Antibiotic Use in U.S. Livestock Production

Summary

Antibiotics are used in livestock production as therapeutics, prophylactics, and growth promoters. These drugs assist in sustaining livestock production and in controlling animal infections that may be transferred to humans. The scientific community is concerned increasingly about the transfer of antibiotic resistance and/or antibiotic resistance determinants from animals to humans. These concerns may lead to increased restrictions on the use of antibiotics in animal agriculture and decreased exports. This report lists many of the antibiotics approved for use in livestock production in the United States (U.S.), the European Union (EU), and the United Kingdom (UK). The report also describes the purposes and prevalence of antibiotic use in the U.S. livestock population, based on several different studies by the National Animal Health Monitoring System (NAHMS) between 1990 and 1997. Antibiotics were used in most phases of swine production and were administered via injection, feed, water and orally. The trend was for antibiotic use to increase in swine production between 1990 and 1995. Approximately 25% of small feedlot cattle operations and 70% of large feedlot operations used antibiotics in the feed. Similarly, approximately 31% of cattle on small feedlot operations and 57% of cattle on large feedlot operations received antibiotics via feed. Tetracycline and derivatives of tetracycline were some of the most frequently used in-feed antibiotics on feedlot operations. Varying percentages of dairy operations and varying percentages of dairy cows on these operations were exposed to antibiotics during lactation and the dry period. Only a few antibiotics have been approved for use in catfish production. Romet was used to manage enteric septicemia of catfish on 41% of affected operations. Although specific volumes of antibiotics and the prevalence of antibiotic use in individual animals was not a goal of these studies, increased restrictions on the use of antibiotics could have significant implications for animal health. Developing economically feasible, chemotherapeutic, and non-chemotherapeutic alternatives to antibiotics (e.g., management strategies) may become vital in order to maintain the health of U.S. livestock and to maintain viable export markets.

General Uses of Antibiotics in Livestock Production

Antibiotics are used for three main purposes in livestock production: (1) as therapeutics for managing clinically apparent diseases, (2) as prophylactics at subtherapeutic concentrations (i.e., usually less than 200 grams per ton), and (3) as growth promoters.

Therapeutics

Therapeutic uses of antibiotics are required to manage clinically apparent diseases, and the therapeutic regimen is dictated by label instructions from the manufacturer, or in accordance with extra-label instructions. As in human medicine, antibiotics were used extensively and unnecessarily in veterinary medicine during their early development in the 1950's and through the 1960's (Frost, 1991). Extensive use of the new "wonder drugs" led to diminished emphases on husbandry and hygiene practices that had been used successfully to combat infectious diseases in

livestock populations. The use of therapeutic and prophylactic antibiotics gradually became a part of a balanced, integrated approach to the control of infectious diseases in all species of animals.

Prophylactic, Sub-therapeutic and Growth Promotion

The earliest evidence of the growth-promoting effects of antibiotics became apparent when it was shown that chickens exposed to small doses of chlortetracycline grew more rapidly than nonexposed chickens (Stokstad, 1950). Oral antibiotics, especially those that act on Gram positive organisms, became widely used at sub-therapeutic levels for their consistent ability to improve the growth of livestock (Crawford, 1983; Droumev, 1983). While part of the reason for this practice is to reduce the risk of disease, it is also accepted that regular intake of oral antibiotics as feed additives has a direct nutrient sparing effect and reduces the production of urea, methane, and ammonia in the intestine, among other effects (Visek, 1978; Walton, 1983). The rationale for the use of antibiotics as growth promoters has been established (Luetzow, 1997). A modulating effect on either the metabolic activity of certain intestinal micro-organisms, or a shift of the balance of the microbial ecosystem, which constitutes an essential part of mammalian digestion, is the proposed mechanism of action. These effects are observed at use levels which are far lower than those achieved in therapeutic use. More efficient digestion during the administration of low levels of anti-microbials decreases the amount of feed necessary to raise and to fatten domestic animals. The beneficial effects of sub-therapeutic doses of antibiotics has not decreased since these effects became known in the 1950's (Frost, 1991).

Besides the claim of growth promotion, secondary effects on the health status at sub-therapeutic levels are also considered by some regulatory agencies (Luetzow, 1997). Direct beneficial effects of the use of oral antibiotics in medicated premixes for livestock include the prevention and relief of suffering caused by pathogenic bacteria. Specific examples in the swine industry include swine dysentery, enterotoxigenic *Escherichia coli*, and porcine proliferative enteropathy, but similar examples exist in other livestock husbandry systems (McOrist, 1997).

Antibiotics used in Livestock Production in U.S.

Table 1. Antibiotics and sulfonamides approved by the U.S. FDA for use in dairy and beef cattle. These antibiotics and sulfonamides may be used for growth promotion and feed efficiency, therapeutic purposes, or both (U.S. Food and Drug Administration, 1998).

Amoxicillin	Lacalocid	Tylosin
Ampicillin	Monensin	Sulfabromomethazine
Bacitracin	Neomycin	Sulfachloropyridazine
Ceftiofur	Oxytetracycline (oral)	Sulfadimethoxine
Chlortetracycline	Oxytetracycline (injection)	Sulfaethoxypyridazine
Dihydrostreptomycin	Penicillin	Sulfamethazine
Erythromycin	Streptomycin	Sulfamethoxine
Furamazone	Tetracycline	
Gentamycin	Tilmicosin	

Table 2. Antibiotics approved by the U.S. FDA for use in hogs. These antibiotics may be used for growth promotion and feed efficiency, therapeutic purposes, or both (U.S. Food and Drug Administration, 1998).

Amoxicillin	Efrotomycin	Penicillin
Ampicillin	Erythromycin	Spectinomycin
Apramycin	Gentamycin	Streptomycin
Arsanilic acid	Lincomycin	Tetracycline
Bacitracin	Neomycin	Tiamulin
Bambermycins	Oleandomycin	Tylosin
Chlortetracycline	Oxytetracycline	Virginiamycin

Table 3. Chemotherapeutics and sulfonamides approved by the U.S. FDA for use in hogs. These chemotherapeutics and sulfonamides may be used for growth promotion and feed efficiency, therapeutic purposes, or both (U.S. Food and Drug Administration, 1998).

Arsanilate sodium	Roxarsone	Sulfamethazine
Arsanilic acid	Sulfaethoxypyridazine	Sulfathiazone
Carbadox	Sulfachlorpyidazine	

Table 4. Antibiotics approved by the U.S. FDA for use in sheep. These antibiotics may be used for growth promotion and feed efficiency, therapeutic purposes, or both (U.S. Food and Drug Administration, 1998).

Chlorotetracycline	Neomycin	Penicillin
Erythromycin	Oxytetracycline	Penicillin/streptomycin

Table 5. Antibiotics approved by the U.S. FDA for use in chickens and turkeys. These antibiotics may be used for growth promotion and feed efficiency, therapeutic purposes, or both (U.S. Food and Drug Administration, 1998).

Bambermycin	Novobiocin	Streptomycin
Bacitracin	Oleandomycin	Tetracycline
Chlortetracycline	Oxytetracycline	Tylosin
Erythromycin	Penicillin	Virginiamycin
Gentamycin	Roxarsone	Fluoroquinolones
Neomycin	Spectinomycin	

Table 6. Coccidiostats approved by the U.S. FDA for use in broilers, turkeys, and layers. Not every coccidiostat in the three categories in the table has been approved for use in all three of these areas of production (U.S. Food and Drug Administration, 1998).

Ionophores	**Sulfonamides**	**Others**
Lasalocid	Sulfachloropyrazine	Amprolium

Maduramycin	Sulfamethazine	Arsanilate
Monensin	Sulfadimethoxine	Buquinolate
Narasin	Sulfamyxin	Clopindol
Salinomycin	Sulfanitran	Dequinate
	Sulfaquinoxaline	Nequinate
		Nicarbazin
		Robenidine
		Zoalene

Table 7. Therapeutic antimicrobial and sulfonamides authorized in the United Kingdom (adapted from Rutter, 1997).

Amoxycillin	Cloxacillin	Spectinomycin
Ampicillin	Danofloxacin mesylate	Spiramycin
Apramycin	Dihydrostreptomycin	Streptomycin sulphate
Baquiloprim	Enrofloxacin	Sulphachlorpyridazine
Benzathine penicillin	Erythromycin	Sulphadiazine
Benzyl Penicillin	Florfenicol	Sulphadimidine
Cefquinome	Framycetin sulphate	Sulphadoxine
Ceftiofur	Lincomycin	Sulphamethoxypyridazine
Cephalexin	Marbofloxacin	Sulphaquinoxalone
Cefoperazone	Nafcillin	Sulphatroxazole
Cefuroxime	Neomycin sulphate	Tetracycline hydrochloride
Cephacetrile sodium	Novobiocin	Tiamulin (fumarate)
Cephalonium	Oxolinic acid	Tilmicosin
Chloramphenicol	Oxytetracycline	Trimethoprim
Chlortetracycline	Phenoxymethyl penicillin	Tylosin
Clavulanic acid	Procaine penicillin	

Table 8. Antibiotic growth promoters that have been approved, not approved or banned by the European Union (EU). The table compares the legal status of active substances for the compounds currently used at a significant degree. The approval status of any one antibiotic does not refer to the status of the antibiotic as a therapeutic or prophylactic agent (e.g., use as coccidiostat in the European Union) (adapted from Luetzow, 1997).

Antibiotic	Approval Status
Avilamycin	approved
Avoparcin	banned; re-evaluation
Bacitracin Zn	approved
Bambermycin	not approved
Lasalocid	only as coccidiostat
Lincomycin	not approved
Monensin	approved
Salinomycin	approved

Spiramycin	approved
Tylosin	approved
Virginiamycin	approved

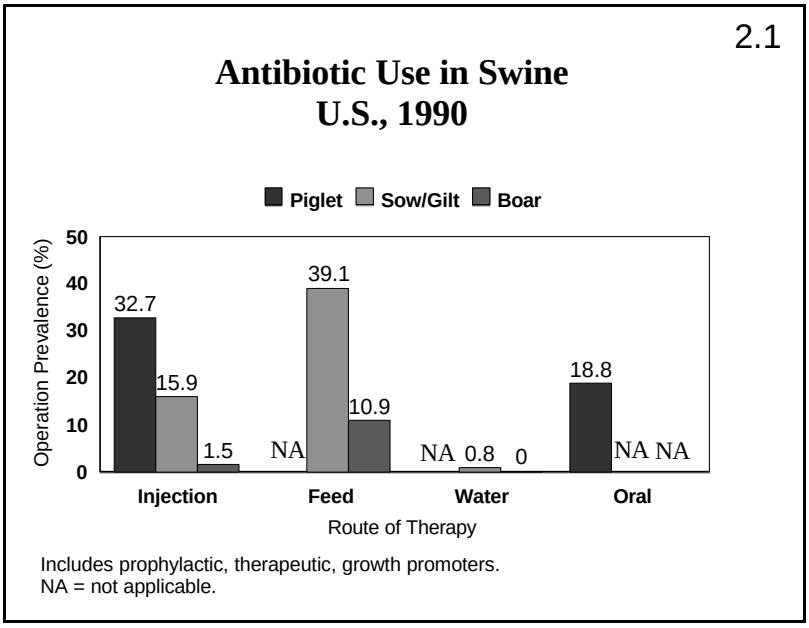
Table 9. Antibiotic growth promoters that have been approved by the United Kingdom (adapted from Rutter, 1997).

Avilamycin	Monensin Sodium	Spiramycin
Bacitracin Zinc	Olaquindox	Tylosin Phosphate
Flavophospholipol	Salinomycin Sodium	Virginiamycin

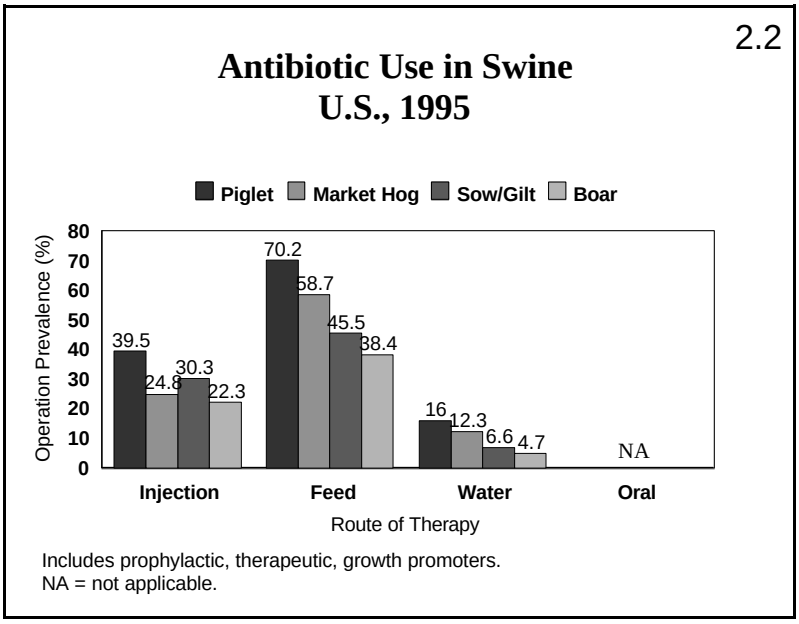
Prevalence of Antibiotic Use on U.S. Livestock and Poultry Operations

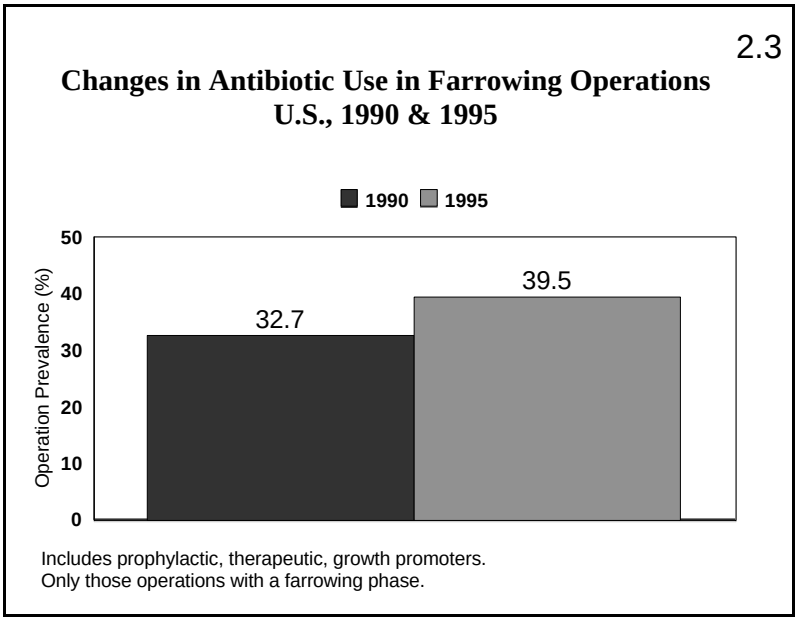
Swine

Antibiotics are approved for use in swine for growth promotion (n = 5), therapeutics (n = 11), and both growth promotion and therapeutics (n = 5) (National Research Council Institute of Medicine 1998, Agrimetrics Associates, Inc., 1994). According to the national population estimates from the NAHMS Swine '90 Study, antibiotics were given to piglets via injection and orally (USDA/APHIS/VS, 1992a) **(Figure 2.1)**. Antibiotics were given to females (i.e., sows and



gilts) via injection and in the feed, but rarely in the water **(Figure 2.1)**. Boars were rarely given antibiotics, regardless of the route **(Figure 2.1)**. In addition to the three production groups (i.e., pigs, females, and boars) that were included in the NAHMS Swine '90 Study, antibiotic use in market hogs was examined in the NAHMS Swine '95 Study (USDA/APHIS/VS, 1995e). Generally, the prevalence of antibiotic use in market hogs in 1995 was similar to prevalence of antibiotic use in piglets and females, for a specific route of therapy **(Figure 2.2)**. Operations with a farrowing phase that used antibiotics via injection increased from 32.7% in 1990 to 39.5% in 1995 **(Figure 2.3)**. Antibiotic use via injection and via water increased for piglets, sows and gilts,



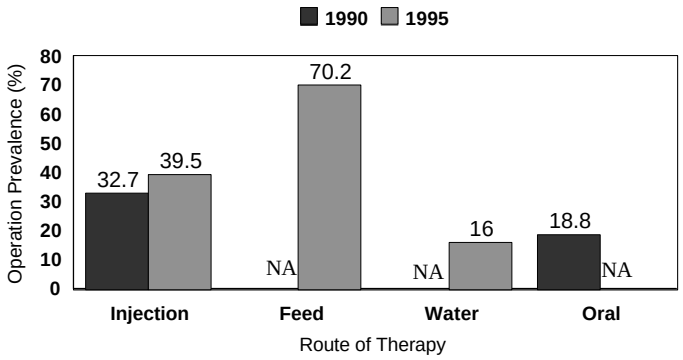


and boars between 1990 and 1995, and use via feed increased dramatically for each group **(Figures 2.4, 2.5, 2.6)**. It cannot be determined if there was a similar trend for market hogs, because the baseline data for market hogs was not collected during the NAHMS Swine '90 Study.

Antibiotic use was examined prospectively in cohorts of piglets and females during the NAHMS Swine '90 Study (USDA/APHIS/VS, 1992a). The percentages of piglets that were given antibiotics via injection and orally were 60.4% and 10.4%, respectively **(Figure 2.7)**. The percentage of females that were given antibiotics via any route was 30.6%. Females were given antibiotics via injection far more frequently than via other routes **(Figure 2.7)**.

2.4

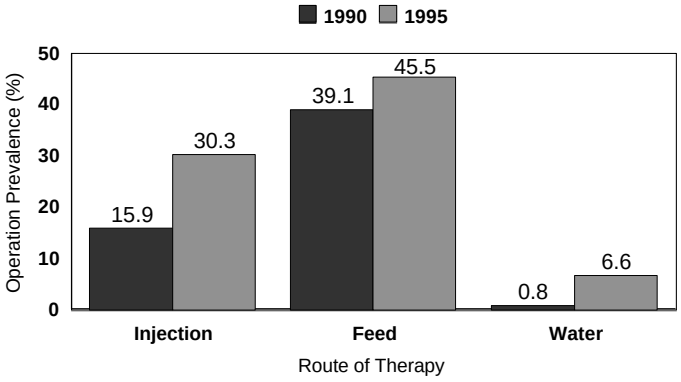
Changes in Antibiotic Use in Piglets U.S., 1990 & 1995



Includes prophylactic, therapeutic, growth promoters.
NA = not available.

2.5

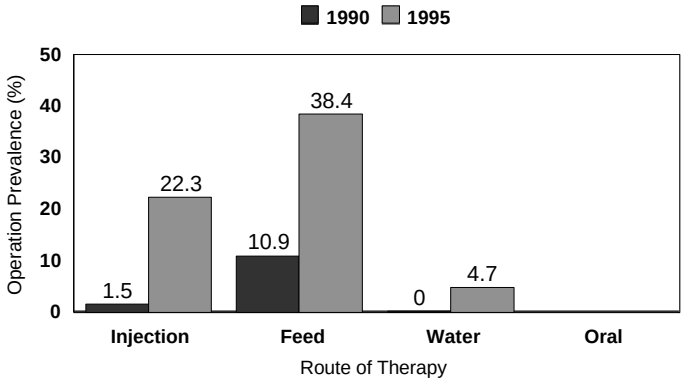
Changes in Antibiotic Use in Sows and Gilts U.S., 1990 & 1995



Includes prophylactic, therapeutic, growth promoters.

2.6

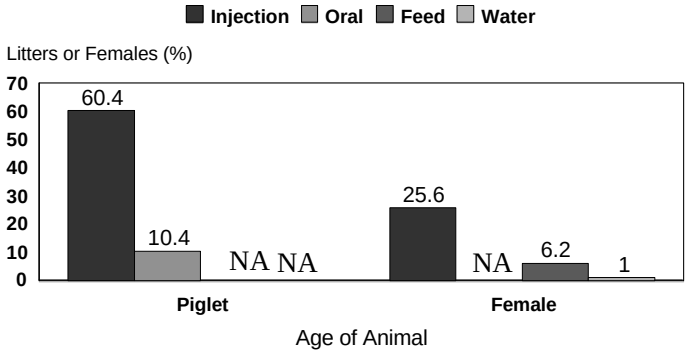
Changes in Antibiotic Use In Boars
U.S., 1990 & 1995



Includes prophylactic, therapeutic, growth promoters.

2.7

Prospective Antibiotic Use in Piglets and Females
U.S., 1990

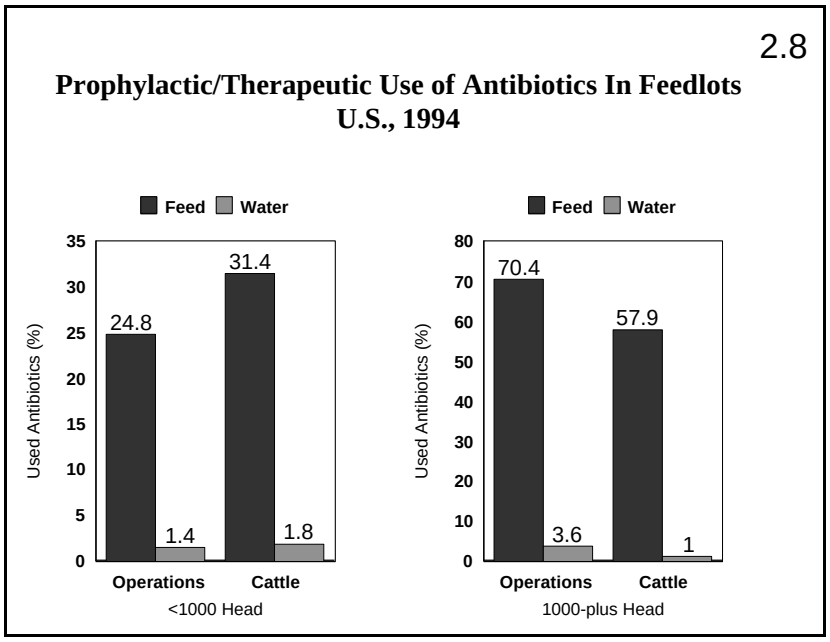


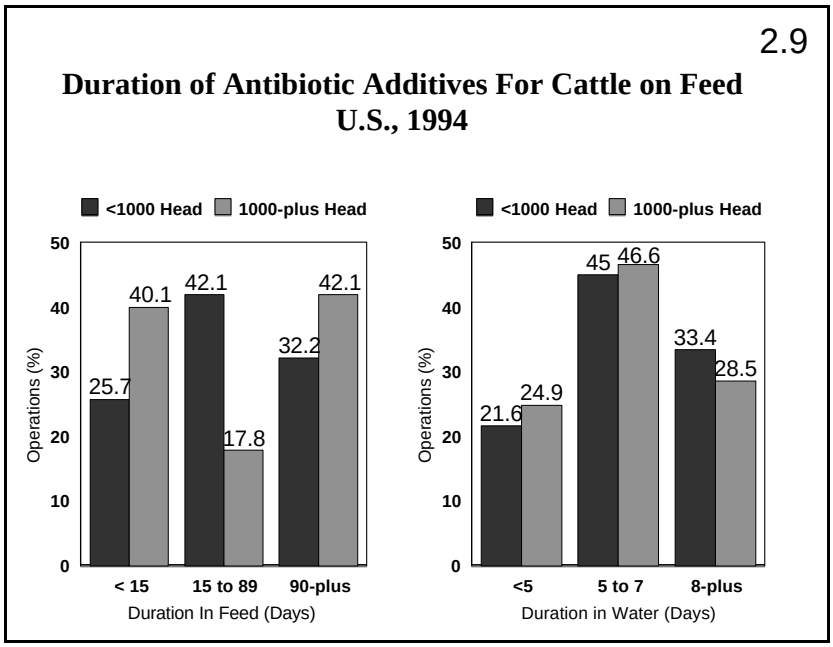
Includes prophylactic, therapeutic, growth promoters.
NA = not available.

Cattle-on-Feed

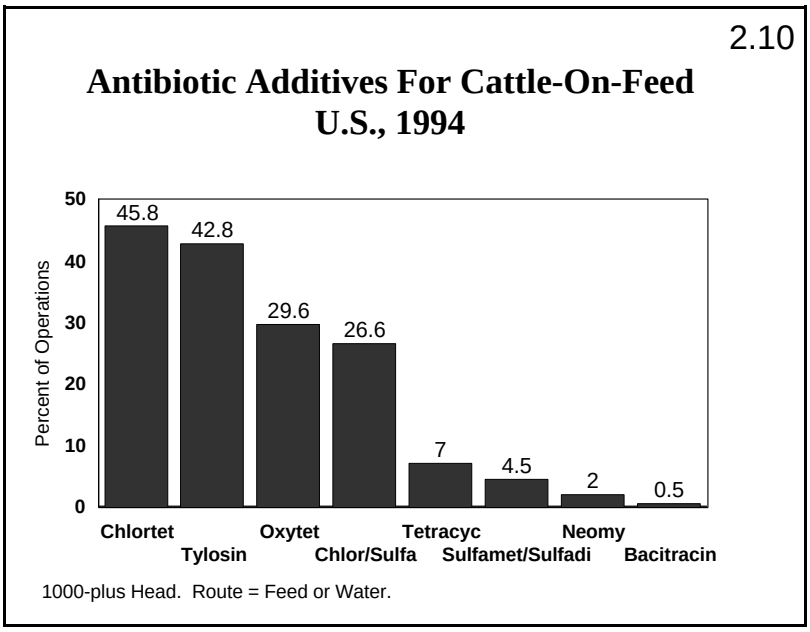
Antibiotics were used in the feed and water on feedlot operations of all sizes in 1994 (USDA/APHIS/VS, 1995b). Large operations, defined as those operations with a capacity of more than 1000 head, were almost three times as likely to use antibiotics in the feed and in the water, when compared to small operations **(Figure 2.8)**. The cattle on the large operations were almost twice as likely to receive antibiotics in their feed and water, when compared to cattle on the small operations **(Figure 2.8)**. The feedlot cattle were exposed to antibiotics in the feed for

90 days or longer on 42% of the large operations and on 32% of the small operations **(Figure 2.9)**. These cattle were exposed to antibiotics in the water for 8 days or longer on 28% of the large operations and on 33% of the small operations **(Figure 2.9)**. Chlortetracycline and tylosin,





the most frequently used antibiotics in feed or water, were used each by more than 40% of the feedlot operations **(Figure 2.10)**.



Dairy

`Dairy '96 studied antibiotic use in dairy cows during the 12 months prior to interviewing the producers (USDA/APHIS/VS, 1996d). Antibiotics were given by injection to 1 to 9% of the milk cows on 48.9% of the operations, and they were given to 10 to 39% of the milk cows on 39.5% of the operations. Only 3.9% of the operations gave no antibiotics via injection. Antibiotics were given by injection during lactation to 1 to 39% of the milk cows on 87.8% of the operations. Only 6.5% of the operations gave no antibiotics via injection during lactation. Antibiotics were given by injection during the dry period to 1 to 39% of the milk cows on 47.3% of the operations. Slightly more than 50% of the operations gave no antibiotics via injection during the dry period. Additional details about routes of injection, sites of injection, the veterinarian's role, antibiotic record systems, and identification of animals having undergone therapy are available from Dairy '96, but have not been presented in this report.

Poultry

Poultry became the focus of a national study by the NAHMS program for the first time in early 1999. Thus, unlike the swine, beef, dairy and the catfish industries, there are no data from the NAHMS program on antibiotic use in the poultry industry. However, a summary of the cost of antibiotic used in broiler and turkey production in the U.S. from 1989 through 1994 has been compiled (Agrimetrics Associates, Inc., 1994). Antimicrobial drugs used were categorized as sulfonamides (n = 6), ionophores (n = 5), miscellaneous (e.g., amprolium; n = 9), antibiotics for growth promotion only (n = 1), antibiotics for infectious diseases only (n = 8), and antibiotics for both growth promotion and infectious diseases (n = 8). These antimicrobials are given to poultry in feed, water, and less frequently via injection. The poultry industry is concerned that only one antibiotic, a fluoroquinolone, has been approved in recent years as a therapeutic for poultry. On

the other hand, the amount of antibiotics used in broiler production between 1989 and 1994 decreased for several reasons, among these being the implementation of multi-faceted preventive medicine programs (e.g. biosecurity), increased efforts to reduce production costs, enhanced focus on residue avoidance, and rapid production of efficacious vaccines by manufacturers.

Catfish

Catfish ’97 was the first national study of food fish by the NAHMS program (USDA/APHIS VS, 1997b). Enteric Septicemia of Catfish (ESC), a bacterial infectious disease, was reported by 56% of U.S. operations. Antimicrobial drug use was not a specific focus of Catfish ‘97, because very few antibiotics have been approved for use in catfish production, and even fewer antibiotics are thought to be efficacious (Personal communication, Bruce Wagner, USDA/APHIS VS, 1999). However, ESC was managed by 41% of these affected operations by feeding Romet, a combination of sulfadimethoxine and ormetroprim.

References

Agrimetrics Associates. *Summary of Data Compiled for the National Academy of Science/NationalResearch Council Joint Panel on Animal Health and Veterinary Medicine*. Chester, VA: Agrimetrics Associates, Inc. AHI (Animal Health Institute). Alexandria, VA.; 1994.

Crawford LM, Teske RH. Growth promotants approved in the U.S. *Veterinary Research Communications.* 1983;7:83-84.

Droumev D. Review of antimicrobial growth promoting agents available. *Veterinary Research Communications.* 1983;7:85-89.

Frost AJ. Antibiotics and animal production. In: Woolcock JB, Editor. *World Animal Science -- Microbiology of Animals and Animal Products.* New York: Elsevier; 1991;A6:181-194.

Luetzow M. Approval procedures for anti-microbial growth promoters: aspects of risk assessment and risk management. In: The Medical Impact of the Use of Antimicrobials in Food Animals.: Geneva: World Health Organization; 1997.

McOrist S. Use of antimicrobials in food production-scope, policies and practices. In: The Medical Impact of the Use of Antimicrobials in Food Animals.: Geneva: World Health Organization; 1997.

Rutter JM. Use of anti-infective drugs in the UK- types of use and conditions/legislation for applications. In: The Medical Impact of the Use of Antimicrobials in Food Animals.: Geneva: World Health Organization; 1997.

Stokstad ELR, Jukes TH. Further observations on the animal protein factor. *Proceedings of the Society of Experimental Biology and Medicine.* 1950;73:523-528.

U.S. Food and Drug Administration. *FDA Approved Animal Drug Products 1999.* Blacksburg, VA: Drug Information Laboratory, Virginia/Maryland Regional College of Veterinary Medicine; 1999.

USDA/APHIS/Veterinary Services. *Feedlot Health Management Report: Part II: Cattle on Feed Evaluation. N172.0195*. Fort Collins, CO: USDA:APHIS:VS, Centers for Epidemiology and Animal Health; 1995b.

USDA/APHIS/Veterinary Services. *Morbidity/Mortality and Health Management of Swine in the United States. N101.0192*. Fort Collins, CO: USDA:APHIS:VS, Centers for Epidemiology and Animal Health; 1992a.

USDA/APHIS/Veterinary Services. *Part I: Reference of 1995 Swine Management Practices. N186.995*. Fort Collins, CO: USDA:APHIS:VS, Centers for Epidemiology and Animal Health; 1995e.

USDA/APHIS/Veterinary Services. *Part I: Reference of 1996 U.S. Catfish Health & Production Practices. N235.597*. Fort Collins, CO: USDA:APHIS:VS, Centers for Epidemiology and Animal Health; 1997b.

USDA/APHIS/Veterinary Services. *Part III: Reference of 1996 Dairy Health and Management Practices. N212.1196*. Fort Collins, CO: USDA:APHIS:VS, Centers for Epidemiology and Animal Health; 1996d.

Visek WJ. The mode of growth promotion by antibiotics. *Journal of Animal Science*. 1978;46:1447-1469.

Walton JR. Modes of action of growth promoting agents. *Veterinary Research Communications*. 1983;7:1-7.