African Journal of Biotechnology Vol. 10(64), pp. 14116-14124, 19 October, 2011
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB10.1662
ISSN 1684–5315 ©2011 Academic Journals

Full Length Research Paper

Prevalence and antimicrobial susceptibility profiles of *Campylobacter jejuni* and *coli* isolated from diarrheic and non-diarrheic goat faeces in Venda region, South Africa

Uaboi-Egbenni, P. O.[1]*, Bessong, P. O.[1], Samie, A.[1] and Obi, C. L.[2]

[1]University of Venda, Department of Microbiology, P. M. B. 5050, Thohoyandou, Limpopo Province, South Africa.
[2]Academic Affairs and Research, Walter Sisulu University, Mthatha, Eastern Cape, South Africa.

Accepted 6 April, 2011

A total of 200 freshly voided goat faeces samples were collected in the study and were examined for the presence of thermophilic *Campylobacter* spp. The samples were obtained randomly from 2 farm settlements in Venda region, South Africa in 2008 to 2009. All samples were analyzed with the mCCDA media with *Campylobacter* supplement in microaerophilic condition provided by the Campygen gas envelope (Oxoid). Of the total 200 samples, the recovery rate was 29% (58 of 200) for all samples. Of the 200 samples, 155 (77.5%) were non-diarrheic and 45 (22.5%) were diarrheic faeces. From the 45 diarrheic faces, 41 (91.1%) were positive for *campylobacters* and of the 155 non-diarrheic faeces, 17 (11.1%) were positive for *campylobacters*. In all, 58 *Campylobacter* species comprising 33 (56.9%) *Campylobacter jejuni* and 8 (13.9%) *Campylobacter coli* strains were from diarrheic and 2 (3.4%) *C. jejuni* and 15 (25.9%) *C. coli* were from non-diarrheic faeces. There was no statistical correlation between the incidence of *C. jejuni* in diarrheic faeces and non-diarrheic faeces. Rate of resistance of *C. jejuni* and *C. coli* to six regularly used antibiotics in human and veterinary campylobacteriosis; ciprofloxacin, gentamycin, ampicillin, tetracycline, nalidixic acid and erythromycin were 40.0, 47.1%, 57.1, 43.5%, 48.6, 56.5%, 42.9, 43.5%, 34.3, 34.5% and 14.3, 17.4%, respectively. In comparison, a significantly higher frequency of resistance to gentamycin was recorded among the *C. jejuni* and *C. coli* isolates (57.1 versus 43.5%) respectively, at $p < 0.005$ from goats in all farms. Resistance to ciprofloxacin and kanamycin was higher among the *C. coli* than *C. jejuni* strains but the difference was not statistically significant. Comparable occurrences of resistance were observed among *C. jejuni* and *C. coli* to erythromycin and nalidixic acid. High prevalence of thermophilic *Campylobacter* spp. in goat could be of public health significance in the Venda region. The observed multi-drug resistance and especially resistance to macrolides and fluoroquinolones in this study pose a threat of transfer of antibiotic resistance to human pathogens because of the close contact between goats and man.

Key words: *Campylobacter jejuni, Campylobacter coli,* microaerophilic, veterinary campylobacteriosis, fluoroquinolones, Venda region.

INTRODUCTION

During the past decade, *Campylobacter jejuni* has been recognized as a major cause of human gastroenteritis. In several developed countries the incidence of campylobacteriosis exceeds that of salmonellosis (Foster, 1986; Skirrow, 1990). In the Netherlands, sentinel studies revealed that campylobacteriosis accounts for approximately 12% of all the cases of acute human gastroenteritis (Hoogenboom-Verdegaal et al., 1989). Foods of animal origin may serve as vehicles of infection (Blaser et al., 1984). In many reports, an asso-ciation has been made between campylobacteriosis and recent consumption of raw or undercooked poultry meat (El-Shenawy and Marth, 1989; Oosterom et al., 1984). Up till now, however, the pathways involved in the infection of

*Corresponding author. E-mail: uaboiegbenni@yahoo.com.

poultry flocks are still unclear. Several factors suspected to be sources or vectors of infection have been the subjects of studies. Kazwala et al. (1990) suggested that, flocks were most likely infected from the environment of the poultry houses.

In Nigeria, small ruminants (sheep and goats) constitute about 35% of the total meat supply (FAO, 1995; Salihu et al., 2009). Sheep and goats have played very important role in offsetting the protein deficiencies which are fairly rampant in the country. There is a growing appreciation of the importance of goats in small-scale integrated farming system in developing countries (Devendra and Mcleroy, 1992). In most developing countries, goats with cattle, sheep and poultry with very poor veterinary inputs and hygiene are reared. The husbandry systems under which goats are reared in Sokoto, Nigeria, bring them in close contact with humans and other animals including dogs and cats (Salihu et al., 2009). This system of rearing is a common practice in developing countries especially in African countries where animal rearing is a common source of protein and income. *Campylobacters* have been reported among healthy and diseased farm animals in Nigeria and Tanzania (Olubunmi and Adeniran, 1986; Jiwa et al., 1994; Raji et al., 2000). It has also been reported in raw milk, goats and cattle in Europe and several other countries (Oporto et al., 2009; Anderson et al., 2006; Baserisalehi et al., 2007; Suzuki and Yamamoto, 2009). Salihu et al. (2009) in their study in Sokoto, Nigeria, noted that 20% of the goat faecal droppings contain *Campylobacter* spp. A prevalence study recently carried out in the Basque country (Northern Spain) identified 28.3% (34/120) of ovine and 18.0% (37/206) of bovine farms positive for *C. jejuni* (Oporto et al., 2007) and even higher values (38.2%, 13/34) in free-range poultry farms (Esteban et al., 2008). The natural habitat of most *Campylobacter* spp. is the intestine of birds and other warm-blooded animals, including seagulls and several other wild birds (Kapperud and Rosef, 1983). Campylobacteriosis is primarily a food-borne disease, because of its low infective dose, it has been estimated that 500 cells of *C. jejuni* can cause human illness (Black et al., 1988). From this, it is clear that even small number of *Campylobacter* cells in water or food due to faecal contamination may be a potential health hazard (Salihu et al., 2009).

Sporadic abortion due to campylobacteriosis has been reported in sheep and goats although goats are known to be more resistant to *Campylobacter* infections resulting in fewer abortions (Moeller, 2009). The three species of *Campylobacter* adjudged to cause abortion are *Campylobacter fetus, C. jejuni* and *Campylobacter lari*. *Campylobacter* infections most often cause late term abortions, stillbirths, or the birth of weak non-viable lambs/ewe (Moeller, 2009).

Recently, the concern for this foodborne infection has increased because of the frequent isolation of antimicrobial resistant strains in humans and animals (Aarestrup and Wegener, 1999). This is a consequence of the massive use of antibiotics in modern intensive animal production for therapy and prevention of diseases, as well as use of same as growth promoters. Hence, food animal origin may represent a vehicle of transmission of resistant *Campylobacter* spp. to humans. This applies particularly for strains resistant to quinolones and erythromycin, widely used for therapy in human systemic infections or in severe long-lasting cases of enteritis (Aarestrup and Engberg, 2001; Pezzotti et al., 2003). However, there was stability pattern in resistance between 1997 and 2001 with a value of 2%. Bywater et al. (2004) in their study of incidence of *Campylobacter* in chicken, cattle and pig and their antimicrobial resistance, observed differential resistance to ciprofloxacin of *Campylobacter coli* and *C. jejuni* isolated from chicken with a prevalence of 39.6 to 14.9%, respectively. In all the tests, they observed higher resistance of *C. coli* over *C. jejuni* to nalidixic acid (39.6, 15.1%), erythromycin (13.6, 1.0%) and tetracycline (58.4, 35.4%). The trend was the same for all the isolates from cattle and pig with *C. coli* showing higher resistance to the aforementioned antibiotics. Pezzotti et al. (2003) in their study of chicken and pork meat noted higher resistance of isolated *C. coli* and *C. jejuni* to ten selected antibiotics. Percentage of resistance of chicken isolates was 78.6 and 52.8 for enfloxacin, 78.5 and 52.8 for ciprofloxacin, 78.6 and 59.7 for nalidixic acid, 48.2 and 31.9 for tetracycline, 25.0 and 12.5 for erythromycin, and 30.4 and 5.6 for streptomycin. For pork meat, resistance trend were similar with *C. coli* showing more resistance to the antibiotics than *C. jejuni,* with exception of gentamycin, where *C. jejuni* resistance was 1.4% and all *C. coli* isolates were susceptible.

The risk factors associated with the infection include occupational exposure to farm animals, consumption of raw milk or milk products and unhygienic food preparation practices (Alterkruse et al., 1999). It has been reported that difficulty in *Campylobacter* detection is responsible for deficiency in the accurate information concerning *Campylobacter* infection in developing countries (Baserisalehi et al., 2006, 2007), but *Campylobacter* is hyper-endemic in developing countries (Salihu et al., 2009). Added to this, is the fact that there is lack of surveillance and database relating to prevalence *of Campylobacter* organisms in developing countries. While the incidence and prevalence of campylobacters have been reported extensively in developed nations among other animals, there is a dearth of information on the shedding patterns of *Campylobacter* spp. by goats in developing nations, South Africa inclusive. This study was intended to determine the prevalence, pathological indices and antibiotic susceptibility profiles of *Campylobacter* species among goats in two farm settlements in Venda region, South Africa.

MATERIALS AND METHODS

Description of the farm settlements

The farm settlements were separated from each other by about 80

Table 1. Data analysis of information obtained from the goat farms in Venda region, Limpopo province South Africa.

Total number of faece	Number	Percentage (%)
	200	**100**
Number of diarrheic faeces	45	22.5
Number of non-diarrheic faeces	155	77.5
Positive diarrheic faeces	41	91.1
***Campylobacters* isolated**		
C. jejuni	35	17.5
C. coli	23	11.5
No. β-haemolytic	55	94.8
No. α-haemolytic	3	5.2

Km and apart from goats other farm animals co-reared were cattle, sheep and chicken. The farms were each located about 500 m from the stream from which the animals drink water and which also serve as water supply for the community. Hence, runoffs after heavy rainfall are capable of contaminating this surface water that serve as source of drinking water for the community and may result in an epidemic situation.

Sample collection

A total of 200 faecal samples were collected from apparently healthy and observed diarrheagenic goats from two farm settlements named X and Y for ethical reasons from the Venda region in the Limpopo province, South Africa, over a period of six months. Freshly voided faeces were collected aseptically in sterile collection tubes, refrigerated in cooler packed with ice and were transported to the laboratory within 1 h of collection. The samples were inoculated directly on mCCDA to which the selective supplement had been added and incubated at 42℃ for 48 h under micro-aerophilic condition using Campygen (Oxoid, CM739, SR 155E, CM 025) (Oxoid Ltd, Basingstoke, RG24 8PW, U.K). This temperature was used for the specific isolation of thermophilic pathogenic *Campylobacter* species.

From the positive agar plates, 2 to 3 colonies showing typical *Campylobacter* features were selected and subcultured and thereafter, were tested for gram-staining, motility, production of oxidase and catalase. These isolates were stored in brain heart infusion agar (BHA) with 15% (V/V) glycerol at -20℃ prior to further characterization. Agglutination tests using *Campylobacter* dryspot (specific for thermophilic *Campylobacter* species and Mast diagnostic test (specific for *C. jejuni, C. coli* and *C. lari*) were done according to the manufacturer's instruction. The dryspot *Campylobacter* test kit (agglutination test for pathogenic *Campylobacter* strains of *C. jejuni, C. coli, Campylobacter upsaliensis and C. lari*) was used in conjunction with Mast diagnostic method which incorporates biochemical tests involving test for hippurate hydrolysis, indoxyl acetate hydrolysis and urea hydrolysis through the urease system. The Oxoid agglutination and Mast tests were done according to the manufacturer's instruction. Agglutination under normal lighting condition is indicative of *Campylobacter* and belongs to any of the four species mentioned earlier (Baker et al., 2006; Chaban et al., 2010). The result from the Mast tests enables speciation of the Campylobacters isolates. The number of faeces samples (diarrheic and non-diarrheic) positive for *Campylobacter* and the number of *C. jejuni* and *C. coli* is shown in Table 1.

PCR confirmation of *Campylobacter*

Genomic DNA was obtained by the whole-cell lysate method as described by Marshall et al. (1999). In order to ascertain if the dryspot/Mast diagnostic kit positive *Campylobacter* isolates were actually *campylobacters*, they were subjected to PCR identification using the general primers for the identification of campylobacteria. However, *Arcobacter* and *Helicobacter* spp. showed negative reaction to the *Campylobacter* dryspot kit. Hence, any amplification of the primer sequences at the 1,004 bp fragment within the coding region of 16S rRNA confirmed that, such isolates are *Campylobacter* spp. and not *Helicobacter* or *Arcobacter* spp. Oligonucleotides primers employed in this study were CAH16S 1a (5' – AAT ACA TCA AAG TCG AAC GA – 3') and CAH16S 1b (TTA ACC CAA CAT CTG ACG AC – 3'), respectively. The oligonucleotides used in this study were synthesized by Inqaba Biotechnologies (Pretoria, South Africa). The micrograph of the PCR products of the 16S rRNA is shown in Figure 1.

Haemolysis test

To ascertain the pathogenic status of the isolates, the *Campylobacter* spp. was subjected to haemolytic test according to the procedure of Samie et al. (2006). Briefly, a 24 h broth culture of *Campylobacter* spp. was cultured by spread plate method on Columbia agar supplemented with sheep blood. Plates were incubated at 35℃ for 24 h.

Thereafter, plates were observed for complete haemolysis and partial haemolysis. The haemolytic profile is shown in Table 2.

Antibiotic susceptibility studies

Antimicrobial agents

The antibiotics tested in this study were: trimethroprim (2.5 µg), nalidixic acid (30 µg), ciprofloxacin (5 µg), gentamycin (10 µg), tetracycline (30 µg), ampicillin (10 µg), erythromycin (15 µg), streptomycin (10 µg), methicillin (µg), cefexime (30 µg), imipenem (µg), kanamycin (30 µg) and vancomycin (30 µg) (Oxoid, Unipath Ltd, Basingstoke, England). However, attention was paid more to the relevant antibiotics used for human and veterinary campylobacteriosis, since these antibiotics are used in cases of campylobacteriosis in humans. Some tetracycline is used as growth promoters in veterinary.

Table 2. Resistance to six (6) commonly used antibiotics in *C. jejuni* and *C. coli* isolated from Goat faeces between 2008 and 2009.

Antibiotic	*C. jejuni*	*C. coli*
	Number tested (35) percent resistant (%)	Number tested (23) percent resistant (%)
Ciprofloxacin	40.0	47.8
Tetracycline	42.9	43.5
Ampicillin	48.6	56.5
Gentamycin	57.1	43.5
Erythromycin	14.3	17.4
Nalidixic acid	34.3	34.8

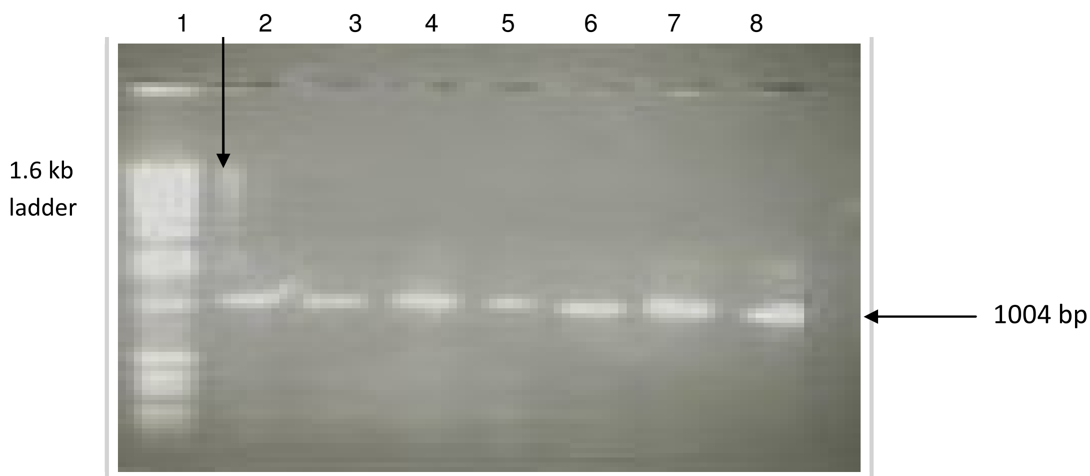

Figure 1. PCR products of the amplified DNA from goats *Campylobacter* isolates aligning at the 1004 bp of a 1.9 kb ladder. Lane 1, 1.6 kb ladder; lane 2 to 8, amplified bands of DNA from goat *Campylobacter* strains.

Antimicrobial susceptibility testing

The method of Gaudreau and Gilbert (1997) was used. Briefly, the confirmed *Campylobacter* isolates were inoculated into plates of Mueller-Hinton agar plates carrying a minimum of five discs. All plates were incubated at 35°C under a microaerophilic atmosphere obtained with a gas generator envelope (Oxoid), for 24 h. The resulting zone diameters were measured with a graduated metre rule. Analysis of diameter was done according to the procedural methods of CLSI (2010) for enterobacteriaceae.

RESULTS

Two hundred (200) freshly voided goat faeces samples were analyzed in the study. The rate of recovery of *Campylobacter* was 29.0% (58 of 200) for all the cases. Of these, 91.1% (41 of 45) were from diarrheic and 11.1% (17 of 155) were from non-diarrheic faecal samples. Overall, 58 *Campylobacter* species comprising of 33 (56.9%) *C. jejuni* and 8 (13.9%) *C. coli* strains were isolated from diarrheic and 2 (3.4%) *C. jejuni* and 15 (25.9%) *C. coli* strains were isolated from non-diarrheic faeces (Table 1). There was a higher prevalence of *C. jejuni* in diarrheic faeces than *C. coli* and vice versa. The high incidence rate of *C. jejuni* in diarrheic faeces is an indication that the campylobacteriosis witnessed among the goats in these farms had their origin from *C. jejuni* infection. This could lead to abortion and stillbirth among goats and a substantial economic loss to the rearers. There was a high incidence of *C. coli* compared with *C. jejuni* in the non-diarrheic faeces; a result that confirmed that the diarrhea noticed in the goats may have been caused by *C. jejuni*.

Haemolytic activity

Out of the 58 *Campylobacter* isolates tested for haemolysis, 55 (94.85) were β- haemolytic and 3 (5.1%) were α-haemolytic. None of the isolates was non-haemolytic (Table 1).

PCR results

The PCR studies of the 16S rRNA fragment of *Campylobacter* DNA showed that the DNA fragment was aligned at 1004 bp (Figure 1).

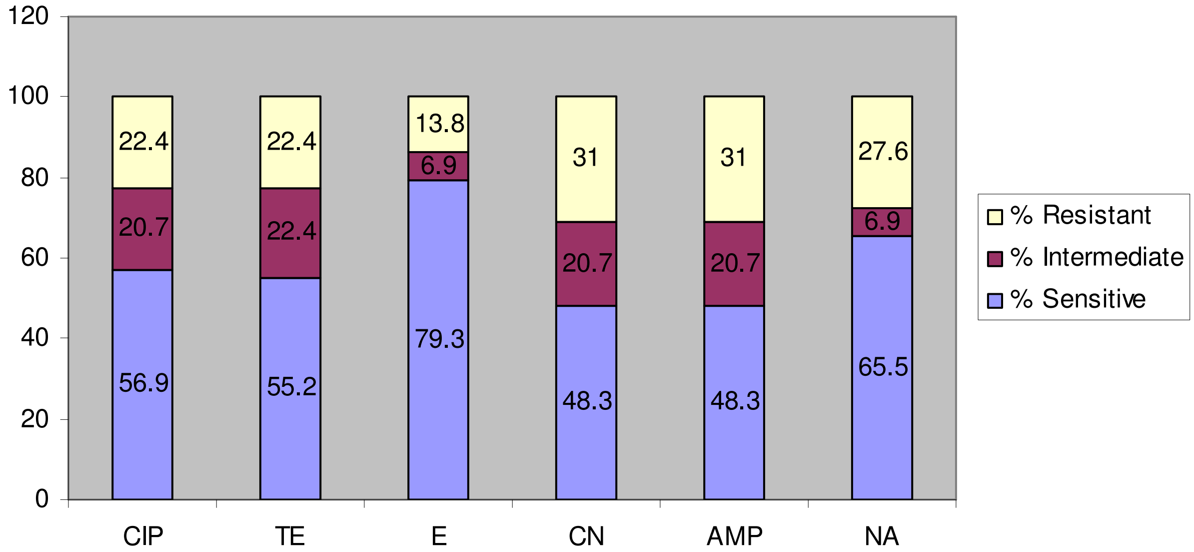

Figure 2. Susceptibility profiles of 90 strains of *C. jejuni* and *C. coli* by disc diffusion using six popularly employed antibiotics for the treatment of campylobacteriosis in humans and animals showing sensitive, intermediate and resistance.

Antimicrobial susceptibility

Figure 2 shows the sensitive, intermediate and resistance profile of the 58 *Campylobacter* isolates exposed to six antibiotics employed in veterinary and human campylobacteriosis according to CLSI (2010) guidelines. The strains were more sensitive to erythromycin (macrolide) than the rest antimicrobials and were more resistant to gentamycin and ampicillin. On the basis of species resistance, *C. coli* isolates were more resistant to the six antibiotics. Individually, there was a high rate of resistance to some or all of the antibiotics. The rate of resistance of *C. jejuni* and *C. coli* to these antibiotics; ciprofloxacin, gentamycin, ampicillin, tetracycline, nalidixic acid and erythromycin were (40.0, 47.1%), (54.3, 60.9%), (57.1, 43.5%), (48.6, 56.5%), (42.9, 43.5%), (34.3, 34.5%) and (14.3, 17.4%), respectively. In comparison, a significantly higher frequency of resistance to gentamycin was recorded among *C. jejuni* and *C. coli* isolates (57.1 versus 43.5%), respectively, at $p < 0.005$ from goats in all the farms (Table 2). Similarly, resistance to ciprofloxacin was higher among *C. coli* and *C. jejuni* isolates from goats but was not statistically significant ($P > 0.005$). For erythromycin and nalidixic acid, comparable occurrences of resistance were recorded among *C. jejuni* and *C. coli* from all the farms. *C. coli* isolates had a higher rate of resistance to ampicillin (56.5%) than *C. jejuni* (48.6%). Multiple resistances were shown to combination of antibiotics by *Campylobacter* isolates from all the farms. For example, 5 (14.3%) *C. jejuni* were resistant to all the six antibiotics, while 8 (34.8%) *C. coli* were also resistant to all the six antibiotics. The rate of multiple resistances among the different *Campylobacter* spp is shown in Table 3. The multiple resistances witnessed in this study to the antibiotics is of public health significance as these multiple antibiotic resistant strains are capable of being disseminated into the wider environment to constitute source of acquisition of antibiotic resistant genes to other pathogens.

DISCUSSION

In this study, 29% (58 out of 200 animals) of the goats sampled were found to harbor *Campylobacter* isolates in their faeces. In a study done in Sokoto State, Nigeria, on 1312 faecal samples, over a period of 2 years, Salihu et al. (2009) found 20% of the faecal samples to be positive for *Campylobacter*. This presence and high prevalence of *Campylobacter* in goat is of serious concern in view of the high rate of consumption of goat meat in most African countries. This prevalence value is low when compared with reported prevalence rates in other food animal by several workers (Stanley and Jones, 2003; Sato et al., 2004; Workman et al., 2005; Verma et al., 2005; Baserisalehi et al., 2007; Uaboi-Egbenni et al., 2008). Few available studies have reported heavy shedding of *Campylobacter* among goats (Salihu et al., 2009). In this study, most *Campylobacters* isolated were from diarrheic faeces, although, few mainly *C. coli* and *C. jejuni* were also isolated from non-diarrheic faeces. More *C. jejuni* (60.4%) were isolated than *C. coli* (39.6%). This observation is in line with the report of Salihu et al. (2009) in Nigeria. However, the studies done in northern Nigeria on sheep showed a high prevalence of *C. coli* than *C. jejuni*.

Table 3. Multidrug resistance patterns of *C. jejuni* and *C. coli* exposed to 6 antibiotics.

Resistance pattern	*C. jejuni*		*C. coli*		*Campylobacter* spp.	
	Number of strain	Strain (%)	Number of strain	Strain (%)	Number of strain	Strain (%)
C,T,E,N,G,A	5	14.3	8	34.8	13	22.4
C, T	6	17.1	7	30.4	13	22.4
C, T, N	7	20.0	11	47.8	18	31.0
G, A	7	20.0	11	47.8	18	31.0

C, Ciprofloxacin; T, tetracycline; E, erythromycin; N, nalidixic acid; G, gentamycin; A, ampicillin.

Although, there is paucity of reports on campylobacteriosis in goats, similar work done on other food animals have indicated enteritis and stillbirth in sheep (Dennis, 1990; Koides, 1991; Raji et al., 2000), new born calves (Padungton and Kareene (2003). Bywater et al. (2004) reported high prevalence of *Campylobacter* among chicken in France and UK (50 and 70%), in cattle in Germany and UK (66 and 50%) and pigs in France, Spain and UK (50, 42 and 35%). These variations in prevalence rate from one country to another shows discrepancies in the prevalence of *Campylobacter* spp. among different animals and may be a reflection of geographic factors and/or differences in strategies to monitor antibiotic use in different countries. Kimberly (1988) reported Jenson and Swiff's diseases of sheep in Philadelphia, LA, USA, resulting from campylobacteriosis caused by *C. jejuni* and its pathogenic allies. While disease conditions resulting from *Campylobacter* infections have been well studied in other farm animals, the nature of disease conditions in goats is still shrouded in obscurity.

Campylobacter have also been described in goat meat. In a recent study in Iran, the highest prevalent of *Campylobacter* spp was found in lamb meat (12.0%), followed by goat meat (9.4%), beef meat (2.4%) and camel meat (0.9%) (Rahimi et al., 2010).

Studies of pathological indices of the *Campylobacter* isolates revealed that of the 58 *Campylobacter* isolates, 55 (94.8%) were β-haemolytic, while 3 (5.2%) were α-haemolytic. This finding support the studies of Samie et al. (2007) in Vhembe district on HIV/AIDS patients where they observed a high prevalence of β-haemolytic *C. jejuni*. These animals may have served as source of infection of human population via contamination of surface and subsurface bodies of water in the Vhembe region.

Resistance to fluoroquinolones and macrolides has shown a tremendous increase over the past two decades (Saenz et al., 1997; Prats et al., 2000; Reina et al., 1994). Quinolone resistance and to a lesser extent, macrolide resistance of *Campylobacter* isolates from the production of animals are now recognized as emerging public health problems (Engberg et al., 2001; Châtre et al., 2010; Smith and Fratamico, 2010). Result from recent susceptibility studies of *C. jejuni* and *C. coli* from poultry meat performed in different countries indicated substantial variations between countries. Relatively high resistance rates in *C. jejuni* strains isolated from chicken meat were reported from Belgium (Van Looveren et al., 2001; Habib et al., 2009), United States (Ge et al., 2003) and Italy (Pezzotti et al., 2003; Rollo et al., 2010), moderates were reported from Switzerland (Ledergerber et al., 2003; Korczak et al., 2009) and northern Ireland (Wilson, 2003), whereas, limited occurrences of anti-microbial resistance among *C. jejuni* was reported from Sweden (Lindmark et al., 2004). A possible explanation for these differences might be that, occurrences of antimicrobial resistance are reflecting the different national and regional policies in relation to the use of antimicrobial agents for food animals. Although, there is a paucity of information on the antimicrobial susceptibility of *Campylobacter* isolates from goats on antibiotics to make effective comparison, various studies are available on the susceptibility profiles of *Campylobacter* isolates from other food animals and small ruminants.

Resistance of *C. jejuni* and *C. coli* to ciprofloxacin, tetracycline, nalidixic acid and erythromycin antibiotics in several food animals have been reported by other workers: cattle, sheep and poultry faeces (de Jong et al., 2009; Oporto et al., 2009; 2007; Sahin et al., 2008; Zweifel et al., 2004; Englen et al., 2005; EFSA, 2007), in swine (Oporto et al., 2007) and from poultry farms (Esteban et al., 2008). The resistance shown by *Campylobacter* isolates from goats to functional anti-biotics used for human and veterinary campylobacteriosis has high public health significance. It brings to question if man has actually been able to unrivalled the various sources of antimicrobial resistance in animals and in the environment. The occurrence of high resistance to antibiotics among *Campylobacter* isolates from goats in this study need further investigation more so as no report on antibiotic susceptibility profile from goats has hitherto been reported.

In this study, we found significant difference in tetra-cycline resistance between *C. jejuni* and *C. coli* isolates. This observation is in line with the findings of Ge et al. (2003) who found that *Campylobacter* isolated from turkey meat showed high resistance than those from chicken meat. Similarly, Oporto et al. (2009) in their study, observed significantly high resistance of

Campylobacter isolated from sheep to those isolated from beef cattle and poultry but less significant value among those isolated from sheep and those from dairy cattle. Gibreel and Taylor (2006) in their review reported varied rates of resistances of *C. jejuni* and *C. coli* to erythromycin among human isolates in several countries. A high prevalence of resistance to most of the antibiotics was observed among *C. coli* isolates than *C. jejuni* isolates. Gibreel and Taylor (2006) observed a high prevalence of resistance among *C. coli* than *C. jejuni* isolated from cattle and pigs to tetracycline, ciprofloxacin and nalidixic acid. Similarly, these workers reported higher prevalence among *C. coli* than *C. jejuni* isolates from pigs and chicken to erythromycin, but higher prevalence of resistance in *C. jejuni* than *C. coli* isolates from cattle to erythromycin. They did not observe resistance to gentamycin in all their isolates except for 0.7% observed with *C. jejuni* and 0% for *C. coli* from cattle. In this study, the most stable antibiotic to the campylobacters isolated from goats in all the farms was erythromycin. This finding is in line with the observation of Bywater et al. (2004) who reported as low as between 1 to 2% resistance of *Campylobacter* spp. isolated from chicken, cattle and pigs.

The high prevalence of resistance to nalidixic acid, ciprofloxacin and tetracycline of *Campylobacter spp.* isolated from goats could be of public health importance. This is so, because a number of investigations from the United States, Thailand and Denmark have shown that infections with macrolide-resistant *Campylobacter* isolates could be associated with an increased risk of adverse events, development of invasive illness or death compared with infections with drug susceptible isolates (Travers and Barza, 2002;Helms et al., 2005). The root of entry of the antibiotic-resistant *campylobacters* to goats has not been elucidated. Speculatively, the pastures on which these animals graze as well as surface waters from which they drink are likely sources of acquisition of these resistant strains of these *campylobacteria*. The isolation of fluoroquinolone, quinolone and macrolide-resistant *Campylobacter* species in goats has again stressed the need for proper surveillance of the use of antibiotics not only as growth promoters but as therapeutic use in veterinary medicine. There is also the need to monitor the emergence of resistant strains in order to develop new and effective antibiotics against campylobacteriosis. This will further protect man from acquisition of antibiotic-resistant *Campylobacter* strains from goat and the wider environment.

Conclusions

The study reported relatively high prevalence of *Campylobacter* species among goats in farms in South Africa. We also reported the isolation of *Campylobacter* species more from diarrheic than non-diarrheic faeces. *C. jejuni* was more commonly isolated when compared with *C. coli.* This study indicated that, goats can act as source of human infections as well as contamination of the wider environment. The isolation of fluoroquinolone, quinolone and macrolide-resistant *Campylobacter* species in goats has again stressed the need for proper surveillance of the use of antibiotics not only as growth promoter but as therapeutic use in veterinary medicine. There is also the need to monitor the emergence of resistant strains in order to develop new and effective antibiotics against campylobacteriosis. This will further protect man from the acquisition of antibiotic-resistant *Campylobacter* strains from goat and the wider environment. The dissemination of these *Campylobacter* organisms in faeces could result in an epidemic, if concerted efforts are not made to address the origin and cause of the observed prevalence. Excreted faeces when passed into the bodies of water and pastures could spread to other animals and humans that use such water as source of water supply for drinking. Based on the location of the farms (close to community stream) and coupled with the fact that other animals are reared together, we would have on our hand an epidemic situation which may be difficult to curtail if effective surveillance is not undertaken timely.

ACKNOWLEDGEMENTS

The authors are grateful to the farm owners whose assistance ensured the commencement and completion of this study. We are also grateful to the authority of the University of Venda, Limpopo province South Africa, who in one way or the other supported this study financially.

REFERENCES

Alterkruse SF, Stern NJ, Fields PI, Swerdlow DL (1999). *Campylobacter jejuni* an emerging food borne pathogen. Emerg. Infect. Dis., 5: 28-35.

Anderson SR, Saadbye P, Shukri NM, Rosenquist H, Nielson NL, Boel J (2006). Antimicrobial resistance among *Campylobacter jejuni* isolated from raw poultry meat at retail level in Denmark. Int. J. Food Microbiol., 107: 250 – 255.

Baker M, Sneyd E, Wilson N (2006). Is the majore increase in notified campylobacteriosis in New Zealand real? Epidemiol. Infect., 6: 1 – 8.

Baserisalehi M, Bahador N, Kapadnis BP (2006). *Campylobacte*r, an emerging pathogen. Res. J. Microbiol., 1: 23-35.

Baserisalehi M, Bahador N, Kapadnis BP (2007). Isolation and characterization of *Campylobacter* spp. from domestic animals and poultry in south of Iran. Pakistan J. Biol. Sci., 10(9): 1519-1524.

Black RE, Levine MM, Clements MI, Hughes TP, Blaser MJ (1988). Experimental *Campylobacter jejuni* infection in human. J. Infect. Dis., 157: 472-479.

Blaser MJ, Taylor DN, Feldman RA (1983). Epidemiology of *Campylobacter jejuni* infections. Epidemiol. Rev., 5: 157-176.

Bywater R, Deluyker H, Deroover E, Deroover E, de Jong A, Marion H, McConville M, Rowan T, Shryock T, Shuster D, Thomas V, Vale M, Walters J (2004). A European survey of antimicrobial susceptibility among zoonotic and commensal bacteria isolated from food-producing animals. J. Antimicrob. Chemother., 54: 744 – 754.

Châtre P, Haenni M, Meunier D, Botrel MA, Calavas D, Madec JY (2010). Prevalence and antimicrobial resistance of *Campylobacter jejuni* and *Campylobacter coli* isolated from cattle between 2002 and 2006 in France. J. Food Prot., 73(5): 825-31.

CLSI (2010). CLSI document M100 – S20. Performance Standards for Antimicrobial Disk Susceptibility Tests. Approved standard M100-S20 Clinical Laboratory Standards Institute Wayne, Pa USA.

de Jong A, Bywater R, Butty P (2009), “A pan-European survey of antimicrobial susceptibility towards human-use antimicrobial drugs among zoonotic and commensal enteric bacteria isolated from healthy food-producing animals.” J. Antimicrob. Chemother., 63(4): 733-744.

Dennis SM (1990). *Campylobacter* abortion in Sheep. In: Kirkbridge CA (Ed.), *Laboratory Diagnosis of livestock abortion*. 3rd Edition. Ames Iowa, Iowa University Press. pp. 82 – 85.

Devendra C, Mcleroy GB (1992). Goat and sheep production in the tropics. Longman, London, pp. 315 – 325.

EFSA (2007). “Report of the Task Force of Zoonoses Data Collection including a proposal for a harmonized monitoring scheme of antimicrobial resistance in *Salmonella* in fowl (*Gallus gallus*), turkeys, and pigs and *Campylobacter jejuni* and *C. coli* in broilers,” The EFSA J., 96: 1 - 46

El-Shenawy MA, Marth EH (1989). *Campylobacter jejuni* and foodborne campylobacteriosis: a review. Egypt. J. Dairy Sci., 17:181-200.

Engberg J, Aarestrup FM, Taylor DE (2001). Quinolone and macrolide resistance in *Campylobacter jejuni* and *C. coli* resistance mechanisms and trends in human isolates. Emerg. Infect. Dis., 7: 24 – 34

Englen]MD, Fedorka-Cray PJ, Ladely SR, Dargatz DA (2005). “Antimicrobial resistance patterns of *Campylobacter* from feedlot cattle,” J. Appl. Microbiol., vol. 99,

Esteban JI, Oporto B, Aduriz G, Juste RA Hurtado (2008). “A survey of food-borne pathogens in free-range poultry farms,” Int. J. of Food Microbiol., 123 (1 – 2): 177-182.

FAO (1995). Animal Health Year Book. Food and Agriculture Organisation of the United Nations. Rome Italy.

Foster EM (1986). New bacteria in the news. A special symposium campylobacteria jejuni. Food Technol. 40:20.

Gaudreau C, Gilbert H (1997). Comparison of disc diffusion and agar dilution methods for antibiotic susceptibility testing of *Campylobacter jejuni* subsp. *jejuni* and *Campylobacter coli.* J. Antimicrob. Chemother., 39: 707-712.

Ge B, White DG, McDermott PF., Girard W, Zhao S, Hubert S, Meng J (2003). Antimicrobial –resistant *Campylobacter* species from retail raw meats. Appl. Environ. Microbiol,, 69: 3005 – 3007.

Gibreel A, Taylor DE (2006). Macrolide resistance in *Campylobacter Jejuni* and Esteban, J.I.,

Habib I, Miller WG, Uyttendaele M, Houf K, De Zutter L (2009). Clonal population structure and antimicrobial resistance of *Campylobacter jejuni* in chicken meat from Belgium.Appl Environ Microbiol., 75(13):4264-72.

Helms M, Simonsen J, Olsen KE (2005). Adverse health events associated with antimicrobial drug resistance in *Campylobacter* species: a registry-based cohort study. J. Infect. Dis., 191: 1050-5.

Hoogenboom-Verdegaal AMM, During M, Leentvaar-Kuypers A, Peerbooms PGH, Kooij WCM, van Vlerken R, Sobczak H (1989). Epidemiologisch en microbiologisch isolated from healthy food-producing animals,” J. Antimicrobial Chemotherapy, 63(4): 733–744, 2009.

Jiwa SFH, Kazwala RR, Nmahungu E (1994). Prevalence of *Campylobacter* spp. in clinical normal goats kept under various management systems in Urban Tanzania. Small Rumin. Res., 15: 97 – 100.

Kapperud G, Rosef O (1983). Avian Wildlife reservoir of *Campylobacter fetus* subsp. jejuni, *Yersinia* spp, and *Salmonella* spp in Norway. Appl. Environ. Microbiol., 45: 375-380.

Kazwala RR, Collins JD, Hannan J, Crinion RAP, O'Mahony H (1990). Factors responsible for the introduction and spread of *Campylobacter jejuni* infection in commercial.

Kimberly CV (1988). Diseases causing abortion. In: Kimberling CV. (Ed.). Jensen and Swiff’s Diseases of Sheep. 3rd Edition, Philadelphia LA and Fabiger, pp. 57 – 63.

Koides P (1991). Incidence of *Campylobacter jejuni/coli* in carcasses of cattle, sheep and swine. Bullet. Hellenic Veterinary Med. Society, 42(4): 241 -244.

Korczak BM, Zurfluh M, Emler S, Kuhn-Oertli J, Kuhnert P (2009). Multiplex strategy for multilocus sequence typing, fla typing, and genetic determination of antimicrobial resistance of *Campylobacter jejuni* and Campylobacter coli isolates collected in Switzerland. J. Clin. Microbiol., 47(7):1996-2007.

Ledergerber U, Regula G, Stephan R, Danuser J, Bissig B, Stark KDC (2003). Risk factors for antibiotic resistance in *Campylobacter* spp. isolated from raw poultry meat in Switzerland. PMC Public Health, 3(39) (http: //www. biomedcentral.com/1471-2458/3/39).

Lindmark H, Harbom B, Thebo L, Andersson L, Hedin G, Osterman B, Lingber T, Andersson Y, Westoo A, Olsson EE (2004). Genetic characterization and antibiotic resistance of *Campylobacter jejuni* isolated from meats, water, and humans in Sweden. J. Clin. Microbiol., 42: 700 – 706.

Marshall SM, Melito PL, Woodward DL, Johnson WM, Rodger FG, Mulvey MR (1999). Rapid Identification of *Campyloabcter, Arcobacter,* and *Helicobacter* Isolates by PCR-Restriction Fragment Length Polymorphism Analysis of the 16S rRNA Gene. J. Clin. Microbiol., 37(12): 4158 – 4160.

Moeller RB (2009). Bacterial Abortions of Sheep and Goats. Tri – County Goat News. http://cekings.ucdavis.edu no. 2, pp. 285–291

Olubunmi PA, Adeniran MOA (1986). Isolation of *Campylobacter* spp. from man and domestic animals in western Nigeria. Bull. Anim. Health Prod. Afr., 32: 224-248.

Oosterom J, den Uyl CH, Banifer JRJ Huisman J (1984). Epidemiological investigations on *Campylobacter jejuni* in households with a primary infection. J. Hyg. Camb., 92:325-332.

Oporto B, Aduriz G, Juste RA, Hurtado (2008). “A survey of food-borne pathogens in free-range poultry farms,” Int. J. Food Microbiol., 123 (1 – 2), 177-182.

Oporto B, Esteban JI, Aduriz G, Juste RA, Hurtado A (2007). “Prevalence and strain diversity of thermophilic campylobacters in cattle, sheep and swine farms,” J. Appl. Microbiol., 103(4): 977 – 984.

Oporto B, Ramon AJ, Hurtado A (2009). Phenotypic and Genotypic Antimicrobial Resistance Profile of *Campylobacter jejuni* Isolated from Cattle, Sheep, and Free-Range Poultry Faeces. Int. J Microbiol., vol., 2009: 1 – 9.

Padungton P, Kaneene JB (2003). *Campylobacter* spp. in human, chickens, pigs and their antimicrobial resistance. J. Vet. Med. Sci., 65: 161-170.

Pezzotti G, Serafin A, Luzzi I, Mioni R, Milan M, Perin R (2003). Occurrence and resistance to antibiotics of *Campylobacter jejuni* and *Campylobacter coli* in animals and meat in northeastern Italy. Int. J. Food Microbiol., 82: 281 – 287.

Prats G, Mirelis B, Llovet T, Munoz C, Miro E, Navarro (2001). “Antibiotic resistance trends in enteropathogenic bacteria isolated in 1985 – 1987 and 1995 – 1998 in Barcelona,” Antimicrobial Agents Chemother., 44(5): 1140 – 1145.

Rahimi E, Ameri M, Kazemeini HR (2010). Prevalence and antimicrobial resistance of Campylobacter species isolated from raw camel, beef, lamb, and goat meat in Iran. Foodborne Pathog. Dis., 7(4):443-7.

Raji MA, Adekeye OJ, Kwaga JKP, Bale JOO (2000). Biosero-group of *Campylobacter* species isolated fromsheep in Kaduna State. Small Rumin. Res., 37: 15-22.

Raji MA, Adekeye OJ, Kwaga JKP, Bale JOO (2000). Biosero-group of *Campylobacter* species isolated fromsheep in Kaduna State. Small Rumin. Res., 37: 15-22.

Reina J, Ros MJ, Serra A (1994). “Susceptibilities to 10 antimicrobial agents of 1,220 *Campylobacter* strains isolated from 1987 to 1993 from feces of pediatric patients.” Antimicrobial Agents Chemotherapy, 38(12): 2917 – 2920.

Rollo SN, Norby B, Bartlett PC, Scott HM, Wilson DL, Fajt VR, Linz JE, Bunner CE, Kaneene JB, Huber JC Jr (2010). Prevalence and patterns of antimicrobial resistance in *Campylobacter* spp isolated from pigs reared under antimicrobial-free and conventional production methods in eight states in the Midwestern United States. J. Am. Vet. Med. Assoc., 236(2):201-10.

Saenz Y, Zarazaga M, Lantero M, Gastanares MJ, Baquero F, Torres C (2000). “Antibiotic resistance in *Campylobacter* strains isolated from animals, foods, and humans in Spain in 1997-1998”, Antimicrobial Agents Chemother., 44(2): 267-271.

Sahin O, Plummer PJ, Jordan DM (2008). “Emergence of a tetracycline-resistant *Campylobacter jejuni* clone associated with outbreaks of ovine abortion in the United States," J. Clin. Microbiol., 46(5): 1663–1671.

Salihu MD, Junaidu AU, Oboegbulem SI, Egwu GO, Tambuwal FM, Yakubu Y (2009). Prevalence of *Campylobacter* species in apparently healthy goats in Sokoto State (Northwestern) Nigeria. Afr. J. Microbiol. Res., 3(9): 572-574

Samie A, Obi CL, Barrett LJ, Powell SM, Guerrant RL (2007). Prevalence of *Campylobacter* species, *Helicobacter pylori* and *Arcobacter* species in stool samples from the Venda region, Limpopo, South Africa: Studies using molecular diagnostic methods. J. Infect., 54(6): 558 – 566.

Samie A, Obi CL, Barrett LJ, Powell SM, Guerrant RL (2006). Prevalence of *Campylobacter* species, *Helicobacter pylori* and *Arcobacter* species in stool samples from the Venda region, Limpopo, South Africa: Studies using molecular diagnostic methods. J. Infect., 20: 1-9

Sato K, Bartlet PC, Kaneene JN, Downs FP (2004). Comparison of prevalence and antimicrobial susceptibilities of Campylobacter sp. Isolates from organic and conventional dairy hers in Wisconsin. Appl. Environ. Microbiol., 70: 1442-1447

Skirrow MB (1990). *Campylobacter.* Lancet, 336: 921-923.

Smith JL, Fratamico PM (2010). Fluoroquinolone resistance in *Campylobacter*. J. Food Prot., 73(6): 1141-52.

Stanley K, Jones K (2003). Cattle and sheep farms as reservoirs of *Campylobacter*. J. Appl. Microbiol., 94 Suppl: 104S-113S.

Suzuki H, Yamamoto S (2009). Campylobacter contamination in retail meats and by-products in Japan: A literature survey. Food Control, 20: 531 – 537.

Travers K, Barza M (2002). Mobildity of infections caused by antimicrobial-resistant bacteria. Clin. Infect. Dis., 34 (Suppl.3): S131 – 4.

Uaboi-Egbenni PO Okolie PN, Adesanya OD, Omonigbehin E, Sobande AO (2008). Epidemiological studies of the incidence of pathogenic *Campylobacter* spp. amongst animals in Lagos metropolis. Afr. J. Biotechnol., 7 (16): 2852-2956.

Van Looveren M, Daube G, De Zutter L, Dumont JM, Lammens C, Wijdooghe M, Vandamme P, Jouret M, Cornelis M, Goosens H (2001). Antimicrobial susceptibilities of *Campylobacter* strains isolated from food animals in Belgium. J. Antimicrob. Chemother., 48: 235 – 40.

Verma KS, Subramanyam KV, Satyanaryana A, Reddy KM (2005). Isolation of Campylobacter jejuni from rectal swabs and carcasses of sheep. Indian J. Compar. Microbiol. Immunol. Infect. Dis., 26 (1):27 – 28.

Wilson IG (2003). Antibiotic resistance of *Campylobacter* in raw retail chickens and imported chicken portions. Epidemiol. Infect., 131: 1181 – 1186.

Workman SN, Mathison GE, Lavoie MC (2005). Pet dogs and chicken meat as reservoirs of *Campylobacter* spp. in Barbados. J. Clin. Microbiol., 43: 2642–2650.

Zweifel C, Zychowska MA, Stephan R (2004). "Prevalence and characteristics of Shiga toxin-producing *Escherichia coli, Salmonella* spp. and *Campylobacter* spp. isolated from slaughtered sheep in Switzerland," Int. J. Food Microbiol., 92(1): 45–53.