academic Journals

Vol. 5(3), pp. 37-41, August 2013 DOI: 10.5897/IJGMB2013.0077 ISSN 2006-9863 © 2013 Academic Journals http://www.academicjournals.org/IJGMB

Full Length Research

The genetic relatedness of drug resistant *E.coli* isolates of human and animal origin in Nigeria

Chijioke A. Nsofor^{1,2}, Christian U. Iroegbu¹, Douglas R. Call² and Margaret A. Davies²

¹Department of Microbiology, University of Nigeria, Nsukka, Enugu State, Nigeria. ²Department of Veterinary Microbiology and Pathology, Washington State University, Pullman, USA.

Accepted 30 July, 2013

Molecular epidemiology of human and animal ecovariants of *Escherichia coli* from different regions of Nigeria were studied using their antibiotic susceptibility patterns, plasmid profile and pulsed-field gel electrophoresis (PFGE). *E. coli* was isolated using eosin methylene blue agar (EMB) and identified by conventional microbiological technique. The isolates were tested against 14 antibiotics using the disc diffusion method. PFGE was performed using Xbal as restriction enzyme according to pulse net protocol. Overall, 42 different antibiotics resistance clusters were observed, with each isolate showing resistance to at least four or more drugs tested. Fingerprinting of 140 isolates by PFGE technique and subsequent cluster analysis revealed a diverse *E. coli* population belonging to 47 distinct subtypes. Cluster analysis of the 120 KB plasmid bearing isolates indicated that these isolates belonged to one unique clonal group with ≥80% genetic similarity to each other, their animal or human origin, geographical distribution and clinical or non-clinical source notwithstanding. The sharing of drug resistant strains between human and animal population has shown that identical clones are circulating among human and animal population in the study area.

Key words: Escherichia coli, epidemiology, animal ecovariants, cluster analysis.

INTRODUCTION

Antimicrobial drugs have played an indispensable role in decreasing illness and death associated with infectious diseases in animals and humans (Daniel et al., 2012). However, selective pressure exerted by antimicrobial drug use also has been the major driving force behind the emergence and spread of drug-resistance traits among pathogenic and commensal bacteria (Aarestrup et al., 2008). In addition, resistance has developed after advent of every major class of antimicrobial drugs, varying in time from as short as 1 year (penicillin) to >10 years (vancomycin) (Levy and Marshall, 2004).

Escherichia coli is usually a commensal bacterium of humans and animals. Pathogenic variants cause intestinal and extraintestinal infections, including gastroenteritis, urinary tract infection, meningitis,

peritonitis and septicemia (von Baum and Marre, 2005; Sodha et al., 2006). Therapeutic options vary depending on the type of infection. For example, for urinary tract infections. trimethoprim/sulfamethoxazole and fluoroquinolones are treatments of choice (Taur and Smith, 2007), whereas for Shiga toxin-producing E. coli antimicrobial infections. drug therapy is not recommended (Igarashi et al., 1999). E. coli is sometimes used as a sentinel for monitoring antimicrobial drug resistance in fecal bacteria because it is found more frequently in a wide range of hosts, acquires resistance easily (Erb et al., 2007), and is a reliable indicator of resistance in salmonellae (Womack et al., 2010).

Molecular tools have been used to correlate animal associated pathogens with similar pathogens affecting

humans and to clearly demonstrate transferable resistant genes carried by plasmids common to both animals and humans (Pitout et al., 2009). The possibility of antibiotic resistance genes circulating among humans, animals and the environment constitutes a direct threat to public health. This threat prompts research into emerging resistance mechanisms, novel approaches to antimicrobial efficacy and stringent control measures in the prudent use of antimicrobials in human and animal medicine.

Comparative sequence analyses of different types of antimicrobial resistance genes suggest that they originated and diversified in environmental communities, from which they were mobilized and propagated into ecologically taxonomically and distant bacterial populations. Plasmid exchange between human and animal E. coli strains is a recognized source for the rapid spread of antimicrobial resistance phenotypes (Fang et al., 2008). The potential significance of plasmids in disseminating antimicrobial resistance genes is further enhanced by the association of plasmids with mobile genetic elements, such as transposons, integrons and insertion (IS) elements (Pitout et al., 2009). To better understand the evolution and dissemination of resistance phenotypes from clinical, agricultural, and environmental settings, it is therefore necessary to perform molecular epidemiological analysis of resistant isolates at three different levels when comparing whole genomes, single plasmids and PFGE.

Although, few studies have evaluated antimicrobial resistant *E. coli* in Nigeria (Okeke et al., 1999, Aibinu et al., 2004, and Umolu et al., 2006), most available data are specific to strains that are pathogenic either to human or animals. Little or no data exist on the molecular epidemiology of human or animal drug resistant *E. coli* isolates in Nigeria. This study, is therefore, aimed at determining the genetic relatedness of drug resistant *E. coli* isolates of human and animal origin in Nigeria.

MATERIALS AND METHODS

Study population

The study population included humans (who were either ill or presumptively healthy) and variety of apparently healthy domestic livestock viz: cattle, goats, swine and chicken obtained from five geopolitical zones of Nigeria viz: South-East, South-West, South-South. North-Central and North-North. In the South-South and South-East, clinical specimens were collected at the University of Port Harcourt Teaching Hospital, Port Harcourt, Rivers State and the Abia State University Teaching Hospital, Aba, Abia State, respectively. The Lagos State University Teaching Hospital, Ikeja, Lagos was the site of specimen collection for the South-West, while the National Hospital, Abuja and Military Reference Hospital, Kaduna State were the sources of specimens from the North-Central and North-North respectively. All samples from these hospitals were clinical specimens from patients who were having gastroenteritis or similar illness. Healthy undergraduate students of Madonna University, Elele were included in the study for the isolation of human commensal E. coli. These individuals reported

no exposure to antibiotics for six months prior to sampling and each person received an explanation of the study objectives and consent form for inclusion in the study. All sampling procedures were in accordance with guidelines of the National Health Research Ethics Committee, Nigeria (www.nhrec.net). All the animals included in this study were (at the time of specimen collection) not showing any sign of ill-health. The cattle and goat specimens came from the Obinze livestock market Owerri, Imo State while the Madonna University Poultry, Anambra State was the source of poultry specimens. The specimens from swine came from a farm located at the Ogborhil area of Abia state. There was no documented evidence of antibiotics use in the farms from which the specimens were collected, although the management of the poultry farm indicated occasional antibiotics use at this facility.

Specimen collection, cultivation and identification of E. coli

Fecal droppings were randomly collected from goats, cattle, pigs and chicken; and care was taken to avoid collecting more than one fecal sample per individual animal. Feces were packed in a sterile plastic container and were transported to the laboratory in ice-box. One gram of each animal's feces was homogenized in 9 ml of sterile saline solution, then the volume of the homogenate was made up to 10 ml to get a 10% suspension. The contents were mixed thoroughly and 10-fold serially diluted and 0.2 ml inoculums from each dilution plated out on Eosin Methylene Blue agar (EMB) (Oxoid, England). Human fecal specimens were streaked directly on EMB agar. No antibiotic was included in the EMB agar plates used for the cultivation. The inoculated plates were incubated overnight at 37°C. A single colony on EMB with green metallic sheen taken to be E. coli was selected from an individual fecal sample for further characterization. E. coli was fully identified using conventional microbiological tests-Indole positive, methyl red positive and citrate negative (Cheesbrough, 2000).

Antibiotics susceptibility testing

The antibiotics susceptibility pattern of the isolates was determined using the disk diffusion method (Cheesbrough, 2000), on Mueller-Hinton agar (Oxoid, England). Inhibition zone diameter values were interpreted using standard recommendations of the Clinical Laboratory Standard Institute (CLSI, 2006). Susceptibility was tested against ampicillin (10 μ g), amoxycillin/clavulanic acid (20/10 μ g), tetracycline (30 μ g), gentamicin (10 μ g), cefpodoxime (10 μ g), cefoxitin (30 μ g), cefpirome (30 μ g), streptomycin (10 μ g), chloramphenicol (30 μ g), nalidixic acid (30 μ g), sulfamethoxazole-trimethoprim (10 μ g) (cotrimaoxazole), cephalothin (30 μ g), nitrofurantoin, ceftriaxone (30 μ g) and cefotaxine (30 μ g) (Oxoid, England). *E. coli* ATCC 25922 was included as a reference strain.

Pulsed-field gel electrophoresis (PFGE)

PFGE was performed using Xbal (New England Biolabs) according to pulse net protocol (www.cdc.gov/pulsenet/protocols.htm). Briefly, DNA fragments were resolved by electrophoresis in 1% SeaKem Gold agarose gels with a CHEF DRII machine (Bio-Rad), using 0.5x Tris-borate-EDTA as the buffer. Gels were run for 18 h at 14°C, using a linearly ramped switching time from 2.2 to 63.8 s and a voltage of 6.0 V/cm². After electrophoresis, the gels were stained in 400 ml of deionized water containing 40 μ l of 10 mg/ml of ethidium bromide for 20 min on a rocker and distained three times for 20 min each with distilled water. Bands were visualized by UV transilluminator (Fisher Scientific) and photographed using Alpha imager (Alpha Innotech Corporation,San Leandro, CA, USA). Digitalized gel images were saved and subjected to analysis with

HA 29 SE APSX KM TES.CXF.MADCP.CD.CTFX HH 25 SS APSX KM TES.CXF.MADCP.CD.CTFX AB 5 NC APSX KM TES.CXF.FAMCP.CD.CTFX AB 5 NC APSX KM TES.CXF.FAMCP.CD.CTFX AB 5 NC APSX KM TES.CXF.FCD.CDT CA 7 COW APSX KM TES.CXF.FCD.CDT CA 7 COW APSX KM TES.CXF.FCD.CDT CA 7 COW APSX KM TES.CXF.FCP.CD.CTFX CA 7 COW APSX KM TES.CXF.FCP.CD.CTFX CA 7 COW APSX KM TES.CXF.FCP.CD.CTFX CA 7 COW APSX KM TES.CXF.FXALCP CO 12 CO AT APSX KM TES.CXF.FXALCP CO 12 CO AT APSX KM TES.CXF.FXALCP CO 12 CO AT APSX KM TES.CXF.FXALCP CO 13 CO XT APSX KM TES.CXF.FXALCP CO 14 CO AT APSX KM TES.CXF.FXALCP CO 15 CA 7 POULTRY APSX KM XM CP CO 16 CO AT APSX KM TES.CXF.FXALCP CO 17 POULTRY APSX KM XM CP CD CTFX PR	Dice (Ope 1,00%) (Tel 2,0%-2.5%) 100-0.0% 30-0.0%) (0.0%-100.0%)	Strain ID	Origin	Drug Resistance profile
AB 5 NC APSX.ONN.NTE.S.CHF.AUX.OP.OD.FX AB 5 SE APONTE.S.NF.F.AUCR.OP.CD.CT APONTE.S.NF.F.S.C.A.R.OP.CD.CT APONTE.S.NF.F.S.C.A.R.OP.CD.CT APONTE.S.NF.F.S.C.A.R.OP.CD.CT APONTE.S.NF.F.AUX.OP.CD.CT APONTE.S.NF.F.S.C.A.R.OP.CD.CT APONTE.S.C.F.F.AUCP APONTE.S.C.F.F.AUX.OP.CD.CT APONTE.S.C.F.F.AUX.OP APONTE.S.C.F.F.AUX.OP APONTE.S.C.F.F.AUX.OP APONTE.S.C.F.F.F	xba1	AA 29	SE	AP,SX,GN,TE,S,C,KF,F,AM,CP,CD,CT
AA 8 SE APONTE 8.5 F.JM.CR.DP.DD.CT CA 7 SE APONTE 8.5 F.JM.CR.DP.DD.CT CA 9 COW APSNTE 8.C.DF.PD.CT APSNTE 8.C.DF.PD.CT APSNTE 8.C.DF.PM.CR.DP.DD.TFX CA 9 COW APSNTE 8.C.DF.PM.CR.DP.DD.TFX CA 10 CON APSNTE 8.C.DF.PM.CR.DP.DD.TFX CA 10 CON APSNTE 8.C.DF.PM.CR.DP.DD.TFX CA 11 CA 11 CA 11 APSNTE 8.C.DF.PM.CR CA 13 CON APSNTE 8.C.DF.PM.CR CD.DT.FX CA 13 CON APSNTE 8.C.DF.PM.CR CD.DT.FX PL 14 POULTRY APSNTE 8.C.DF.F.DR CD.TFX PL 14 POULTRY APSNTE 8.C.DF.F.DR CD.TFX PL 2 POULTRY APSNTE 8.C.F.F.DR.DCD.TFX EMS PL 2 POULTRY APSNTE 8.C.F.F.P.DR.DT CD.TFX PL 2 POULTRY APSNTE 8.C.F.F.		PH 2	SS	AP,SX,TE,S,C,KF,,AM,CR,CP,CD,CT,FX
CA 7 COW APSIXTES.CARCP.CDCTRX CA 7 COW APSIXTES.CARCP.CDCTRX CA 7 COW APSIXTES.CARCP.CDCTRX CA 7 COM APSIXTES.CARF.PARCP CA 7 COM		AB 5	NC	AP,SX,GN,NA,TE,S,C,KF,F,AM,CP,CD,FX
CA 8 COW APSKTEB.CARP.PCT WD 11 NON APSKTEB.CARP.PCT GO 15 GOAT APSKTEB.CARP.PCT GO 16 GOAT APSKTEB.CARP.AMCP GO 17 APSKTEB.CARP.AMCP GO 18 GOAT APSKTEB.CARP.AMCP F1 PIG APSKTEB.CARF.AMCP GO 10 GOAT APSKTEB.CARF.AMCP GO 110 GOAT APSKTEB.CARF.AMCP GO 111 FLIT POULTRY APSKTEB.CARF.AMCP FLIT POULTRY APSKTEB.CARF.POP PL17 POULTRY APSKTEB.CARF.POP PL17 POULTRY APSKTEB.CARF.POP PL18 SS APSKTEB.CARF.POP PL17 POULTRY		AA 8	SE	AP,GN,TE,S,KF,F,AM,CR,CP,CD,CT
K0 11 NN APSXTES.CRF.FAM.CR G0 16 G0 AT APSXTES.CRF.FAM.CR G0 12 G0 AT APSXTES.CRF.FAM.CR G0 14 G0 7 APSXTES.CRF.FAM.CR G0 15 PG APSXTES.CRF.FAM.CR G0 12 G0 AT APSXTES.CRF.FAM.CR G0 13 GONT APSXTES.CRF.FAM.CR G0 14 GONT APSXCEM.FF.MCR G0 15 GONT APSXTES.CRF.FAM.CR G0 16 GONT APSXCEM.FF.MCR G0 17 APSXCEM.FF.MCR.PCD.CDTFX H1 DUITRY APSXCEM.FF.MCP.DD.CDTFX PL 17 POULTRY APSXS.CRF.FAM.CR G0 18 GONT APSX.CNA.TE.S.CKF.F.CD PL 17 POULTRY APSXS.CNA.TE.S.CKF.F.CD PL 20 POULTRY APSXS.CNA.TE.S.CKF.F.CD PL 21 POULTRY APSX.CNA.TE.S.CKF.F.CD PL 22 POULTRY APSXS.CNA.FE.S.CKF.F.AM.CR PL 23 POULTRY APSXS.CNA.FE.S.CKF.F.AM.CR PL 24 POULTRY APSX.CNA.TE.S.CKF.F.AM.CR <		CA 7	COW	AP,GN,TE,S,C,F,CR,CP,CD,CT,FX
G0 16 G0 AT AP SK ON TES CREP AMACP G0 12 G0 AT AP SK TES CREP AMACP G0 12 G0 AT AP SK TES CREP F0 16 PI SK AP SK TES CREP FAMACR F0 16 PI SK AP SK TES CREP FAMACR F0 16 PI SK AP SK TES CREP FAMACR F0 16 PI SK SC REF FAMACR AP SK TES CREP FAMACR G0 10 G0 AT AP SK TES CREP FAMACR G1 10 NN AP SK TES CREP FAMACR F1 14 POULTRY AP SK TES CREP FAM CR F1 14 POULTRY AP SK TES CREP FAM CR F1 14 POULTRY AP SK TES CREP AMCR F1 15 SW AP SK TES CREP AMCR F1 15 SW AP SK TES CREP AMCR F1 15 SW AP SK		CA 9	COW	AP,SX,TE,S,C,KF,CP,CT
OO6 OOAT APSKTES.CKFF.AM.CR P016 P03 APSKTES.CKFF.AM.CR P017 P03 COM APSKTES.CKFF.AM.CR P017 P03 COM APSKTES.CKFF.CP P117 P04.TTY APSKTES.CKFF.CP P17 P117 P04.TTY APSKTES.CKFF.CP P17 P120 P04.TTY APSKTES.CKFF.CP P17 P1217 P04.TTY APSKTES.CKFF.CP P17 P178 P04.TTY APSKTES.CKFF.CP P17 P120 P04.TTY APSKTES.CKFF.CP P17 P178 P18 APSKTES.CKFF.AM.CP P17 P14 P18 SK APSK		KD 11	NN	AP,SX,TE,S,C,AM,CR,CP,CD
012 0017 APSXTES.CXFF AM.CR 013 00AT APSXTES.CXFF AM.CP 010 00AT APSXTES.CXFF AM.CP 010 00AT APSXTES.CXFF AM.CP 0110 00AT APSXTES.CXFF AM.CR 0111 00AT APS		GO 16	GOAT	AP,SX,GN,TE,S,C,KF,F,AM,CP
PG 16 PG 3 APSKTED.KFF PG 17 PG 3010 GOAT APSKTED.KFF PG 10 GOAT APSKTED.KFF APSKTED.KFF PG 110 GOAT APSKTED.KFF APSKTED.KFF PG 110 GOAT APSKTED.KFF APSKTED.KFF PG 110 GOAT APSKTED.KFF APSKTED.KFF PG 111 PG 113 GOAT APSKTED.KFF PG 114 POULTRY APSKTED.KFF APSKTED.KFF PG 114 POULTRY APSKTED.KFF APSKTED.KFF PL 27 POULTRY APSKTED.KFF APSKTED.KFF PL 28 POULTRY APSKTED.KFF APSKTED.KFF PL 29 POULTRY APSKTED.KFF APSKTED.KFF PL 24 POULTRY APSKTED.KFF APSKTED.KFF PL 35 APSKTED.KFF APSKTED.KFF APSKTED.KFF PL 412 SW APSKTED.KFF APSKTED.KFF PL 42 SW APSKTED.KFF APSKTED.KFF PG 30 PG 30 PG 30 PG 30	10 11 10 111	GO 6	GOAT	AP,SX,TE,S,CR,CP
PG 17 PG 37 PG 37 PG 37 PG 37 PG 37 PS 35 CMF F2P (CF) X PG 37 PS 35 CMF F2P (CD) CT FX PF 14 POULTRY PS 35 CMF F2P (CD) CT FX PF 14 POULTRY PS 35 CMF F2P (CD) CT FX PF 14 POULTRY PS 35 CMF F2P (CD) CT FX PF 14 POULTRY PS 35 CMF F2P (CD) CT FX PF 14 SS PS 35 CMF F2P (CD) CT FX PF 14 SS PS 35 CMF F2P (CD) CT FX PF 14 SS PS 35 CMF F2P (CD) CT FX PF 14 SS PS 35 CMF F2P (CD) CT FX PF 14 SS PS 35 CMF F2P (CD) CT FX PF 14 SS PS 35 SS 35 PS 35 SS 35 PS 35 PS 35 PS 35	1 1 MIN 221201	GO 12	GOAT	AP,SX,TE,S,C,KF,F,AM,CR
G0 10 G0 17 AP SX 50.475 PC TFX JA 10 NN AP SX 60N AF EC OFF FAM CRC, 0P, DD CT G0 13 COW AP SX 60N AF EC OFF FAM CRC, 0P, DD CT G0 14 POULTRY AP SX 60N AF EC OFF FAM CRC, 0P, DD CT P1 17 POULTRY AP SX 60N AF EC OFF FAM CRC P2 2 POULTRY AP SX 60N AF EC OFF FAM P1 2 POULTRY AP SX 60N AF EC OFF FAM CRC P1 2 POULTRY AP SX 60N AF EC OFF FAM CP CD CTFX P1 35 AP SX 60N AF EC OFF FAM CP CD CTFX P1 47 POULTRY AP SX 60N AF EC OFF FAM CP CD CTFX P1 48 SX AP SX 60N AF EC OFF FAM CP CD CTFX P1 48 SX AP SX 60N AF EC OFF FAM CP CD CTFX P1 41 SX AP SX 60N AF EC OFF FAM CP CD CTFX P1 41 SX AP SX 60N AF EC OFF FAM CP CD CTFX P1 41 SX AP SX 750 AF FAM CP CD CTFX P1 41 SX AP SX 750 AF FAM CP CD CTFX P1 41 SX AP SX 750 AF FAM CP CD CTFX P2 42 F00 AP SX 750 AF FAM CP CD CTFX P2 43	ſĹ	PG 16	PIG	AP,SX,TE,S,C,KF
A 10 NN APSKONALTE.CKFF.AMCR.OP.CD.CT CA 13 COW APSKONAKTE.AK CA 13 COW APSKONAKTE.AKF.PM CA 13 COW APSKONAKTE.CKFF.AMCR APSKONATES.CKF.AMCR PL 14 POULTRY APSKS.CKFF.AMCR PL 14 POULTRY APSKS.CKFF.AMCR PL 20 POULTRY APSKS.CKFF.AMCR APSKONATES.CKFF.OP.CD LA 16 SW APSKONATES.CKFF.OP.CD LA 16 SW APSKONATES.CKFF.OP.CD LA 16 SW APSKONATES.CKFF.AMCP CA 24 COW APSKITES.CKFF.AMCP CA 24 COW APSKITES.CKFF.AMCP CA 25 COW APSKITES.CKFF.AMCP.CD.CTT PG 15 PIG APSKITES.CKFF.AMCP.CD.CTT AA 18 SE APSKITES.CKFF.AMCP.CD.CTT AA 28 SE APSKITES.CKFF.AMCP.CD.CTT AA 38 SE APSKITES.CKFF.AMCP.CD.CTT AA 39 SK APTES.CKFF.AMCP.CD.CTT AA 30 SE APSKITES.CKFF.AMCP.CD.CTT AA 30 SE		PG 17	PIG	AP,SX,TE,C,KF,F,AM,CP
CA 13 COW APSKOR XEFF.M PL 14 POULTRY APSKOR XEFF.MCR PL 14 POULTRY APSKOR XEFF.MCR PL 17 POULTRY APSKOR XEFF.PC PL 2 POULTRY APSKOR XEFF.CPCD PL 2 POULTRY APSKOR XEFF.CPCD PL 2 POULTRY APSKOR XEFF.CPCD PL 2 POULTRY APSKOR XEFF.CPCD EM6 SS APSKOR XEFF.CPCD EM6 APSKOR XEFF.CPCD EM6 SS APSKOR XEFF.CPCD EM6 APSKOR XEFF.C		GO 10	GOAT	AP,SX,S,C,KF,F,CP,CT,FX
0018 GONT APSXNETESACKFANCR PL14 POULTRY APSXNETESACKFANCR PL32 POULTRY APSXNETESACKFANCR PL32 POULTRY APSXNETESACKFACR PL32 POULTRY APSXNETESACKFFCP PL32 POULTRY APSXNETESACKFFCP PL32 POULTRY APSXNETESACKFFCP PL33 POSKONFARACR PL44 SS APSKONATESACKFFCP PL44 SS APSKONATESACKFFCP PL44 SS APSKONATESACKFFCPCD PL44 SS APSKONTESACKFFANCP PL412 SW APSKONTESACKFFANCP PG15 PIG APSKONTESACKFFANCPCOCT PG15 PIG APSKONTESACKFFANCPCOCTFX A28 SE APSKONTESACKFFANCPCOCTFX A32 SE APSKONTESACKFFANCPCOCTFX A32 SE APSKONTESACKFFANCPCOCTFX A32 SE APSKONTESACKFFANCPCOCTFX A33 SE APSKONTESACKFFANCPCOCTFX A33 SE APSKONTESA		JA 10	NN	AP,SX,GN,NA,TE,C,KF,F,AM,CR,CP,CD,CT
PL 14 POULTRY AP SKXEF ALOR POLIC TFX PL 17 POULTRY AP SKXEF S.C.KFF.CP PL 20 POULTRY AP SKX.ES.C.KFF.ADC PL 20 POULTRY AP SKX.CNAFT.ES.C.KFF.CP.CD PL 20 POULTRY AP SKX.CNAFT.ES.C.KFF.CP.CD PL 21 POULTRY AP SKX.CNAFT.ES.C.KFF.CP.CD PL 26 POULTRY AP SKX.CNAFT.ES.C.KFF.CP.CD PL 46 SS AP SKX.CNAFT.ES.C.KFF.CP.CD PL 47 SS AP SKX.CNAFT.ES.C.KFF.CP.CD PL 48 SS AP SKX.ES.C.KFF.AM.CP.CD.CTX PH 48 SS AP SKX.ES.C.KFF.AM.CP.CD.CTX CA24 COW AP SKX.ES.C.KFF.AM.CP.CD.CT CA25 COW AP SKX.ES.C.KFF.AM.CP.CD.CT CA26 COW AP SKX.ES.C.KFF.AM.CP.CD.CT CA26 COW AP SKX.ES.C.KFF.AM.CP.CD.CT CA26 COW AP SKX.ES.C.KFF.AM.CP.CD.CT CA27 SE AP SKX.ES.C.KFF.AM.CP.CD.CTT CA28 SE AP SKX.ES.C.KFF.AM.CP.CD.CTFX CA22 SE AP SKX.ES.C.KFF.AM.CR.CD.CTFX		CA 13	COW	AP,SX,GN,S,KF,F,AM
PL:7 POULTRY APSKTEGKFFGP PL:20 POULTRY APSKTEGKFFGAM PL:20 POULTRY APSKTEGKFFGAM PC:20 POULTRY APS		GO 18	GOAT	AP,SX,NA,TE,S,C,KF,AM,CR
PL20 POULTRY APSXS.D.KF.FAM.OR PL2 POULTRY APSXS.D.KF.FAM.OR PL2 POULTRY APSXS.D.KF.FAM.OR PL2 POULTRY APSXS.D.KF.FAM.OR L1 SS APSX.GNAN.TE.S.CKF.FAM.OR L1 SV APSX.GNA.TE.S.CKF.FAM.OR L1 SV APSX.TE.S.CKF.FAM.OR L1 SV APSX.TE.S.CKF.FAM.OR L1 SV APSX.TE.S.CKF.FAM.OR CA24 COW APSX.TE.S.CKF.FAM.OR CA23 COW APSX.TE.S.CKF.FAM.OR CA24 COW APSX.TE.S.CKF.FAM.OR CA23 COW APSX.TE.S.CKF.FAM.OR CA24 COW APSX.TE.S.CKF.FAM.OR CA23 COW APSX.TE.S.CKF.FAM.OR CA24 COW APSX.TE.S.CKF.FAM.OR CA24 COW APSX.TE.S.CKF.FAM.OR CA23 SE APSX.TE.S.CKF.FAM.OR A1 SE APSX.TE.S.CKF.FAM.OR A2 SE APSX.TE.S.CKF.FAM.OR.OP.OD.TK A3 SE <td></td> <td>PL 14</td> <td>POULTRY</td> <td>AP,SX,KF,F,AM,CP,CD,CT,FX</td>		PL 14	POULTRY	AP,SX,KF,F,AM,CP,CD,CT,FX
PL2 POULTRY APSXS.DKF.FM.QPC.DCTFX EM6 SS APSX.GNNA,TE.S.C.KF.F.M.QPC.DD EM6 SS APSX.GNNA,TE.S.C.KF.F.M.QPC.DD L118 SW APSX.GNNA,TE.S.C.KF.F.M.QPC.DD L118 SW APSX.GNNA,TE.S.C.KF.F.M.QPC.DD L112 SW APSX.GNNA,TE.S.C.KF.F.M.QPC.DD CA31 COW APSX.GNTES.C.KF.F.M.QPC.DD CA31 COW APSX.GNTES.C.KF.F.M.QPC.DD.CT CA31 COW APSX.GNTES.C.KF.F.M.QPC.DD.CT CA31 COW APSX.GNTES.C.KF.F.M.QPC.DD.CT CA31 SE APSX.GNTES.C.KF.F.M.QPC.DD.CT AA28 SE APSX.GNTES.C.KF.F.M.QPC.DD.CT AA28 SE APSX.GNTES.C.KF.F.AM.QPC.DD.CT AA28 SE APSX.GNTES.C.KF.F.AM.QPC.DD.CT AA28 SE APSX.GNTES.C.KF.F.AM.QPC.DD.CTFX AA28 SE APSX.GNTES.C.KF.F.AM.QPC.DD.CTFX AA28 SE APSX.GNTES.C.KF.F.AM.QPC.DD.CTFX AA29 SE APSX.GNTES.C.KF.F.AM.QPC.DD.CTFX AA22 SE APSX.GNTES.C.KF.F.AM.Q		PL 17	POULTRY	AP,SX,TE,S,C,KF,F,CP
EM 6 SS AP SK (ON AN TE 5.0 KF F.CD) LA 16 SW AP SK (ON AN TE 5.0 KF F.CP, CD) LA 16 SW AP SK (ON AN TE 5.0 KF F.CP, CD) LA 16 SW AP SK (ON AN TE 5.0 KF F.CP, CD) LA 16 SW AP SK (ON CHARCHARD) LH 12 SW AP SK (ON CHARCHARD) CA 24 COW AP SK (ON CHE C.CKF F.AM CP CD) CT CA 23 COW AP SK (ON CHE C.CKF F.AM CP CD) CT CA 24 COW AP SK (ON CHE C.CKF F.AM CP CD) CT CA 25 COW AP SK (ON CHE C.CKF F.AM CP CD) CT CA 26 COW AP SK (ON TE S.CKF F.AM CP CD) CT PG 15 PIG AP SK (ON TE S.CKF F.AM CP CD) CT FX A112 SE AP SK (ON TE S.CKF F.AM CP CD) CT FX A12 SE AP SK (ON TE S.CKF F.AM CP CD) CT FX A12 SE AP SK (ON TE S.CKF F.AM CP CD) CT FX A33 SE AP SK (ON TE S.CKF F.AM CP CD) CT FX A33 SE AP SK (ON TE S.CKF F.AM CP CD) CT FX A33 SE AP SK (ON TE S.CKF F.AM CP CD) CT FX A4 </td <td></td> <td>PL 20</td> <td>POULTRY</td> <td>AP,SX,S,C,KF,AM,CR</td>		PL 20	POULTRY	AP,SX,S,C,KF,AM,CR
EM 6 SS AP SKON ATES.CKF.F.OP.CD LA 16 SW AP SKON TES.CKF.F.AMCP.CDF.K PH 4 SS AP SKON TES.CKF.F.AMCP.CDF.K CA 24 COW AP SKON TES.CKF.F.AMCP.CDF.K CA 24 COW AP SKON TES.CKF.F.AMCP.CDF.K CA 24 COW AP SKON TES.CKF.F.AMCP.CD.CT CA 23 COW AP SKITES.CKF.F.AMCP.CD.CT CA 24 COW AP SKITES.CKF.F.AMCP.CD.CT CA 25 COW AP SKITES.CKF.F.AMCP.CD.CT AA 1 SE AP SKITES.CKF.F.AMCP.CD.CT AA 1 SE AP SKITES.CKF.F.AMCP.CD.CT AA 1 SE AP SKITES.CKF.F.AMCP.CD.CT AA 12 SE AP SKITES.CKF.F.AMCP.CD.CT AA 12 SE AP SKITES.CKF.F.AMCP.CD.CTF.K AA 23 SE AP SKITES.CKF.F.AMCR.CD.CTF.K AA 24 SE AP SKITES.CKF.F.AMCR.CD.CTF.K AA 25 SE AP SKITES.CKF.F.AMCR.CD.CTF.K AA 28 SE AP SKITES.CKF.F.AMCR.CD.CTF.K AA 25 SE AP SKITES.CKF.F.AMCR.CD.CTF.K		PL 2	POULTRY	AP,SX,S,C,KF,F,AM,CP,CD,CT,FX
Line So AP SUBMATE SAF PH4 SS AP SUTES.CAF ALCP PH4 SS AP SUTES.CAFF ALCP Line SW AP SUTES.CAFF ALCP Line SW AP SUTES.CAFF ALCP CA24 COW AP SUTES.CAFF ALCP CA23 COW AP SUTES.CAFF ALCP CA24 COW AP SUTES.CAFF ALCP CA25 COW AP SUTES.CAFF ALCP PG 15 PIG AP SUTES.CAFF ALCP AA SE AP SUTES.CAFF ALCP COLTFX AA SE AP SUTES.CAFF ALCP COLTFX AA SE AP SUTES.CAFF ALCP COLTFX AA SE AP SUTES.CAFF ALCR CP COLTFX AA SE AP SUTES.CAFF ALCR CP CO		EM 6	SS	AP,SX,GN,NA,TE,S,C,KF,CP,CD
PH4 SS APSXTES.CKFFAMCP LA12 SW APSXGN.TE.S.C.KFFAMCP.CD.FX CA24 COW APSXGN.TE.S.C.KFFAMCP.CD.FX CA24 COW APSXGN.TE.S.C.KFFAMCP.CD.CT CA24 COW APSXTES.C.KFFAMCP.CD.CT CA25 COW APSXTES.CKFFAMCP.CD.CT CA26 COW APSXTES.CKFFAMCP.CD.CT CA26 COW APSXTES.CKFFAMCP.CD.CT CA26 COW APSXTES.CKFFAMCP.CD.CT CA27 SE APSXTES.CKFFAMCP.CD.CT AA1 SE APSXTES.CKFFAMCP.CD.CT AA1 SE APSXTES.CKFFAMCP.CD.CT AA1 SE APSXTES.CKFFAMCP.CD.CT AA1 SE APSXTES.CKFFAMCR.CD.CT AA1 SE APSXTES.CKFFAMCR.CD.FX AA28 SE APSXTES.CKF.PAMCR.CD.CT AA19 SE APSXTES.CKF.PAMCR.CD.CT AA22 SE APSXTES.CKF.PAMCR.CD.CT AA2 SE APSXTES.CKF.PAMCR.CD.CT AA2 SE APSXTES.CKF.PAMCR.CD.CT		EM 8	SS	AP,SX,GN,NA,TE,S,C,KF,F,CP,CD
LA 12 SW AP SKOTE SCAFF AMCP CO.FX CA 24 COW AP SKITES.CKFF AMCP CO.FX CA 25 COW AP SKITES.CKFF AMCP CO.CT CA 26 COW AP SKITES.CKFF AMCP CO.CT CA 27 NN AP SKITES.CKFF AMCP CO.CT CA 28 COW AP SKITES.CKFF AMCP COC.CT CA 28 COW		LA 16	SW	AP,GN,NA,TE,S,KF
CA 24 COW AP SXTES.CAFF.CP.CT CA 34 COW AP SXTES.CAFF.CP.CT CA 35 COW AP SXTES.CAFF.CP.CT CA 35 COW AP SXTES.CAFF.CP.CT CA 35 COW AP SXTES.CAFF.CD PG 30 PIG AP SXTES.CF.F.AM AA 1 SE AP SXTES.CF.F.AM AA 1 SE AP SXTES.CF.F.AM.CTFX AA 31 SE AP SXTES.CF.F.AM.CTFX AA 41 SE AP SXTES.CF.F.AM.CTFX AA 32 SE AP SXTES.CF.P.CD CT L1 9 SW AP SXTES.CF.P.CD CT L4 35 SE AP SXTES.CF.P.CD CT L4 35 SE AP SXTES.CF.P.CD CT L4 35 SE AP SXTES.CF.P.AM.CR.CD CD.TFX AA 22 SE AP SXTES.CF.F.AM.CR.CD CD.TFX AA 24 SE AP SXTES.CF.F.AM.CR.CD CD.TFX AA 4 SE AP SXTES.CF.F.AM.CR.CP.CD.CT K0 28 NN AP SXTES.CF.F.AM.CR.CP.CD.CT K0 28 NN AP SXTES.CF.F.AM.CR.CP.CD.CT		PH 4	SS	AP,SX,TE,S,C,KF,AM,CP
CA 31 COW APARTES.CARD.OCT CA 25 COW APARTES.CARF.AMCO.CT PG 20 PIG AP.SX.TE.S.C.KF.F.AM. PG 30 PIG AP.SX.TE.S.C.KF.F.AM A2 35 E AP.SX.TE.S.C.KF.F.AM. A2 38 SE AP.SX.TE.S.C.KF.F.AM. A2 38 SE AP.SX.TE.S.C.KF.F.AM. A2 38 SE AP.SX.TE.S.KF.F.AM. A2 38 SE AP.SX.TE.S.KF.P.AM.CP.CD.CTT A4 28 SE AP.SX.TE.S.KF.P.AM.CP.CD.CTT A4 29 SE AP.SX.TE.S.KF.P.AM.CR.CP.CD.CTFX A4 20 SE AP.SX.TE.S.KF.P.AM.CR.CP.CD.CTFX A3 35 SE AP.SX.TE.S.KF.F.AM.CR.CP.CD.CTFX A4 2 SE AP.SX.TE.S.KF.F.AM.CR.CP.CD.CTFX A4 3 SE AP.SX.TE.S.KF.F.AM.CR.CP.CD.CTFX A4 3 SE AP.SX.TE.S.KF.F.AM.CR.CP.CD.CTFX A4 3 SE AP.SX.TE.S.K.F.F.AM.CR.CP.CD.CTFX A4 3 SE AP.SX.TE.S.K.F.F.AM.CR.CP.CD.CTFX A4 3 SE AP.SX.TE.S.K.F.F.AM.CR.CP.CD.CTFX		LA 12	SW	AP,SX,GN,TE,S,C,KF,F,AM,CP,CD,FX
CA 25 COW APSKITES.CKFFAMCPCOLCT PG 20 PIG APSKITES.CKFFAMCPCOLCT APSKITES.CKFFAMCPCOLCT AA1 SE APSKITES.CKFFAMCPCOLCTFX AA2 SE APSKITES.CKFFAMCPCOLCTFX AA1 SE APSKITES.CKFFAMCPCOLCTFX AA1 SE APSKITES.CKFFAMCPCOLCTFX AA1 SE APSKITES.CKFFAMCRCPCOLCTFX AA1 SE APSKITES.CKFFAMCRCPCOLCTFX AA2 SE APSKITES.CKFFAMCRCPCOLCTFX AA2 SE APSKITES.CKFFAMCRCPCOLCTFX AA2 SE APSKITES.CKFFAMCRCPCOLCTFX AA2 SE APSKITES.CKFFAMCRCPCOLCTFX AA2 SE APSKITES.CKFFAMCRCPCOLCTFX AA3 SE APSKITES.CKFFAMCRCPCOLCTFX AA4 SE APSKITES.CKFFAMCRCPCOLCTFX AC2 SE APSKITES.CKFFAMCRCPCOLCTFX AC4 SE APSKITES.CKFFAMCRCPCOLCTFX AC4 SE APSKITES.CKFFAMCRCPCOLCTFX AC4 SE APSKITES.CKFFAMCRCPCOLCTFX AC5 SCOW APSKITES.CKFFAMCRCPCOLCTFX APSKITES.CKFFAMCRCPCOLCTFX AC4 NN APSKITES.CKFFAMCRCPCOLCTFX APSKITES.CKFFAMCRCPCOLCT AC5 COW APSKITES.CKFFAMCRCPCOLCTFX APSKITES.CKFFAMCPCOLCTFX APSKITES.CKFAMCPCOLCTFX APSKITES.CKFAMCPCOLCTFX APSKITES.CKFAMCPCOL		CA 24	COW	AP,SX,TE,S,C,KF,F,CP,CT
PG 20 PG 20 <td< td=""><td></td><td>CA 31</td><td>COW</td><td>AP,NA,TE,S,C,AM,CD,CT</td></td<>		CA 31	COW	AP,NA,TE,S,C,AM,CD,CT
PG 15 PG 35 PG 35 <td< td=""><td></td><td>CA 25</td><td>COW</td><td>AP,SX,GN,TE,S,C,KF,F,AM,CP,CD,CT</td></td<>		CA 25	COW	AP,SX,GN,TE,S,C,KF,F,AM,CP,CD,CT
AA 1 SE AP SXTED KF FAMCTRX AA 28 AP SXTED KF FAMCPC DCUTT AA 28 AA 12 SE AP SXTED KF AMCPC DCUTT AA 12 SE AP SXTED KF AMCRCP COUTT L1 19 SW AP SXTED KF AMCRCP COUTT LA 12 SE AP SXTED KF AMCRCP COUTFX AA 22 SE AP SXTED KF AMCRCP COUTFX AA 23 SE AP SXTED KF AMCRCP COUTFX AA 24 SE AP SXTED KF AM CRCP COUTFX AA 25 SE AP SXTED KF AM CRCP COUTFX AA 4 SE AP SXTED KF AM CRCP COUTFX AA 25 SE AP SXTED KF AM CRCP COUTFX AA 18 SE AP SXTED KF AM CRCP COUTFX AA 18 SE AP SXTED KF AM CRCP COUTFX AA 18 SE AP SXTED KF FAM CRCP COUTFX AA 18 SE AP SXTED KF FAM CRCP COUTFX AA 18 SE AP SXTED KF FAM CRCP COUTFX AA 18 SE AP SXTED KF FAM CRCP COUTFX AA 19 SE AP SXTED KF FAM CRCP COUTFX AA 18 <td< td=""><td></td><td>PG 20</td><td>PIG</td><td>AP,SX,TE,S,C,KF,F,CD</td></td<>		PG 20	PIG	AP,SX,TE,S,C,KF,F,CD
AA 28 SE AP 5X CON ESCREF AMICOP COLCT AA 14 SE AP 5X TE 5.0 KF F AMICOP COLCTFX AA 12 SE AP 5X TE 5.0 KF F AMICOP COLCTFX AA 12 SE AP 5X TE 5.0 KF F AMICOP COLCTFX AA 22 SE AP 5X TE 5.0 KF F AMICOP COLCTFX AA 22 SE AP 5X TE 5.0 KF F AMICOP COLCTFX AA 33 SE AP 5X TE 5.0 KF F AMICOP COLCTFX AA 33 SE AP 5X TE 5.0 KF F AMICOP COLCTFX AA 34 SE AP 5X TE 5.0 KF F AMICOP COLCTFX AA 4 SE AP 5X TE 5.0 KF F AMICOP COLCTFX AA 4 SE AP 5X TE 5.0 KF F AMICOP COLCTFX AA 4 SE AP 5X TE 5.0 KF F AMICOP COLCTFX AA 2 SE AP 5X TE 5.0 KF F AMICOP COLCTFX AA 2 SE AP 5X TE 5.0 KF F AMICOP COLCTFX AA 2 SE AP 5X TE 5.0 KF F AMICOP COLCTFX AA 2 SE AP 5X TE 5.0 KF F AMICOP COLCTFX AA 2 SE AP 5X TE 5.0 KF F AMICOP COLCTFX AA 2 SE AP 5X TE 5.0 KF F AMICOP COLCTFX AA 2 <		PG 15	PIG	AP,SX,TE,S,KF,F,AM
AA 14 SE AP SKTEB.CKPF.AM.CRC.PCD.CTFX AA 12 SE AP SKTEB.CKPF.AM.CRC.PCD.CTFX AA 12 SE AP SKT.B.S.CKPF.CD.CT AA 22 SE AP SKT.B.S.CKPF.AM.CRC.PCD.CTFX AA 22 SE AP SKT.B.S.CKF.F.AM.CRC.PCD.CTFX AA 23 SE AP SKT.B.S.CKF.F.AM.CRC.PCD.CTFX AA 24 SE AP SKT.B.S.CKF.F.AM.CRC.PCD.CTFX AA 44 SE AP SKT.B.S.CKF.F.AM.CRC.PCD.CTFX AA 45 SE AP SKT.B.S.CKF.F.AM.CRC.PCD.CTFX AA 46 SE AP SKT.B.S.CKF.F.AM.CRC.PCD.CTFX AA 47 SE AP SKT.B.S.CKF.F.AM.CRC.PCD.CTFX AA 48 SE AP SKT.B.S.CKF.F.AM.CRC.PCD.CTFX AA 49 SE AP SKT.B.S.CKF.F.AM.CRC.PCD.CTFX AA 49 SE AP SKT.B.S.CKF.F.AM.CRC.PCD.CTFX AC 20 SE AP SKT.B.S.CKF.F.AM.CRC.PCD.CTFX AC 20 SE AP SKT.B.S.CKF.F.AM.CRC.PCD.CTFX AC 20 SE AP SKT.B.S.CKF.F.AM.CRC.PCD.CTFX AC 20 SE AP SKT.B.S.CKF.F.AM.CRC.PCD.CT AC 20 SE AP SKT.B.S.CKF.F.AM.CRC.PCD.CT AC 20 SE AP SKT.B.S.CKF.F.AM.CRC.PCD.CT AC 20 SE AP SKT.B.S.CKF.F.AM.CRC.PCD.CTFX AC 20 SE AP SKT.B.S.CKF.F.AM.CRC.PCD.CT AC 20 SE AP SKT.B.S.CKF.F.AM.CRC.PCD.CTFX AC 20 SE AP SKT.B.S.CKF.F.AM.CTES.CKF.F.AM.CTES.CKF.F.AM		AA 1	SE	AP,SX,TE,C,KF,F,AM,CT,FX
AA 12 SE AP 5XTEB.CKPE DOT AA 12 SE AP 5XTEB.CKPE DOT AP 5X.00.TES.AMCR.ODFX AP 5X.00.TES.AMCR.ODFX AA 22 SE AP 5X.TEB.CKPF.AMCR.OP.CD.OTFX AA 3 SE AP 5X.TEB.CKFF.AMCR.OP.CD.OTFX AA 3 SE AP 5X.TEB.CKFF.AMCR.OP.CD.OTFX AA 4 SE AP 5X.TEB.CKFF.AMCR.OP.CD.OTFX AA 4 SE AP 5X.SAN.TEB.CKFF.AMCR.OP.CD.CTFX AA 4 SE AP 5X.TEB.CKFF.AMCR.OP.CD.CTFX AA 4 SE AP 5X.TEB.CKFF.AMCR.OP.CD.CTFX AA 4 SE AP 5X.SAN.TEB.CKFF.AMCR.OP.CD.CTFX AA 4 SE AP 5X.TEB.SCFF.AMCR.OP PG 7 PIG AP 5X.TEB.SCFF.AMCR.OP P1 0 POULTRY AP 5X.TEB.SCFF.AMCR.OP P1 10 POULTRY AP 5X.TEB.SCFF.AMCR.OP P1 10 POULTRY AP 5X.TEB.SCFF.AMCR.OP P1 40 POULTRY AP 5X.TEB.SCFF.AMCP.OP.CD.CTFX NA 47 55 SF AP AD 7D.OTFX AP 53 AP 53 AP 53.XN.TEB.SCFF.AMCP.OP.CD.CTFX NN		AA 28	SE	AP,SX,GN,TE,S,C,KF,F,AM,CP,CD,CT
LA 19 SW AP 5X,GN TE 5,AM,CR CD FX A2 2 SE AP 5X,TS,JK F,AM,CR,CP,CD CT FX A3 3 SE AP 5X,TS,JK F,AM,CR,CP CD CT FX A3 2 SE AP 5X,TS,JK F,AM,CR,CP CD CT FX A4 2 SE AP 5X,TS,JK F,FAM,CR,CD CT FX A4 4 SE AP 5X,TS,JK F,FAM,CR,CD CT FX A4 4 SE AP 5X,TS,JK F,FAM,CR CD CT FX A18 SE AP 5X,TS,JK F,FAM,CR CD CT FX A19 SE AP 5X,TS,JK F,FAM,CR CD CT FX A7 SE AP 5X,TS,JK F,FAM,CR A119 SE AP 5X,TS,JK F,FAM,CR A119 SE AP 5X,TS,JK F,FAM,CR A119 SE AP 5X,TS,JK F,FAM,CR A110 SE AP 5X,TS,JK F,FAM,CR A110 SE AP 5X,TS,JK F,FAM,CR A110 SE AP 5X,TS,JK F,FAM,CR A111 SE AP 5X,TS,JK F,F		AA 14	SE	AP,SX,TE,S,C,KF,AM,CR,CP,CD,CT,FX
A12 SE AP.SINGHI-LEND COLTFX A33 SE AP.SINGHI-LENF, AMC.RCP.CD.CTFX A3 SE AP.SINGHI-LENF, AMC.RCP.CD.CTFX A3 SE AP.SINGHI-LENF, AMC.RCP.CD.CTFX A4 SE AP.SINGHI-SC.KFF, FAM.CR.CP.CD.CTFX A4 SE AP.SINGHI-SC.KFF, FAM.CR.CP.CD.CTFX A4 SE AP.SINGHI-SC.KFF, FAM.CR.CP.CD.CTFX A4 SE AP.SINGHI-SC.KFF, FAM.CR.CP.CD.CTFX A5 SV AP.SINGHI-SC.KFF, FAM.CR.CP.CD.CTFX A5 SV NN AP.SINGHI-SC.KFF, FAM.CR.CP.CD.CTFX A6 NN AP.SINGHI-SC.KFF, FAM.CR.CP.CD.CTFX <td></td> <td>AA 12</td> <td>SE</td> <td>AP,SX,TE,S,C,KF,CD,CT</td>		AA 12	SE	AP,SX,TE,S,C,KF,CD,CT
AA 3 SE AP SX.GN.TE.XF.F.AM.CR.CP.CD.CT.FX LA 8 SW AP SX.T.S.C.KF.F.AM.CR.CP.CD.CT.FX AA 2 SE AP XT.T.S.C.KF.F.AM.CR.CP.CD.CT.FX AA 4 SE AP SX.T.S.C.KF.F.AM.CR AF 7 PIG AP SX.S.AM.CP.CD.CT AA 18 SE AP SX.T.S.KF.F.AM.CR AA 27 SE AP SX.T.S.KF.F.CR AP SX.T.S.KF.F.CR AP SX.T.S.KF.F.AM.CR AA 27 SE AP SX.T.S.KF.F.CR AP CR 20 CT AA 28 COW AP SX.T.S.KF.F.AM.CR 20 CT TK		LA 19	SW	AP,SX,GN,TE,S,AM,CR,CD,FX
LA 8 SW AP 5X TES.CKF FAM CR.CD, CT.FX AA 2 SE AP XF: AM.CR.CPF.DD.CT.FX AA 4 SE AP SX TES.CL.KF.FAM.CR.CDC.DC.T AA 4 SE AP SX TES.CL.KF.FAM.CR.CDC.DC.T AA 18 SE AP SX TES.CL.KF.FAM.CR.CP.CD.CT AA 18 SE AP SX TES.CL.KF.FAM.CR.CP.CD.CT AA 18 SE AP SX TES.CL.KF.FAM.CR.CP.CD.CT K0 28 NN AP SX.CDN.AG.KF.FAM.CR.CP.CD.CT K0 28 NN AP SX.TES.CL.KF.FAM.CR.CP.CD.CT K0 28 NN AP SX.TES.CL.KF.FAM.CR.CP.CD.CT K0 20 NN AP SX.TES.CL.KF.FAM.CR.CP.CD.CT K0 21 NN AP SX.TES.CL.KF.F.CR.CP.CD.CT K0 24 NN AP SX.TES.CL.KF.F.CR.CP.CD.CT K0 24 NN AP SX.TES.CL.KF.F.AM.CP.CD.CT K0 25 NN AP SX.TES.CL.KF.F.AM.CP.CD.CT.FX K0 3 NN <td< td=""><td></td><td>AA 22</td><td>SE</td><td>AP,SX,TE,S,KF,AM,CR,CP,CD,CT,FX</td></td<>		AA 22	SE	AP,SX,TE,S,KF,AM,CR,CP,CD,CT,FX
A 2 SV APSN.TES.JKF.FAM.CP.DOLTFX A 4 SE APSN.TES.JKF.FAM.CP.DOLTFX A 4 SE APSN.TES.JKF.FAM.CP.DOLTFX A 4 SE APSN.TES.JKF.FAM.CP.DOLT A 4 IS SE APSN.TES.JKF.FAM.CP.CD.DT A 4 IS SE APSN.TES.JKF.FAM.CP.CD.DT A 4 IS SE APSN.TES.JKF.FAM.CP.CD.DT KD 4 NN APSN.TES.JKF.FAM.CP.CD.TT KD 4 NN APSN.TES.JKF.FAM.CP.CD.TT KD 4 NN APSN.TES.JKF.FAM.CP.CD.TT KD		AA 3	SE	AP,SX,GN,TE,KF,F,AM,CR,CP,CD,CT,FX
AA4 SE AP.SXTEB.CKF.FAM. PG7 PIG AP.SX.B.M.OP.CD.CT A18 SE AP.SX.TB.S.CKF.FAM.CR A22 NN AP.SX.TB.S.CKF.FAM.CR A22 SE AP.SX.TB.S.CKF.FAM.CR A22 NN AP.SX.TB.SX.CF.FAM.CR A22 SE AP.SX.TB.SX.FF.FAM.CR A227 SE AP.SX.TB.SX.FF.AM.CP.OD.CT KD2 NN AP.SX.TB.SX.FF.AM.CP.OD.CT KD4 NN AP.SX.TB.SX.FF.AM.CP.OD.CT KD4 NN AP.SX.TB.SX.FF.AM.CP.OD.CT KD3 NN AP.SX.TB.SX.FF.AM.CP.OD.CT <td< td=""><td></td><td>LA 8</td><td>SW</td><td>AP,SX,TE,S,C,KF,F,AM,CR,CD,CT,FX</td></td<>		LA 8	SW	AP,SX,TE,S,C,KF,F,AM,CR,CD,CT,FX
PG 7 PIG AP SX 5.4M CD DCT AA 18 SE AP SX TE S.C.KF F.AM CR.CP CD FX K0 28 NN AP SX TE S.C.KF F.AM CR.CP CD FX K0 28 NN AP SX TE S.C.KF F.AM CR.CP P1 10 POULTRY AP SX TE S.KF F.AM CR.CP CD CT K0 2 NN AP SX TE S.KF F.AM CR.CP CD CT K0 4 NN AP SX TE S.KF F.AM CR.CP CD CT K0 4 NN AP SX TE S.KF F.AM CR.CP CD CT TK K0 4 NN AP SX TE S.KF F.AM CR.CP CD CT TK K0 3 NN AP SX TE S.KF F.AM CR.CP CD CT TK K0 3 NN AP SX TE S.KF F.AM CR.CP CD CT TK K0 3 NN AP SX TE S.KF F.AM CR.CP CD CT TK K0 3 NN AP SX TE S.KF F.AM CR.CP CD CT TK K0 3 NN AP SX TE S.KF F.AM CR.CP CD CT TK K0 26 COW AP SX TE S.KF F.F AM CR.CP CD CT TK K0 27 NN AP SX TE S.KF F.F AM CR.CP CD CT TK		AA 2	SE	AP,KF,AM,CR,CP,CD,CT,FX
AA 18 SE AP 5X, TE, S, CKF, F, AM, CR, CP, CD, FX K0 28 NN AP 5X, CRN, AS, CKF, F, AM, CR, CP, CD, FX K0 28 NN AP 5X, CRN, AS, CKF, F, AM, CR, CP, CD, CT K0 28 NN AP 5X, CRN, AS, CKF, F, AM, CR, CP, CD, CT K0 28 VIT AP 5X, CRN, AS, CKF, F, CP, CD, CT K0 24 NN AP 5X, TE, S, KF, F, CP, CD, CT K0 24 NN AP 5X, TE, S, KF, F, CP, CD, CT K1 15 SW AP 5X, TE, S, CKF, F, CT LA 11 SW AP 5X, TE, S, CKF, F, CR, CP, CD, CT T K0 3 NN AP 5X, TE, S, CKF, F, CR, CP, CD, CT T K0 3 NN AP 5X, TE, S, CKF, F, AM, CP, CD, CT TK K0 3 NN AP 5X, TE, S, CKF, F, AM, CP, CD, CT TK K0 3 NN AP 5X, TE, S, CKF, F, AM, CP, CD, CT TK K0 45 COW AP 5X, TE, S, CKF, F, AM, CP, CD, CT T K0 42 NN AP 5X, SN, NA, TE, S, CKF, F, AM, CP, CD, CT T K0 42 NN AP 5X, NN, NT, S, SKF, S, CYP, CP, CT FX		AA 4	SE	AP,SX,TE,S,C,KF,F,AM,
KD 28 NN AP 5X CN A26 KF F AM CR AA 27 SE AP 5X, TE 3, KF F AM CR CP AP 25, CN A26 KF F AM CR CP AP 5X, TE 3, KF F AM CR CP CD, CT KD 28 NN AP 5X, TE 3, KF F AM CR CP CD, CT KD 28 NN AP 5X, TE 3, KF F AM CR CP CD, CT KD 4 NN AP 5X, TE 3, KF F AM CR CP CD, CT FX LA 11 SW AP 5X, TE 3, KF F AM CR CP CD, CT FX KD 3 NN AP 5X, TE 3, KF F AM CP CD, CT FX KD 3 NN AP 5X, TE 3, KF F AM CP CD, CT FX KD 3 NN AP 5X, TE 3, KF F AM CP CD, CT FX KD 4 NN AP 5X, TE 3, KF F, AM CP CD, CT FX KD 3 NN AP 5X, TE 3, CK F, F AM CP CD, CT FX KD 4 NN AP 5X, TE 3, CK F, F AM CP CD, CT FX KD 3 NN AP 5X, TE 3, CK F, F AM CP CD, CT FX KD 4 NN AP 5X, TE 3, CK F, F AM CP CD, CT FX KD 4 NN AP 5X, TE 3, CK F, F AM CP CD, CT FX KD 4 NN AP 5X, TE 3, CK F, F AM CP CD, CT FX		PG 7	PIG	AP,SX,S,AM,CP,CD,CT
AA 27 SE AP 5X,TE 3,KF F, AM,OR,OP PI 10 POULTRY AP 35X,TE 3,KF F, AM,OR,OP K0 2 NN AP 35X,TE 3,KF F, CR,OP,OD,OT K0 4 NN AP 35X,TE 3,KF F, CR,OP,OD,OT LA 11 SW AP 5X,TE 3,KF F, CR LA 15 SW AP 5X,TE 3,KF F, AM,OP,OD,OT,FX LA 15 SW AP 5X,TE 3,KF F, AM,OP,OD,OT,FX K0 3 NN AP 35X,TE 3,KF F, AM,OP,OD,OT,FX K0 3 NN AP 35X,TE 3, CK F, F, AM,OP,OD,OT K0 3 NN AP 35X,TE 3, CK F, F, AM,OP,OD,OT K0 42 COW AP 35X,TE 3, CK F, F, AM,OP,OD,OT K0 42 COW AP 35X,NA,TE 3, SK F, F, OP CTF X		AA 18	SE	AP,SX,TE,S,C,KF,F,AM,CR,CP,CD,FX
PL 10 POULTRY AP 5X (CN AAT ES, KF F, CC PC DC CT KD 2 NN AP 5X, TE 3.CK FF, CC, CC PC DC T KD 4 NN AP 5X, TE 3.CK FF, CC PC DC T KD 4 NN AP 5X, TE 3.CK FF, CC PC DC T LA 11 SW AP 5X, TE 3.KF AM CP DC DC TF, K LA 15 SW AP 5X, TE 3.KF AM CP DC DC TF, K PL 9 POULTRY AP 5X, TE 3.KF AM CP DC DC TF, K KD 3 NN AP 5X, TE 3.KF AM CP DC DC T CA 5 COW AP 5X, TE 3.KF AM CP DCDCT KD 27 NN AP 5X, TE 3.KF AM CP CDC T KD 28 COW AP 5X, TE 3.KF AM CP CDC T KD 28 COW AP 5X, TE 3.KF AM CP CDC T		KD 28	NN	AP,SX,GN,NA,S,C,KF,F,AM,CR
KD 2 NN APSX.TE.S.C.KF.F.CR.CP.CD.CT KD 4 NN APSX.TE.S.C.KF.F.CR.CP.CD.CT.F.X LA 11 SW APSX.TE.S.C.KF.F.CT LA 15 SW APSX.TE.S.C.KF.F.AUCP.CD.CT.F.X LA 15 SW APSX.TE.S.C.KF.F.AUCP.CD.CT.F.X KD 3 NN APSX.TE.S.C.KF.F.AUCP.CD.CT.F.X KD 3 NN APSX.TE.S.C.KF.F.AUCP.CD.CT.T CA 5 COW APSX.TE.S.C.KF.F.AUCP.CD.CT CA 28 COW APSX.TE.S.C.KF.F.AUCP.CD.CT.F.X			SE	AP,SX,TE,S,KF,F,AM,CR,CP
KD 4 NN APSX.TE.S.KF.AM.CRO.CP.CD.CT.FX LA 11 SW APSX.NT.E.S.KF.AM.CRO.CP.CD.CT.FX LA 15 SW APSX.TE.S.KF.AM.CP.CD.CT.FX PL 9 POULTRY APSX.TE.S.KF.AM.CP.CD.CT.FX KD 3 NN APSX.TE.S.KF.F.AM.CP.CD.CT.FX KD 3 NN APSX.TE.S.KF.F.AM.CP.CD.CT.FX KD 37 NN APSX.TE.S.KF.F.AM.CP.CD.CT.FX KD 47 NN APSX.TE.S.KF.F.AM.CP.CD.CT.FX KD 27 NN APSX.TE.S.KF.F.CP.CP.CD.CT.FX KD 27 NN APSX.NN.TE.S.KF.F.CP.CP.CT.FX KD 28 COW APSX.NN.TE.S.KF.F.CP.CT.FX			POULTRY	AP,SX,GN,NA,TE,S,KF,CR,CP,CD,CT
LA 11 SW AP,SX,NA,TE,S,C,KF,F,CT LA 15 SW AP,SX,TE,S,C,KF,F,CT LA 15 SW AP,SX,TE,S,C,KF,F,CM PL 9 POLUTRY AP,SX,TE,S,C,KF,F,CM,OP,CD,CT KD 3 NN AP,SX,NA,TE,S,C,KF,F,GM,OP,CD,CT CA 5 COW AP,SX,TE,S,C,KF,F,GM,OP,CD,CT KD 27 NN AP,SX,NA,TE,S,C,KF,F,GM CA 28 COW AP,SX,NA,TE,S,KF,F,CP,CT,FX			NN	AP,SX,TE,S,C,KF,F,CR,CP,CD,CT
LA 15 SW AP,SX,TE,S,KF,AM PL9 POULTRY AP,SX,TE,S,KF,FAR,OP,CD,CT,FX K0 3 NN AP,SX,TE,S,CKF,F,CR,CP,CD,CT CA5 COW AP,SX,TE,S,CKF,F,AM,CP,CD,CT K0 27 NN AP,SX,CN,A,TE,S,CKF,F,AM, CA 28 COW AP,SX,NA,TE,S,KF,F,CP,CT,FX				
PL 9 PU 9 POULTRY AP SIXTE 3.C KFF FAM CP5 0.0 TFK K KD 3 NN AP SIXTE 3.C KFF FAM CP5 0.0 TG K CA 5 COW AP SIXTE 3.C KFF FAM CP5 0.0 TG K KD 3 NN AP SIXTE 3.C KFF FAM CP5 0.0 TG K CA 5 COW AP SIX TE 3.C KFF FAM CP5 0.0 TG K CA 28 COW AP SIX NUTE 3.KFF FCP CFF FX				AP,SX,NA,TE,S,C,KF,F,CT
KD 3 NN AP,SX,NA,TE,S,C,KF,F,CR,CP,CD,CT CA 5 COW AP,SX,TE,S,C,KF,F,AM,CP,CD,CT KD 27 NN AP,SX,TE,S,C,KF,F,AM CA 28 COW AP,SX,NA,TE,S,C,KF,F,CP,CT,FX				
CA 5 COW APSXTEB.CXF.FAM.CPCD.CT KD 27 NN AP.SX.ONNA.TE.3.C.KF.F.AM CA 28 COW AP.SX.NN.TE.S.KF.F.CPCTF.K				
KD 27 NN AP.SX.GN.NA.TE.S.C.KF.F.AM CA 28 COW AP.SX.NA.TE.S.K.F.F.CP.CT.FX				
CA 28 COW AP,SX,NA,TE,S,KF,F,CP,CT,FX				
		KD 27		AP,SX,GN,NA,TE,S,C,KF,F,AM
CA 29 COW AP,SX,NA,C,KF,CP,CT	THE R. L. C. LEWIS CO. L.	CA 29	COW	AP,SX,NA,C,KF,CP,CT

Figure 1. The genetic relatedness of *E. coli* Isolates from humans and animals in Nigeria. AP = Ampicillin, SX = Cotrimaoxazole; GN = Gentamycin, NA = Nalidixic acid, TE = Tetracycline. S = Streptomycin, C = Chloramphenicol, KF = Cephalothin, F = Nitrofurantoin, CR = Ceftriaxone, AM = Amoxycillin clavulanic acid, CP = Cefpirome, CD = Cefpodoxime, CT = Cefotaxine, FX = Cefoxitin, SE = South-East, SW = South-West, SS = South-South, NN = North-Central, NC = North-Central.

BioNumerics software version 4.0 (Applied Maths, Sint-Martens-Latem, Belgium). Cluster analysis was performed by using the unweighted pair group for arithmetic means average (UPGMA) based on Dice coefficients to quantify the similarities.

RESULTS AND DISCUSSION

The *E. coli* isolates were studied for genetic relatedness using PFGE technique. PFGE fingerprints and cluster analysis showed that, the 140 isolates fingerprinted formed a relatively diverse population belonging to 47 distinct PFGE subtypes. These isolates belonged to one unique clonal group with >80% similarity with each other despite diverse hosts (human vs. animals) or sample sources (geographical regions or clinical vs. non-clinical) (Figure 1).

Considering the genetic relatedness of the isolates from various sample sources, those from south-east

showed a unique trend. The 19 isolates fingerprinted belonged to 8 distinct PFGE subtypes with 57.9% showing ≥80% genetic relatedness. This indicates a dissemination of single clonal group in the south east. The isolates from the south-west showed a slightly similar trend to the south east. Of the 14 isolates that were typeable by PFGE, 7 distinct PFGE subtypes were observed with 50% showing ≥80% genetic relatedness. In the south-south zone, 4 isolates (28.6%), were 90% genetically related, the highest genetic diversity observed in human isolates was recorded in the isolates from north-north zone. Of the 23 isolates fingerprinted, 13 distinct PFGE subtypes were observed.

Generally, the isolates from animal specimens were more genetically diverse when compared to those from human specimens. Of the 24 isolates from cattle specimens fingerprinted, 11 distinct PFGE subtypes was recorded with 33.3% of the isolates showing \geq 80% genetic relatedness. In goat specimens, 5 out of 16 isolates (31.3%); in pig, 4 out of 14 (28.6%); and in poultry specimens, 2 out of 9 isolates (22.2%) were \geq 80% genetically related, respectively

One of the strengths of the current research is that we restricted our analysis to only one *E. coli* isolate per fecal sample thereby maximizing biological independence between isolates. Furthermore, sampling was geographically distributed. The independence between isolates was consistent with generally high diversity of PFGE profiles observed in this study. There were some groupings for human isolates, but these included isolates from multiple geographic locations suggesting a potential common source for human isolates.

However, there was a correlation between antibiotic resistance and PFGE profile; cluster analysis indicated that, these isolates belonged to one unique clonal group with >80% similarity, each of the isolates being resistant to six or more antibiotics (Figure 1). This indicates that there are shared E. coli clones circulating among human and animal population. Most studies of antibiotic resistance in animal agriculture have been directed toward pathogenic bacteria (Bottner et al., 1995; DebRoy and Maddox, 2001). The findings of this PFGE typing provide a unique perspective on the role of commensal E. coli as a potential reservoir of resistance genes for multiple antibiotics. Monitoring resistance in commensal bacteria, such as *E. coli*, is important, as they can gain access to the food chain. Zhao et al. (2001) reported the presence of extended-spectrum cephalosporin-resistant E. coli and Salmonella spp. in retail ground meat, signifying the public health importance of this issue. Nonpathogenic multidrug-resistant strains of E. coli in the intestinal microflora serve as an important reservoir of mobile resistance genes which can be transferred in the intestines to other bacterial species, including pathogens such as Salmonella spp. (Hoyle et al., 2004). This can be important mechanism for acquiring an antibiotic resistance in pathogenic bacteria that pose a challenge

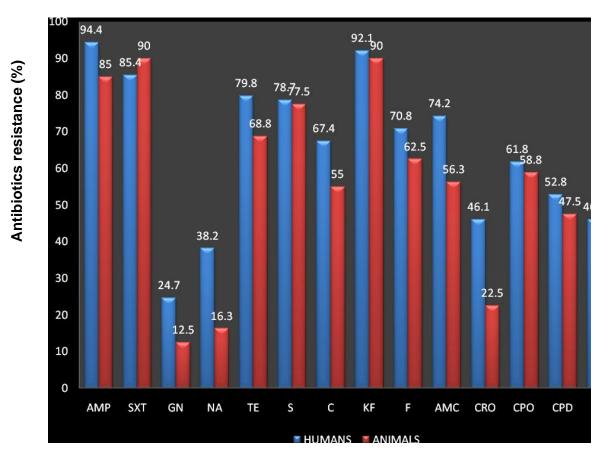


Figure 2. Percentage antibiotic resistance of *E. coli* isolates from humans and animals in Nigeria. AMP = Ampicillin, SXT = Cotrimaoxazole, GN = Gentamycin, NA = Nalidixic acid, TE = Tetracycline, S-Streptomycin, C = Chloramphenicol, KF = Cephalothin, F = Nitrofurantoin, AMC = Amoxycillin clavulanic acid, CRO = Ceftriaxone, CPO = Cefpirome, CPD = Cefpodoxime, CTX = Cefotaxine, FOX = Cefoxitin.

for effective antibiotic therapy.

In conclusion, the sharing of drug resistant strains between human and animal population as shown by PFGE in this study proved that identical clones are circulating among human and animal population in the study area (Figure 2). This suggests that commensal *E. coli* from animals can perhaps play a dynamic role in the ecology of multidrug resistance in the Nigerian human population.

ACKNOWLEDGEMENTS

This work was supported in part by the Paul G. Allen School for Global Animal Health and by the Agricultural Research Center at Washington State University Pullman, USA. It is part of Dr. Nsofor PhD. Research Project.

REFERENCES

Aarestrup FM, Wegener HC, Collignon P (2008). Resistance in

bacteria of the food chain: epidemiology and control strategies. Expert Rev. Anti Infect. Ther. 6:733–50

- Aibinu I, Adenipekun E, Odugbemi T (2004). Emergence of quinolone resistance amongst *Escherichia coli* strains isolated from clinical infections in some Lagos state hospitals. Nig. J. Microbiol. 3: 1442-1449.
- Bottner A, Schmid P, Humke R (1995). In vitro efficacy of cefquinome (INN) and other anti-infective drugs against bovine bacteria isolates from Belgium, France, Germany, The Netherlands, and the United Kingdom. J. Vet. Med. 42:377-383
- Cheesbrough M (2000). District Laboratory Practice in Tropical Countries, Part 2. Cambridge University Press, Cambridge, UK; 434pp.
- Daniel AT, Shaohua Z, Emily T, Sherry A, Aparna S, Mary JB, Patrick FM (2012). Antimicrobial Drug Resistance in *Escherichia coli* from Humans and Food Animals, United States, 1950–2002. Emerg. Infect Dis. 18(5): 741–749.
- DebRoy C, Maddox CW (2001). Identification of virulence attributes of gastrointestinal *Escherichia coli* isolates of veterinary significance. Ani. Health Res. Rev. 2:129-140.
- Erb A, Stürmer T, Marre R, Brenner H (2007). Prevalence of antibiotic resistance in *Escherichia coli*: overview of geographical, temporal, and methodological variations. Eur. J. Clin. Microbiol. Infect. Dis. 26:83–90.
- Fang H, Ferda A, Göran H, Dornbusch K (2008). Molecular Epidemiology of Extended-Spectrum β-Lactamases among *Escherichia coli* Isolates collected in a Swedish hospital and its

associated health care facilities from 2001 to 2006 J. Clin. Microbiol 46(2): 707–712.Health.

- Hoyle DV, Shaw DJ, Knight HI, Davison HC, Pearce MC, Low JC, Gunn GJ, Woolhouse J (2004). Age-related decline in carriage of ampicillin-resistant *Escherichia coli* in young calves. Appl. Environ. Microbiol. 70: 6927-6930
- Igarashi T, Inatomi J, Wake A, Takamizawa M, Katayama H, Iwata T (1999). Failure of prediarrheal antibiotics to prevent hemolytic uremic syndrome in serologically proven *Escherichia coli* O157:H7 gastrointestinal infect. J. Pediatr. 135: 768–769.
- Levy SB, Marshall B (2004). Antibacterial resistance worldwide: causes, challenges and responses. Nat Med. 10 122–9.
- Okeke IN, Steinrück H, Kanack KJ, Simon JE, Lars S, James BK, Adebayo L (1999) Antibiotic-Resistant Cell-Detaching *Escherichia coli* Strains from Nigerian Children. J. Clin. Microbiol. 40(1): 301–305.
- Pitout JDD, Daniel BG, Lorraine C, Kevin BL (2009). Molecular Characteristics of Extended-Spectrum-β-Lactamase-Producing *Escherichia coli* Isolates Causing Bacteremia in the Calgary Health Region from 2000 to 2007: Emergence of Clone ST131 as a Cause of Community-Acquired Infections. Antimcro. Agents Chemoth. 53(7): 2846–2851
- Sodha SV, Lynch M, Wannemuehler K, Leeper M, Malavet M, Schaffzin J (2006). Multistate outbreak of *Escherichia coli* O157:H7 infections associated with a national fast-food chain,: a study incorporating epidemiological and food source trace back results. Epidemiol. Infect. 2011. 139:309–16.
- Taur Y, Smith MA (2007). Adherence to the Infectious Diseases Society of America guidelines in the treatment of uncomplicated urinary tract infection. Clin. Infect. Dis. 44: 769–74.
- Umolu P, Idia OO, Tatfeng Y, Omorogbe FI, Aisabokhale F, Ugbodagah OP (2006). Antimicrobial susceptibility and plasmid profiles of *Escherichia coli* isolates obtained from different human clinical specimens in Lagos – Nigeria. J. American Sci. 2(4), 1931-1956.

- Von BH, Marre R (2005). Antimicrobial resistance of *Escherichia coli* and therapeutic implications. Intl. J. Med. Microbiol. 295: 503–511.
- Womack NA, Kabera CM, Tong EA, Jones S, Gaines S, Bartholomew M (2010). The NARMS Working Group The use of *Escherichia coli* as a sentinel for antimicrobial resistance in *Salmonella* In: Abstracts of the National Foundation for Infectious Diseases Annual Conference on Antimicrobial Resistance, Bethesda, Maryland, February 1–3, 2010. Bethesda (MD): The Foundation;. Abstract no. P12.
- Zhao S, White PF, McDermott S, Friedman L, English S, Ayers J, Meng JJ, Maurer RH, Walker RD (2001). Identification and expression of cephamycinase *bla*_{CMY} genes in *Escherichia coli* and *Salmonella* isolates from food animals and ground meat. Antimicro. Agents Chemothep. 45: 3647-3650.