 31.3%; aztreonam - 26.0%; oxytetracycline - 22.9%; cefaclor and gentamicin - 21.9%; spectinomycin - 20.8%; moxifloxacin - 17.7%; furadonin and neomycin - 14.6%; azithromycin and pefloxacin - 13.5%; lomefloxacin - 10.4%; cefazolin - 9.4%; kanamycin, sisomycin and furagin - 8.3%; pipercillin and carbenicillin - 7.3%; polymyxin-B and streptomycin - 5.2%; doripenem - 4.2%; cefdinir and ampicillin - 3.1%; cefepime, cepiprof and cefotaxime - 2.1%; clarithromycin, clindamycin and sulfadiazine - 1.0%; sensitivity to ceftazidime and spiramycin was not manifested in any of the Salmonella cultures. In the course of the study, it was found that 100% of the studied Salmonella cultures were completely resistant to ceftixime, fusidic acid, lincomycin, linezolid, metronidazole, nafcillin, oleandomycin, oxacillin, benzylpenicillin, pristinamycin, rifampicin, and they were not reflected in the table and the graph. High resistance of Salmonella isolates was manifested against clarithromycin - 95.8%; spiramycin, cefepime and cefoperazone - 93.8%; doripenem - 92.8%; sulfadiazine and cefpodoxime - 90.6%; cefotaxime - 87.5%; pefloxacin - 86.5%; cefdinir and clindamycin - 78.1%; clindamycin and neomycin - 72.9%; pipercillin - 71.9%; lomefloxacin - 70.8%; moxifloxacin - 68.8%; streptomycin - 67.7%; cefazolin - 66.7%; kanamycin - 64.6%; azithromycin and sisomycin - 59.4%; furadonin - 55.2%; doxycycline - 52.1%; cefaclor, furagin, tetracycline and oxytetracycline - 51.0%; polymyxin-B and spectinomycin - 50.0%; gentamicin - 47.9%; chlortetracycline - 43.8%; carbenicillin - 41.7%; aztreonam - 28.2%; gatifloxacin - 22.9%; sulfadiazine - 21.9%; cephalaxin, fosfomycin and sulfamethizole - 19.8%; ceftriaxone - 18.8%; norfloxacin - 16.7%; amoxicillin - 15.6%; enrofloxacin and trimetroprim - 12.5%; cefotaxime / clavulanic acid, ofloxacine and ciprofloxacin - 10.4%; co-trimoxazole - 7.3%; amoxiclav - 1.0%, respectively.

Thus, as a result of the studies carried out, a wide circulation of multi-resistant Salmonella cultures at poultry enterprises was established. Prevention of this phenomenon requires constant improvement of measures aimed at combating the uncontrolled use of antibiotics, through systemic monitoring, as well as the use of alternative ways of treatment and prevention of infectious diseases of animals (vaccines, bacteriophages, lysisines, lyozymes, etc.).

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