Bull. Vet. Inst. Pulawy 46, 165-178, 2002

SALMONELLA SEROVARS FOUND IN ANIMALS AND FEEDING STUFFS IN 2001 AND THEIR ANTIMICROBIAL RESISTANCE

ANDRZEJ HOSZOWSKI AND DARIUSZ WASYL

Department of Microbiology,
National Veterinary Research Institute,
24-100 Pulawy, Poland
e-mail: ahosz@piwet.pulawy.pl

The majority of *Salmonella* strains isolated in veterinary laboratories in Poland in 2001 originated from poultry (82%), swine (4%), and animal feeding stuffs (10%). Thirty-two serovars were observed among tested strains. Antimicrobial susceptibility testing revealed the recent trends in *Salmonella* resistance. The increase in the number of resistant strains was observed. Multiresistance occurred mostly in *Salmonella* Typhimurium and to fewer extend in *Salmonella* Hadar and *Salmonella* Choleraesuis. Quinolone efficacy diminished due to high nalidixic acid resistance accompanied with intermediate susceptibility to enrofloxacin.

Key words: *Salmonella*, serovars, antimicrobial resistance.

Poland, as an EU applicant country, has to enhance veterinary diagnostic laboratory practices for monitoring zoonoses and agents thereof, including salmonellosis and *Salmonella*. European Union Member States follow the Zoonosis Directive (92/117/EEC) imposing gathering the epidemiological data concerning number of animal salmonellosis cases and prevalence of isolated *Salmonella* serovars. In most countries testing of antimicrobial resistance of strains originating from animals is performed on regular basis. The data are used to draw up and introduce *Salmonella* control programmes in animals.

Polish veterinary legislation is aimed to conform EU regulations. However, laboratory testing system is not fully efficient and great majority of *Salmonella* isolates of animal, animal feeding stuffs and food origin remain unidentified below species level. Continuous monitoring of antimicrobial resistance is neglected both in human and veterinary medicine and only fragmentary data are available at present (17, 19, 35, 36).

The identification of *Salmonella* serovars within isolates obtained from regional veterinary diagnostic laboratories is one of the tasks to be achieved in the Department of Microbiology (National Veterinary Research Institute – NVRI). The Department participates in WHO Global *Salmonella* Surveillance System as well as in External Quality Assurance System for *Salmonella* identification and susceptibility testing.

The goals of the present study are as follows: 1) to recognize the major sources of *Salmonella* isolations; 2) to range the epidemiological importance of *Salmonella* serovars and their prevalence in poultry, swine and animal feeding stuffs;

3) to investigate antimicrobial resistance of *Salmonella* strains originated from animals and feeding stuffs.

Material and Methods

Salmonella isolation and identification procedures follow PN-ISO 6579 “Microbiology - General guidance on methods for the detection of *Salmonella*”. Bacterial isolates revealing typical growth and biochemical features are further tested with *Salmonella* specific diagnostic sera to determine the antigenic structure according to Kauffmann-White scheme (30).

The identifications covered 791 *Salmonella* strains isolated in 2001 in veterinary regional laboratories (n = 737) and NVRI (n = 54) from poultry (82%), swine (4%), animal feeding stuffs (10%) and other sources (4%). Biochemical and serological testing was performed according to generally accepted rules. Diagnostic sera were purchased from Immunolab (Gdynia, Poland), Sifin (Berlin, Germany) and Statens Serum Institute (Copenhagen, Denmark).

Agar diffusion method according to NCCLS guidelines (26) was applied for antimicrobial susceptibility testing of *Salmonella* isolates (n = 213). The following discs (Oxoid) were used: chloramphenicol (30 µg), kanamycin (30 µg), gentamicin (10 µg), streptomycin (10 µg), tetracycline (30 µg), ampicillin (10 µg), amoxycillin (10 µg), cefuroxime (30 µg), nalidixic acid (30 µg), enrofloxacin (5 µg), ciprofloxacin (5 µg), sulphonamides compound (300 U), sulfametoxazole/trimethoprim (23.75 µg + 1.25 µg) and trimethoprim (5 µg). The results were recorded and analysed with WHONet 5 software.

The independence test at 0.05 significance was used for statistical purposes.

Results

Over 300 000 samples were tested for *Salmonella* in regional veterinary diagnostic laboratories in 1999 (Table 1). The percentage of positive results ranged from 0.7% in food and animal feeding stuffs to 7.3% in samples originating from poultry.

Table 1
Number of samples tested for *Salmonella* in regional diagnostic laboratories in 1999 (data reported to NVRI in 2000)

Samples tested		Number (%) of *Salmonella* positive samples
Origin	Number	
Poultry	124743	9157 (7.3)
Farms and hatcheries	18839	160 (0.9)
Food and feeding stuffs	154562	1107 (0.7)
Other*	4590	165 (3.6)
Total	302734	10589 (3.5)

* swine, pigeons, pheasants, fur and exotic animals, environment.

Table 2

Salmonella isolates by source and serovar, 2001

Salmonella serovars	Source of isolation: poultry – chickens	poultry – geese	poultry – ducks	poultry – turkeys	poultry – farms[1]	swine	pigeons	other animals	feeding stuffs[2]	food[3]	wastes[4]	unknown[5]	total
Agona	3	2		1		1			11		2		20
Anatum									1				1
Braenderup									2				2
Choleraesuis						19				1			20
Cubana									9				9
Derby	1					1			16	1			19
Dessau									7				7
Enteritidis	241	12	4	4	22	2	1	1[a]	5	3		7	302
Fischerkietz				1									1
Gallinarum	12												12
Hadar	20	1	2	1	3				1		1		29
Heidelberg									1				1
Indiana		1	3						1				5
Infantis	10								1		2		13
Isangi	1								3				4
Kingston									4				4
Kottbus			1										1
Liverpool									1				1
Livingstone									2				2
Mbandaka	8				1				2				11
Montevideo	1		1										2
Muenster									1				1
Newlands	1									1			2
Parkroyal	1					1							2
Sandiego	1		3										4
Senftenberg	3			1	1								5
Tennesee	2												2
Thompson	1		1						1				3
Typhimurium	27	13			1	9	2	1[b]	6	1			60
Virchow	7									1			8
Zanzibar	1												1
47:z_6:1,6								1[c]					1
1,4,12 : - : -							2						2
Salmonella R	5	2							3				10
unknown	222								1			1	224
total	568	31	15	8	28	33	5	3	79	8	5	8	791

[1] – farms and hatcheries; [2] – animal feeding stuffs and components, dog feed; [3] – food of animal origin; [4] – wastes and sewage sludge; [5] – source of isolation unknown;
[a] – ostrich; [b] – lanerfalcon; [c] – turtle.

Table 3
Prevalence of *Salmonella* serovars in 2001 compared to 1994 – 2000

Rank	*Salmonella* serovar	Number (%) of *Salmonella* isolates	
		2001	
1.	Enteritidis	302	(53.3)
2.	Typhimurium	60	(10.6)
3.	Hadar	29	(5.1)
4.	Agona	20	(3.5)
5.	Choleraesuis	20	(3.5)
6.	Derby	19	(3.4)
7.	Infantis	13	(2.3)
8.	Gallinarum	12	(2.1)
9.	Mbandaka	11	(1.9)
10.	Cubana	9	(1.6)
	Other [a]	72	(12.7)
	Total (n = 32)	567	(100.0)
		1994 - 2000	
1.	Enteritidis	1592	(58.6)
2.	Typhimurium	212	(7.8)
3.	Mbandaka	116	(4.3)
4.	Agona	98	(3.6)
5.	Choleraesuis	72	(2.7)
6.	Infantis	50	(1.8)
7.	Hadar	43	(1.6)
8.	Isangi	43	(1.6)
9.	Gallinarum	41	(1.5)
10.	Senftenberg	39	(1.4)
	Other [b]	410	(15.1)
	Total (n = 75)	2716	(100.0)

[a] - Anatum, Braenderup, Dessau, Fischerkietz, Heidelberg, Indiana, Isangi, Kingston, Kottbus, Liverpool, Livingstone, Montevideo, Muenster, Newlands, Parkroyal, Sandiego, Senftenberg, Tennesee, Thompson, Virchow, Zanzibar, 47:z_6:1,6, 1,4,12:-:-, rough *Salmonella* (R);

[b] – Alfort, Amsterdam, Anatum, Bareilly, Bovismorbificans, Braenderup, Brandenburg, Bredeney, Cayar, Cerro, Chester, Colindale, Cubana, Derby, Djugu, Driffield, Dublin, Duisburg, Essen, Falkensee, Fischerkietz, Gaminara, Give, Goldcoast, Hawana, Heidelberg, Indiana, Irumu, Istambul, Kaapstad, Kambole, Kapemba, Kiambu, Kottbus, Livingstone, London, Louga, Kedoudou, Minessota, Montevideo, Nakuru, Newlands, Newport, Ngili, Oranienburg, Orion, Parkroyal, Pomona, Potsdam, Putten, Rissen, Sainpaul, Sandiego, Schwarzengrund, Stanley, Tennesee, Thompson, Tschiongwe, Virchow, Westhampton, Worthington, 11:z_4,z_{35}:-, 35:i:z_{35}; 58:z_{52}:z_{35}, 60:z_{52}:z_{53}, rough *Salmonella* (R).

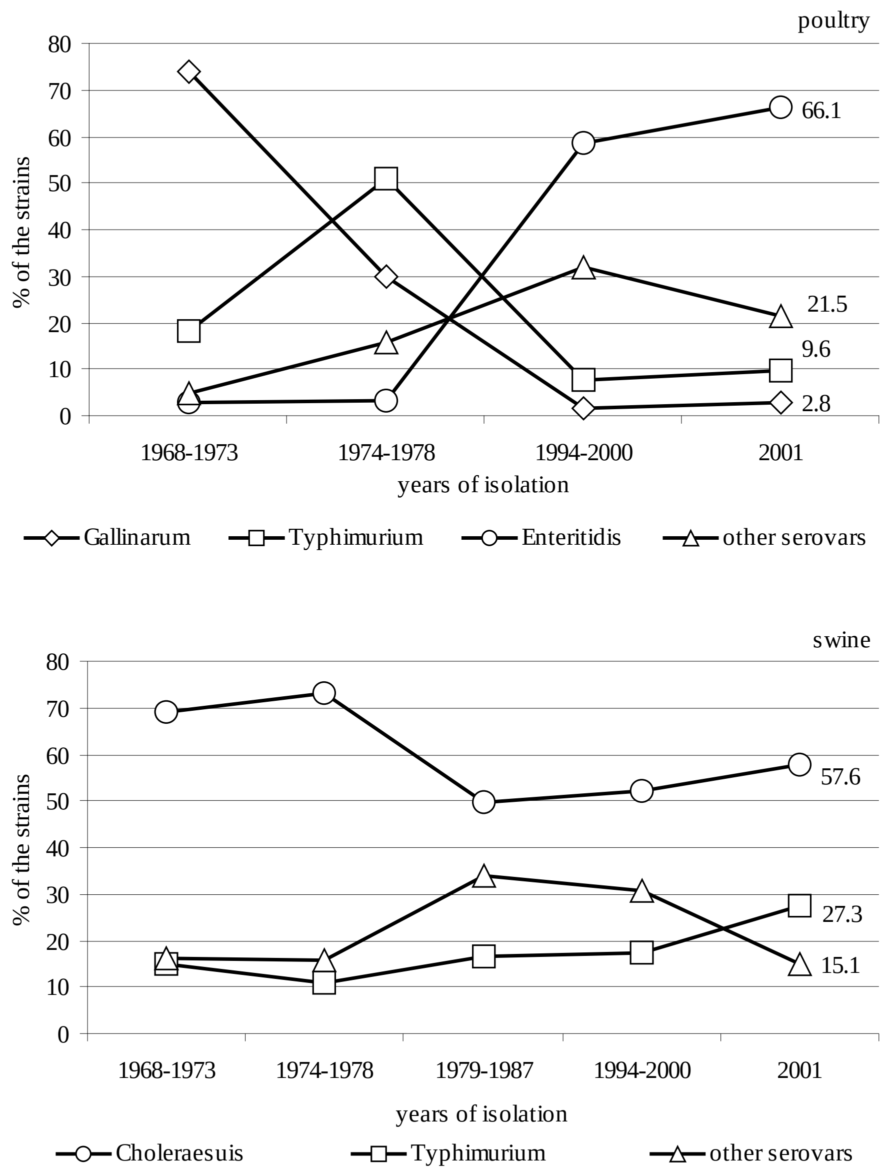

Fig. 1. Prevalence of *Salmonella* serovars in poultry and swine.

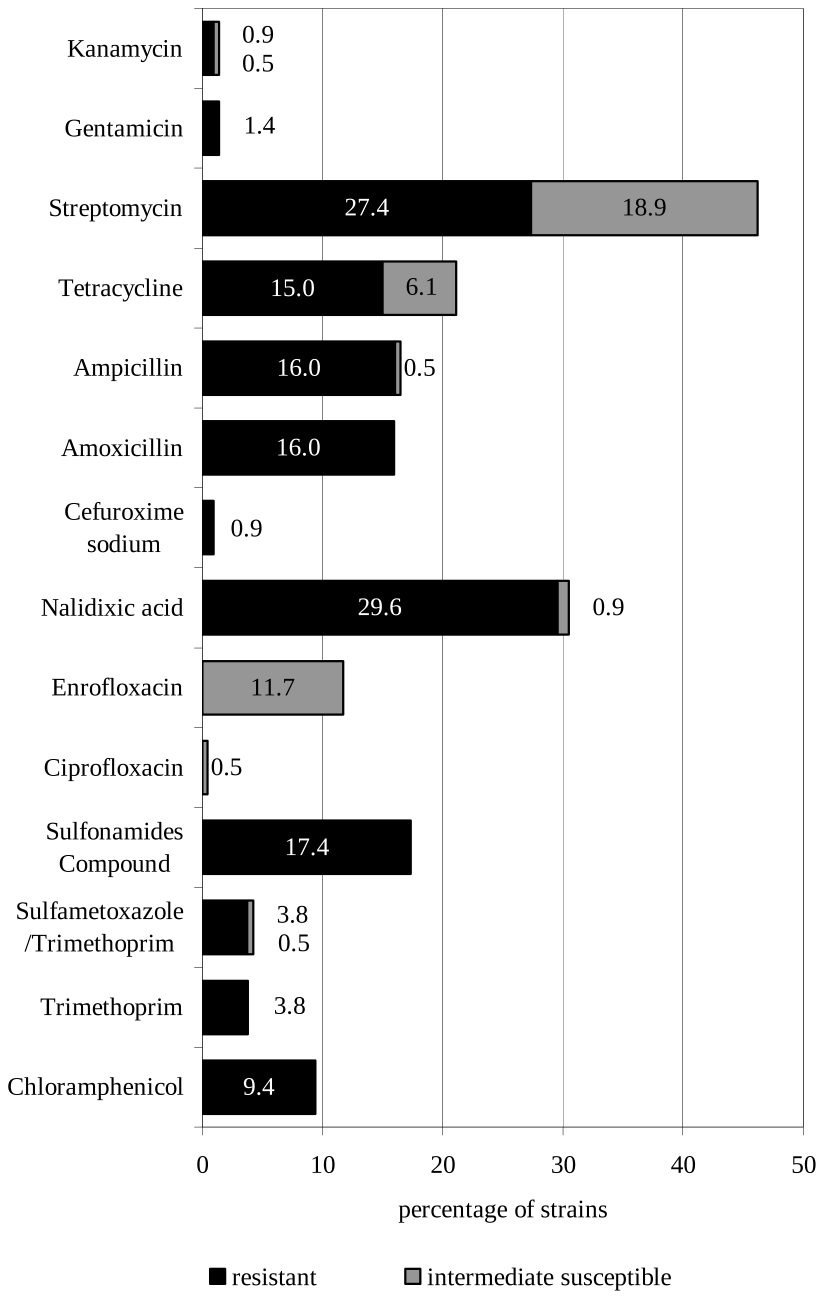

Fig. 2. Reduced antimicrobial susceptibility in *Salmonella* strains (n=213).

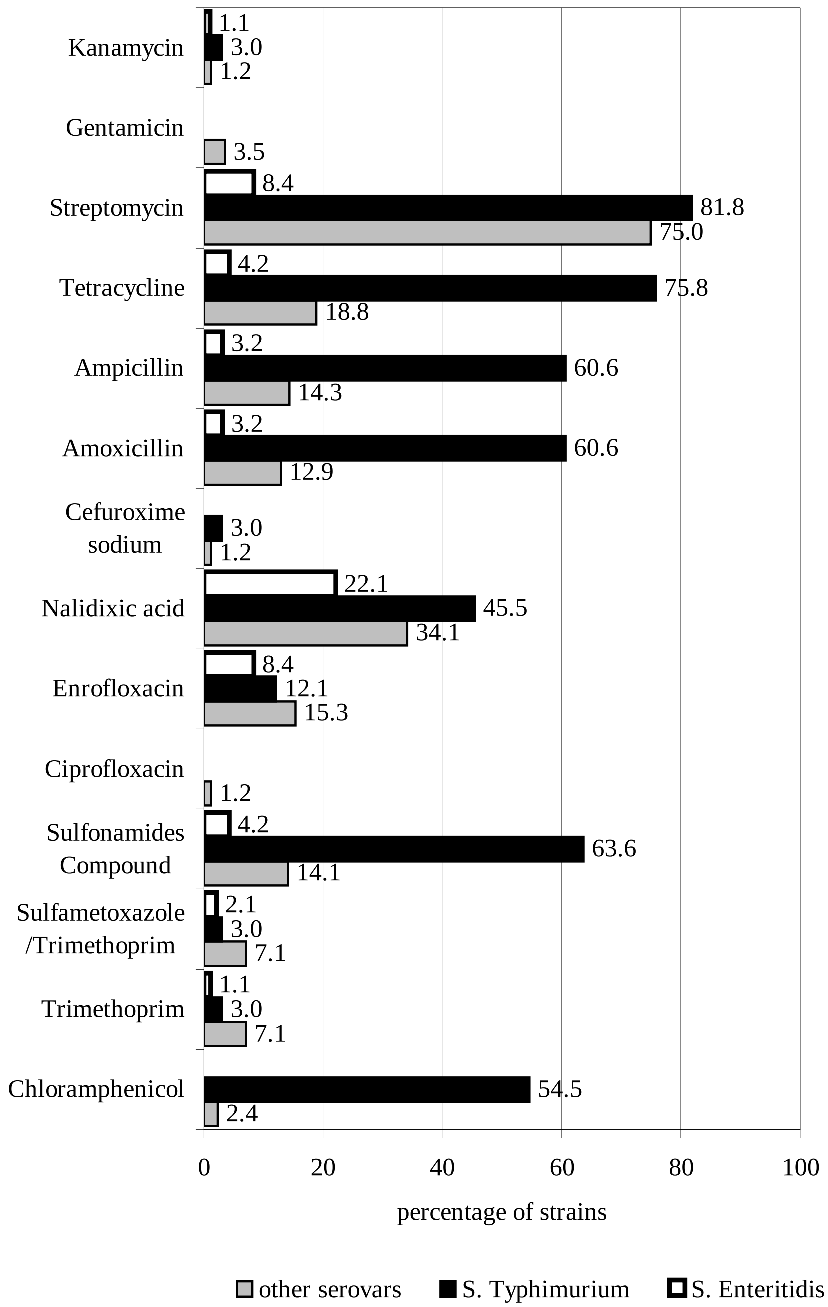

Fig. 3. Reduced antimicrobial susceptibility in *Salmonella* serovars.

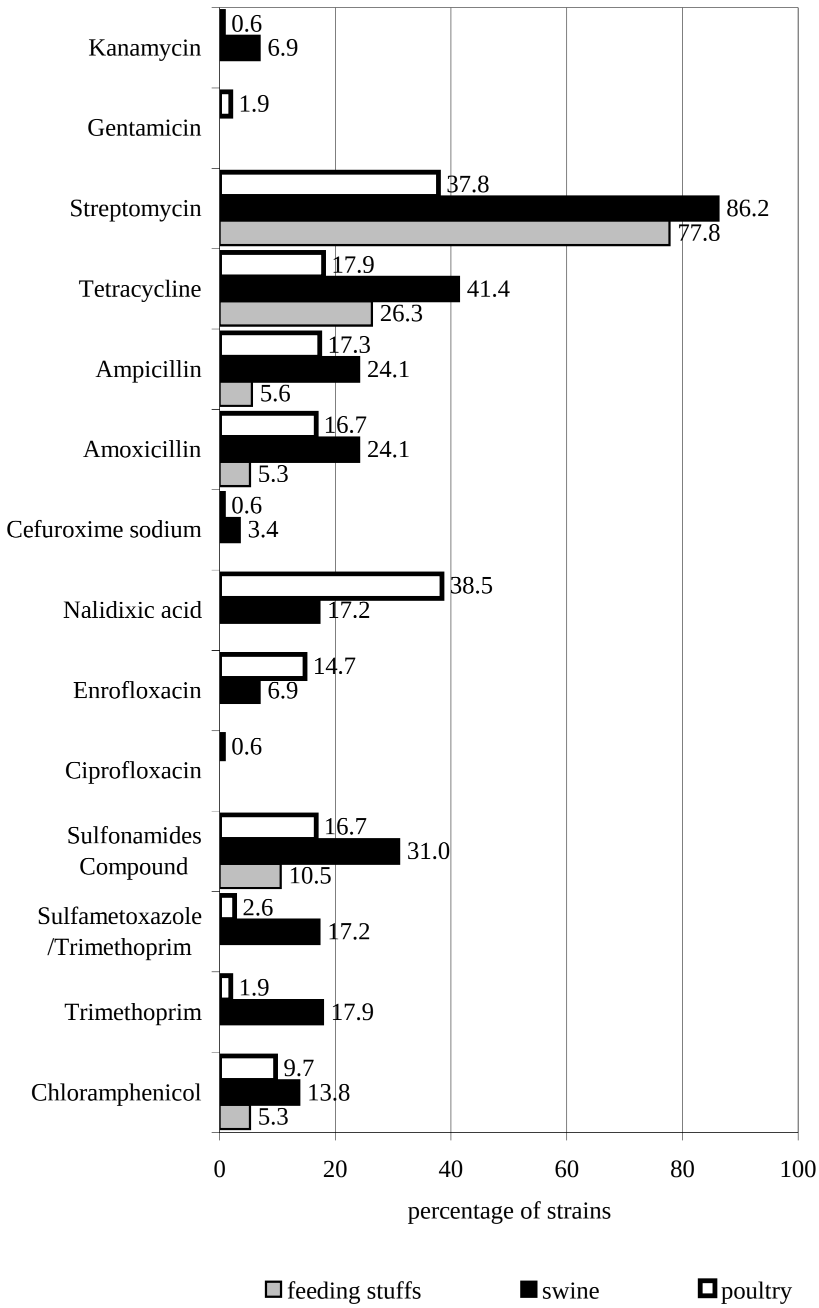

Fig. 4. Reduced antimicrobial susceptibility by source of *Salmonella* isolation.

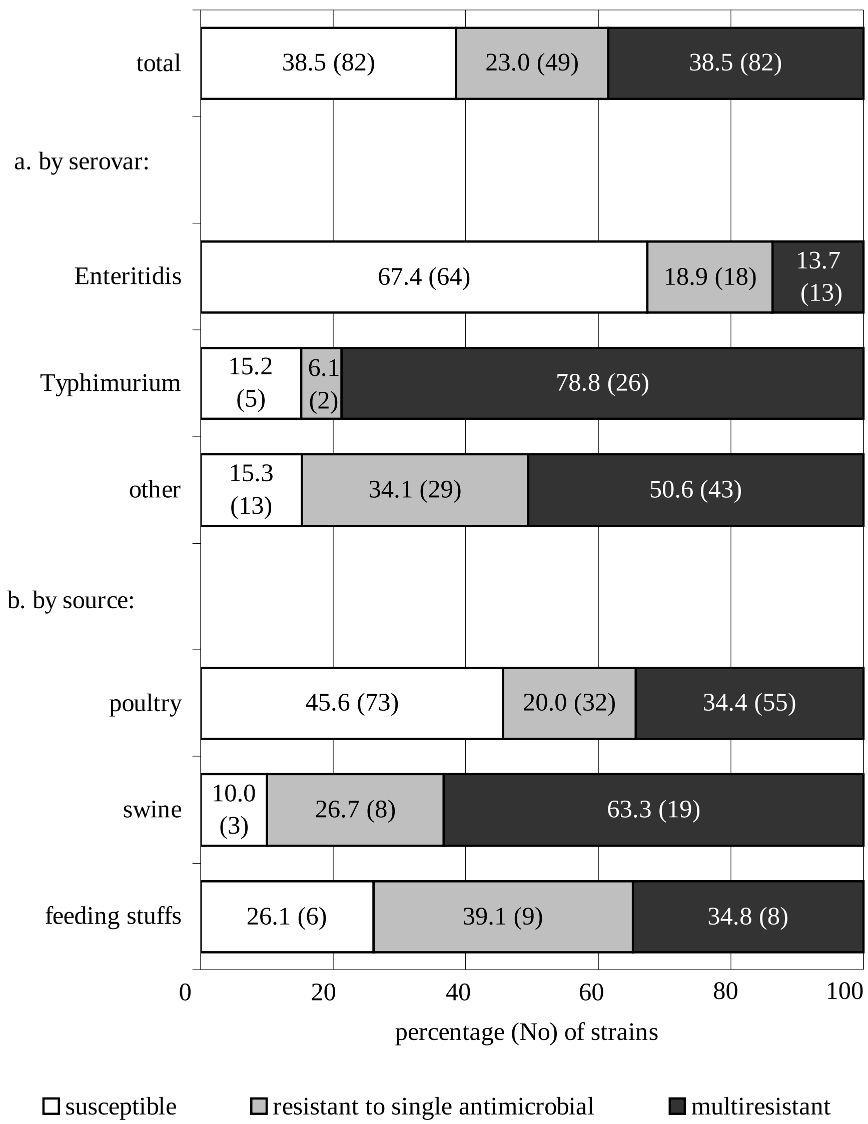

Fig. 5. Character of antimicrobial resistance by *Salmonella* serovars and source of isolation.

Number of *Salmonella* strains tested in 2001 is listed in Table 2. Thirty-two serovars were identified. Some of the strains revealed autoagglutination (*Salmonella* R) or atypical antigenic properties (1,4,12:–:–).

Table 3 presents the list of ten top serovars isolated in 2001 and from 1994 to 2000. *Salmonella* Enteritidis remains the most frequent serovar found, followed by *Salmonella* Typhimurium.

Fig. 1 shows trends in *Salmonella* prevalence in poultry and swine during the past decades in Poland. *Salmonella* Enteritidis and *Salmonella* Choleraesuis predominate in poultry and swine, respectively. *Salmonella* Typhimurium is the second most frequent serovar found in both above mentioned animal species.

Fig. 2 presents reduced antimicrobial susceptibility of *Salmonella* isolates. None of the used antimicrobials was fully efficacious against all the tested strains. Streptomycin was found to be the less effective (27.4% of resistant and 18.9% of intermediate susceptible strains). Nalidixic acid resistance was noted in 29.6% of strains. Quinolone intermediate susceptibility to enrofloxacin, nalidixic acid and ciprofloxacin was recorded in 11.7%, 0.9% and 0.5% of isolates, respectively. Tetracycline, β-lactams, sulphonamides and chloramphenicol reduced susceptibility ranged from 9.4% to 21.1%. Resistance to other antimicrobials was low (0.5% - 4.3%).

Fig. 3 presents differences in the resistance level of *Salmonella* strains among the most prevalent serovars. *Salmonella* Typhimurium was more often ($P \leq 0.001$) resistant to tetracycline, ampicillin, amoxicillin, sulphonamides compound, and chloramphenicol. In comparison to others, *Salmonella* Enteritidis less frequently developed streptomycin resistance ($P \leq 0.001$) and nalidixic acid resistance ($P \leq 0.05$).

Poultry isolates showed low streptomycin ($P \leq 0.001$) and tetracycline resistance ($P \leq 0.05$), whereas high ($P \leq 0.05$) nalidixic acid resistance (Fig. 4). Strains of swine origin were more often ($P \leq 0.001$) resistant to trimethoprim and its combinations with sulphonamides in comparison to poultry isolates.

Eighty-two (38.5%) strains were susceptible to all antimicrobials (Fig. 5). Of the remaining isolates, 23.0% were resistant to single antimicrobials and 38.5% showed multiresistance. Thirty-seven different resistance profiles were observed (data not shown). Multiresistance covering up to 8 antibiotics (data not shown) was noted more frequently in *Salmonella* Typhimurium isolates than in the case of any other serovar ($P \leq 0.001$). *Salmonella* Enteritidis showed the lowest level of resistance among serovars of epidemiological significance. Isolates of swine origin were more resistant than those obtained from poultry and feeding stuffs ($P \leq 0.01$).

Discussion

The obtained results indicate that poultry is the major source of *Salmonella* isolation (Table 1). It is in accordance with other observations (1, 3, 5, 28, 33, 38). S*almonella* infections in other species are underestimated because there is no such surveillance in Poland. Epidemiological data from other countries show that salmonellosis is a serious problems in pigs, cattle, horses or even exotic animals (2, 4, 6, 14, 21, 25, 34, 37, 38). In Poland, salmonellas in swine are recovered mostly from a serious clinical cases or at slaughter, during sanitary inspection of the carcasses. Exotic animals are occasionally found to be *Salmonella* carriers, but the isolates frequently belong to rare or unique serovars (20). Animal feeding stuffs, although not very often

Salmonella contaminated (Table 1), cause a potential risk of transmission of the infection to food animals and further to man (18, 21, 41). Animal and human beings excrete salmonellas with faeces and contaminate the environment (16, 17) thus closing the *Salmonella* circulation cycle (41).

At present, more than 2500 *Salmonella* serovars are known (30). Most of them are extremely rare. Only few serovars (e.g. Enteritidis, Typhimurium, Hadar, *etc.*) are distributed world-wide and are important from epidemiological point of view (31, 33, 41). According to National *Salmonella* Reference Centre (Gdynia, Poland) 192 serovars were noted in Poland (27). Since 1994 we have observed 81 serovars of animal, feeding stuffs and food origin (Table 3). From the late seventies we face the pandemic spread of *Salmonella* Enteritidis. It predominates in humans and animals, mostly in poultry (3, 5, 20, 33, 41). Simultaneously *Salmonella* Gallinarum diminished in poultry in Poland and other countries (5, 20, 31, 32, 41). The other species-specific serovar – *Salmonella* Choleraesuis often occurs in swine world-wide including Poland (7, 11, 39, 41). However, in West European countries this serovar was replaced by *Salmonella* Typhimurium (4, 9, 14, 22). It spreads clonally, by horizontal and vertical routes of transmission in animals as well as through contaminated feeding stuffs (2, 8, 12, 15). *Salmonella* Typhimurium is the second most frequent serovar found for several years in Poland in humans and animals (20, 28). The present study revealed that its prevalence in pigs is increasing (Fig. 1). As shown in Table 2 feeding stuffs are contaminated with a variety of other serovars that cause also infections in animals (18, 19, 20).

Antimicrobial resistance in bacteria has recently attracted more attention (1, 8, 14, 29, 34, 35, 36, 37). In *Salmonella* it is focused mostly on the general increase in number of resistant strains, multiresistance, spread of resistant clones or resistance genes and diminishing efficacy of some antimicrobial classes quite lately introduced into medical and veterinary practice (7, 41). Most of the trends were noted in the present study.

Compared to previous investigation (19), we noted the increase in resistance to most of antimicrobials tested and in the number of multiresistant isolates. The level of resistance depends on serovar and source of *Salmonella* isolation (Figs 3, 4, 5). The highest number of resistant and multiresistant strains was noted in *Salmonella* Typhimurium, including pentaresistant phenotype ACSSuT (ampicillin, chloramphenicol, streptomycin, sulphonamides, and tetracycline). These clones of *Salmonella* Typhimurium DT 104 (data not shown) are spread within animal population and animal feeding stuffs. Multiresistance in other serovars is less frequently encountered, but taking into consideration our results and observations of others (35, 42), *Salmonella* Hadar and *Salmonella* Choleraesuis should be emphasised. *Salmonella* Enteritidis strains are the least resistant of all the tested isolates. Regarding source of isolation (Fig. 5), salmonellas obtained from pigs are more resistant than those of other origin. These data confirmed our earlier observation (39).

Increasing quinolone resistance and expanded-spectrum β-lactamase (ESBL) producing salmonellas have been recently reported (10, 13, 23, 40). Occasionally we observed cephalosporin-resistance and some β-lactam resistance mostly due to multiresistant clones of *Salmonella* Typhimurium. However, none of the strains was an ESBL-producer (data not shown). We noted relatively high number of strains showing nalidixic acid resistance accompanied with reduced susceptibility to enrofloxacin. It proves that *Salmonella* strains found in Poland have accomplished the first step in fluoroquinolone resistance development – single point mutation in gyrase gene. Fortunately, ciprofloxacin, fluoroquinolone not licensed for use in animals, is still of high efficacy (Fig. 2). The quinolone resistance is observed in different serovars and sometimes it is combined with other resistance mechanisms, including multiresistance (24, 29). Therefore, it is considered one of the major threats to disease control and therapy (7, 13, 40).

It is concluded that a continuous monitoring of *Salmonella* infections in animals as well as food and feeding stuffs contamination should be introduced in Poland. Antimicrobial resistance and its fast changes have to be traced. An efficacious system of *Salmonella* identification in veterinary laboratories should provide epidemiological relevant data on regular basis. Gathered data will be crucial in salmonellosis control and national *Salmonella* eradication programs.

References

1. Aarestrup F.M., Bager F., Jensen N.E., Madsen M., Meyling A., Wegener H.C.: Resistance to antimicrobial agents used for animal therapy in pathogenic-, zoonotic and indicator bacteria isolated from different food animals in Denmark: a baseline study for the Danish Integrated Antimicrobial Resistance Monitoring Programme (DANMAP). APMIS, 1998, **106**, 745-770.
2. Aarestrup F.M., Jensen N.E., Baggesen D.L.: Clonal spread of tetracycline resistant *Salmonella* typhimurium in Danish dairy herds. Vet. Rec., 1997, **140**, 313-314.
3. Angulo F.J., Swerdlow D.L.: *Salmonella* enteritidis infections in the United States. J. Am. Vet. Med. Assoc., 1998, **213**, 1729-1731.
4. Baggesen D.L., Aarestrup F.M.: Characterisation of recently emerged multiple antibiotic-resistant *Salmonella enterica* serovar typhimurium DT104 and other multiresistant phage types from Danish pig herds. Vet. Rec., 1998, **143**, 95-97.
5. Bäumler A.J., Hargis B.M., Tsolis R.M.: Tracing the origins of *Salmonella* outbreaks. Science, 2000, **287**, 50-52.
6. Bradley T., Angulo F., Mitchell M.: Public health education on *Salmonella spp*. and reptiles. J. Am. Vet. Med. Assoc., 2001, **219**, 754-755.
7. Chiu C.H., Wu T.L., Su L.H., Chu C., Chia J.H., Kuo A.J., Chien M.S., Lin T.Y.: The emergence in Taiwan of fluoroquinolone resistance in *Salmonella enterica* serotype Choleraesuis. N. Engl. J. Med., 2002, **346**, 413-419.
8. Davies M.A., Hancock D.D., Besser T.E., Rice D.H., Gay J.M., Gay C., Gearhart L., DiGiacomo R.: Changes in antimicrobial resistance among *Salmonella enterica* serovar Typhimurium isolates from humans and cattle in the Northwestern United States, 1982–1997. Emerg. Infect. Dis., 1999, **5**, 802-806.
9. Davies P.R., Bovee F.G., Funk J.A., Morrow W.E., Jones F.T., Deen J.: Isolation of *Salmonella* serotypes from feces of pigs raised in a multiple-site production system. J. Am. Vet. Med. Assoc., 1998, **212**, 1925-1929.
10. Dunne E.F., Fey P.D., Kludt P., Reporter R., Mostashari F., Shillam P., Wicklund J., Miller C., Holland B., Stamey K., Barrett T.J., Rasheed J.K., Tenover F.C., Ribot E.M., Angulo F.J.: Emergence of domestically acquired ceftriaxone-resistant *Salmonella* infections associated with AmpC beta-lactamase. JAMA, 2000, **284**, 3151-3156.

11. Farrington L.A., Harvey R.B., Buckley S.A., Droleskey R.E., Nisbet D.J., Inskip P.D.: Prevalence of antimicrobial resistance in Salmonellae isolated from market-age swine. J. Food. Prot., 2001, **64**, 1496-1502.
12. Fedorka-Cray P.J., Collins K.L., Stabel T.J., Gray J.T., Laufer J.A.: Alternate routes of invasion may affect pathogenesis of *Salmonella* typhimurium in swine. Infection and Immunity, 1995, **63**, 2658-2664.
13. Fey P.D., Safranek T.J., Rupp M.E., Dunne E.F., Ribot E., Iwen P.C., Bradford P.A., Angulo F.J., Hinrichs S.H.: Ceftriaxone-resistant *Salmonella* infection acquired by a child from cattle. N. Engl. J. Med., 2000, **342**, 1242-1249.
14. Gebreyes W.A., Davies P.R., Morrow W.E.M., Funk J.A., Altie C.: Antimicrobial resistance of *Salmonella* isolates from swine. J. Clin. Microbiol., 2000, **38**, 4633-4636.
15. Harris I.T., Fedorka-Cray P.J., Gray J.T., Thomas L.A., Ferris K.: Prevalence of *Salmonella* organisms in swine feed. JAVMA, 1997, **210**, 382-385.
16. Henry D.P., Frost A.J., O'Boyle D., Cameron R.D.A.: The isolation of salmonellas from piggery waste water after orthodox pondage treatment. Australian Vet. J., 1995, **72**, 478-479.
17. Hoszowski A., Wasyl D.: *Salmonella spp*. found in wastes, sewage sludge, compost and their antimicrobial resistance. Bull. Vet. Inst. Pulawy, 2001, **5**, 163-170.
18. Hoszowski A., Wasyl D.: Typing of *Salmonella enterica* subsp. *enterica* serovar Mbandaka isolates. Vet. Microbiol., 2001, **80**, 139-148.
19. Hoszowski A., Wasyl D., Truszczyński M.: Lekooporność szczepów *Salmonella* izolowanych od zwierząt i pasz na terenie Polski w latach 1994 - 1996. Medycyna Wet., 1998, **54**, 33-37.
20. Hoszowski A., Wasyl D., Truszczyński M.: *Salmonella* serovars determined in the National Veterinary Research Institute among strains isolated from veterinary sources in 1994 to 1998. Bull. Vet. Inst. Pulawy, 2000, **44**, 33-38.
21. Jones P.W., Collins P., Brown G.T., Aitken M.: Transmission of *Salmonella* mbandaka to cattle from contaminated feed. J. Hyg. (Lond)., 1982, **88**, 255-263.
22. Letellier A., Messier S., Pere J., Menard J., Quessy S.: Distribution of *Salmonella* in swine herds in Quebec. Vet. Microbiol., 1999, **67**, 299-306.
23. Llanes C., Kirchgesner V., Plesiat P.: Propagation of TEM- and PSE-type beta-lactamases among amoxicillin-resistant *Salmonella spp*. isolated in France. Antimicrob. Agents Chemother., 1999, **43**, 2430-2436.
24. Malorny B., Schroeter A., Helmuth R.: Incidence of quinolone resistance over the period 1986 to 1998 in veterinary *Salmonella* isolates from Germany. Antimicrob. Agents Chemother., 1999, **43**, 2278-2282.
25. Nauerby B., Pedersen K., Dietz H.H., Madsen M.: Comparison of Danish Isolates of *Salmonella enterica* Serovar Enteritidis PT9a and PT11 from Hedgehogs (*Erinaceus europaeus*) and Humans by Plasmid Profiling and Pulsed-Field Gel Electrophoresis. J. Clin. Microbiol., 2000, **38**, 3631-3635.
26. NCCLS.: Performance standards for antimicrobial disk and dilution susceptibility tests for bacteria isolated from animals; tentative standard. M31-T, NCCLS, Wayne, PA, USA, 1997.
27. Państwowy Zakład Higieny, Główny Inspektorat Sanitarny: Meldunek 12/A/01 o zachorowaniach na choroby zakaźne i zatruciach związkami chemicznymi zgłoszonych w okresie od 1.12 do 15.12.2001. Warszawa, 2001.

28. Państwowy Zakład Higieny, Główny Inspektorat Sanitarny: Choroby zakaźne i zatrucia w Polsce w 2000 roku. Warszawa, 2001.
29. Piddock L.J.: Fluoroquinolone resistance in *Salmonella* serovars isolated from humans and food animals. FEMS Microbiol. Rev., 2002, **26**, 3-16.
30. Popoff M.Y. Antigenic formulas of *Salmonella* serovars. 2001. 8th edition. WHO Collaborating Centre for Research on *Salmonella*. Institute Pasteur, Paris, Cedex 15, France.
31. Poppe C., Johnson R.P., Forsberg C.M., Irwin R.J.: *Salmonella* enteritidis and other *Salmonella* in laying hens and eggs from flocks with *Salmonella* in their environment. Can. J. Vet. Res., 1992, **56**, 226-232.
32. Rabsch W., Hargis B.M., Tsolis R.M., Kingsley R.A., Hinz K.H., Tschäpe H., Bäumler A.J.: Competitive exclusion of *Salmonella* Enteritidis by *Salmonella* Gallinarum in poultry. Emerg. Infect. Dis., 2000, **6**, 443-448.
33. Saeed A.M. (ed.): *Salmonella enterica* serovar Enteritidis in humans and animals. Epidemiology, pathogenesis and control. (Ames: Iowa State University Press), 1999.
34. Sternberg S.: Antimicrobial resistance in bacteria from pets and horses. Acta Vet. Scand., 1999, **92** (Suppl.), 37-50.
35. Szych J., Cieślik A., Paciorek J., Kałużewski S.: Multidrug resistance to antibacterial agents of *Salmonella* rods isolated from humans during 1998-1999 period. Med. Sci. Monit., 2000, **6** (Suppl. 3), 71.
36. Szych J., Cieślik A., Paciorek J., Kałużewski St.: Wielooporność na leki przeciwbakteryjne pałeczek *Salmonella enterica* subspecies *enterica* izolowanych w Polsce w latach 1998-2000. Med. Dośw. Mikrobiol., 2001, **53**, 17-29.
37. van Duijkeren E., van Klingeren B., Vulto A.G., Sloet van Oldruitenborgh-Oosterbaan M.M., Breukink H.J., van Miert A.S.: In vitro susceptibility to antimicrobial drugs of 62 *Salmonella* strains isolated from horses in The Netherlands. Vet. Microbiol., 1995, **45**, 19-26.
38. Veterinary and Agrochemical Research Centre (VAR) Belgian National Reference Laboratory for *Salmonella*. Ministry of Small Enterprises, Trades and Agriculture, Brussels, Belgium, 1999.
39. Wasyl D., Hoszowski A. Antibiotic susceptibility in *Salmonella* swine isolates. Salinpork, 4th International Symposium on the Epidemiology and Control of *Salmonella* and other food borne pathogens in Pork. Leipzig, Germany, 2001.
40. Winokur P.L., Brueggemann A., DeSalvo D.L., Hoffmann L., Apley M.D., Uhlenhopp E.K., Pfaller M.A., Doern G.V.: Animal and human multidrug-resistant, cephalosporin-resistant *Salmonella* isolates expressing a plasmid-mediated CMY-2 AmpC-lactamase. Antimicrob. Agents Chemother., 2000, **44**, 2777-2783.
41. Wray C., Wray A. (eds.): *Salmonella* in domestic animals. (Oxon, UK and New York: CABI Publishing), 2000.
42. Yang S.J., Park K.Y., Kim S.H., No K.M., Besser T.E., Yoo H.S., Kim S.H., Lee B.K., Park Y.H.: Antimicrobial resistance in *Salmonella enterica* serovars Enteritidis and Typhimurium isolated from animals in Korea: comparison of phenotypic and genotypic resistance characterization. Vet. Microbiol., 2002, **86**, 295-230.