Treatment of Bacterial Pneumonia in Feedlot Cattle

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Pneumonia associated with *Pasteurella* bacteria is widely acknowledged to be the most important disease of feedlot cattle. In a 13,000-head capacity feedlot in Davis area, uncomplicated bacterial pneumonias were responsible for 42.5% of all deaths over an 18-month period (Table 1). In addition, secondary bacterial pneumonias were a contributing factor in many deaths attributed to infectious bovine rhinotracheitis, bovine viral diarrhea, salmonellosis, cellulitis, paresis and polyarthritis during this same period. Efforts to control these losses were hampered by inadequate information concerning antimicrobic therapy. Consequently, a study of the relationships between the bacteria associated with feedlot pneumonia and the antibiotics used in treatment was initiated. It was hoped that improved knowledge concerning these relationships might permit more precise therapeutic management of the disease. Initial work included microbiologic examination of the pneumonic lesions from 500 lungs. Significant bacterial flora consisted mainly of *Pasteurella hemolytica, P. multocida* and *Corynebacterium pyogenes,* alone or in various combinations (Tables 2 and 3). Other bacteria were isolated infrequently. *C. pyogenes* was isolated infrequently except from chronic lesions (Table 4).

On December 27, 1972, a prophylactic chlortetracycline feeding program was initiated in the cooperating feedlot. All incoming cattle were fed 500 mg of chlortetracycline[1] in each 10 lb. of starting ration during the first 21 days after arrival. A total of 5,258 cattle were medicated between December 27, 1972, and March 6, 1973. Initial results were thought to be favorable as judged by reduced sick pen populations. However, by the end of February it was clear that an increasing proportion of sick cattle were not responding satisfactorily to treatment. This refractoriness could be correlated with a marked increase in antimicrobic resistance* in *Pasteurella* bacteria isolated from fatal cases of pneumonia (Tables 5-7). Antimicrobic-resistant *Pasteurella* pneumonia continued to be a serious problem until early in 1974, when inshipments were terminated during a 3-month period. When receiving commenced again in May, the problem did not recur (Table 7). An identical phenomenon was observed with salmonellosis (Table 8). Infection cycles of both diseases were apparently broken by a 3-month absence of cattle rendered susceptible by stresses of shipping and feedlot adaptation.

Beginning in the summer of 1973, when antimicrobic-resistant *Pasteurella* pneumonia was rampant, studies were initiated to determine the relationships between *P. hemolytica* and *P. multocida* and the antibiotics which are commonly used in treating bovine pneumonia. The minimum inhibitory concentrations of oxytetracycline, penicillin G, erythromycin, dihydrostreptomycin, ampicillin and tylosin were determined for *P. hemolytica* and *P. multocida* (Figure 1). The bacteria were isolated from the nasal secretions of cattle with pneumonia and from the pneumonic lungs of dead cattle. The next step was to determine how best to achieve and maintain inhibitory concentrations in the blood of treated animals. Oxytetracycline HC1[2], procaine penicillin G in aqueous suspension[3], erythromycin[4], dihydrostreptomycin sulfate[5], ampicillin trihydrate[6], and tylosin[7] were administered to normal Hostein calves in varying dosages and by several routes of administration. It was soon determined that it was not practical to attempt treatment of infections with antibiotics to which the causative bacteria were classified resistant (Figures 2-7). Attention was therefore focused on identifying dosages and methods of administration which demonstrated greatest potential for successful management of infections caused by antibiotic-sensitive *Pasteurella* bacteria. It was decided that oxytetracycline would be used in a dose of 5 mg/lb. of body weight, and administered by the subcutaneous route. This regimen resulted in blood serum concentrations which were inhibitory for 18 of 19 sensitive *Pasteurella* bacteria throughout a 24-hour treatment interval (Figure 2). Intravenous and intramuscular

[1]CTC-10, Diamond Shamrock Chemical Co., 60 Park Place, Newark, N.J. 07102.
*Determined by the Kirby-Bauer paper disk method.

[2]Terramycin Injectable Solution and [3]Procaine Penicillin G in Aqueous Suspension, Agricultural Division, Pfizer Inc., New York, N.Y. 10017. [4]Gallimycin Injectable, Agricultural and Veterinary Products Division, Abbott Laboratories, North Chicago, Ill. 60064. [5]Dihydrostreptomycin Sulfate Injectable Solution, Burns Biotec Laboratories Division, Oakland, Ca. 94621. [6]Polyflex, Veterinary Products, Bristol Laboratories, Division of Bristol-Myers Co., Syracuse, N.Y. 13201. [7]Tylan 200, Elanco Products Co., A Division of Eli Lilly and Co., Indianapolis, Ind.

Table 1

Causes of Death (1-22-72 - 8-31-73)

Diagnosis	No. of Cases	% of Total*
Primary bacterial pneumonias	378	42.5
Interstitial pneumonia	76	8.5
BVD	68	7.6
Salmonellosis	68	7.6
Bloat	56	6.3
IBR	29	3.3
Hemophilus TEME	22	2.5
Cellulitis	14	1.6
Paresis	13	1.5
Anaplasmosis	13	1.5
Urolithiasis	12	1.3
Polyarthritis	11	1.2
Post-castration hemorrhage	9	1.0
Empyema	9	1.0
Suppurative meningio-encephalitis	9	1.0
TRP	8	
Trauma	6	
Peritonitis	6	
Infectious myositis	5	
Myelomalacia (HPR)	5	
Septicemia	5	
Esophagitis (HPR)	4	
Suffocation	4	
Traumatic pharyngitis	4	
Abomasal ulcer	3	
Cast	3	
Necrotic laryngitis	3	
Castration infection	2	
Drug reaction	2	
Fatal hemorrhage	2	
Mycotic ruminitis	2	
O-P toxicity	2	
Portal vein occlusion	2	
Pulmonary abscesses	2	
Pyelonephritis	2	
Fracture	2	
Bladder rupture	1	
Dystocia	1	
Encephalopathy	1	
Intestinal obstruction	1	
Intussusception	1	
Liver abscesses	1	
Non-suppurative encephalitis	1	
Pericarditis	1	
Pharyngeal abscess	1	
Strangulation	1	
Uterine prolapse	1	
Vaginal perforation	1	
Vegetative endocarditis	1	
Verminous bronchopneumonia	1	
Undetermined	15	
Unknown (not autopsied)	170	
TOTAL	1,060	

*Unknowns not excluded. A total of 890 was utilized.

administration of oxytetracycline was less effective in maintaining inhibitory serum concentrations.

Concentrations of penicillin G in serum, resulting from injections of procaine penicillin G in aqueous suspension, were not markedly influenced by route of

Table 2

Results of Microbiological Examination of Lungs from 500 Cases of Bovine Bacterial Pneumonia

Organisms Isolated	No. of Isolations	Frequency of Isolation (%)
Mycoplasma	331	86.2*
Pasteurella hemolytica	260	52.0
P. multocida	130	26.0
Escherichia coli (non-hemolytic)	70	14.0
Corynebacterium pyogenes	61	12.2
Proteus spp.	22	4.4
Pasteurella spp.	21	4.2
E. coli (hemolytic)	15	3.0
Negative (no growth)	13	2.6
Salmonella newport	10	2.0
Hemophilus oakley	7	1.4
Actinobacillus-like organisms	5	1.0
Streptococcus viridans	5	1.0
Alpha streptococci	4	0.8
Corynebacterium spp.	2	0.4
Enteric spp.	2	0.4
Alcaligenes fecalis	1	0.2
Flavobacterium spp.	1	0.2
Pseudomonas aeruginosa	1	0.2
S. dublin	1	0.2
S. typhimurium	1	0.2
Staphylococcus aureus	1	0.2
Streptococcus fecalis	1	0.2
Streptococcus fecium	1	0.2
All *Pasteurellas*	414	82.8

*A total of 381 lungs were examined for mycoplasmas.

administration (Figure 3). A dose of 60,000 units/lb. resulted in concentrations which were inhibitory for all sensitive *Pasteurella* bacteria throughout a 24-hour treatment interval. This dose was initially rejected on the basis of cost and convenience. A dose of 20,000 units/lb. was chosen for evaluation in the cooperating feedlot, since it provided serum concentrations which were inhibitory for all sensitive *Pasteurella* isolates for eight hours after administration and which were inhibitory for 15 of 28 isolates throughout a 24-hour treatment interval. Initial results were favorable. During the first 3½ months only one of 17 fatal pneumonia cases occurring in cattle treated with penicillin G resulted from a penicillin-sensitive *Pasteurella* infection (Table 9). Subsequently, there was an increase in mortality resulting from infections with penicillin-sensitive *Pasteurella* bacteria, and dosage was increased to 30,000 units/lb. The present treatment program includes the evaluation of procaine penicillin G in a dose of 60,000 units/lb. in pneumonia cases which have not responded to 30,000 units/lb.

Erythromycin was administered in a dose of 20 mg/lb. by intramuscular injection. The peak serum concentrations achieved with this regimen were not inhibitory for a majority of *Pasteurella* bacteria (Figure 4). Of 458 pneumonia cases treated with erythromycin, 28% responded favorably (Table 10). It is likely that efficacy would be greatly improved if the

Table 3

Results of Microbiologic Examination of Lungs from 384 Cases of Bovine Bacterial Pneumonia

Organisms Isolated in Association	No. of Isolations	Frequency of Isolation (%)
Mycoplasma, Pasteurella hemolytica	126	32.8
Mycoplasma, P. multocida	57	14.8
P. hemolytica	16	4.2
Mycoplasma, P. hemolytica, P. multocida	16	4.2
Mycoplasma, P. hemolytica, Corynebacterium pyogenes	14	3.6
Mycoplasma, P. multocida, C. pyogenes	10	2.6
Mycoplasma	10	2.6
Mycoplasma, P. hemolytica, Escherichia coli (non-hemolytic)	10	2.6
Mycoplasma, C. pyogenes	9	2.3
Mycoplasma, E. coli (non-hemolytic)	9	2.3
Negative (no growth)	7	1.8
Mycoplasma, Pasteurella spp.	6	1.6
P. multocida	6	1.6
Mycoplasma, P. hemolytica, E. coli (hemolytic)	5	1.3
Mycoplasma, P. multocida, E. coli (non-hemolytic)	5	1.3
E. coli (non-hemolytic)	5	1.3
Mycoplasma, E. coli (hemolytic and non-hemolytic)	4	1.0
Proteus	4	1.0
Miscellaneous associations	65	16.9

dosage could be increased to 50 mg/lb., so as to achieve serum concentrations in the 8 μgm/ml range (Figures 1 and 4). This was precluded by the occurrence of severe local tissue reaction at the site of injection and occasional transient central nervous system derangement when the 20 mg/lb. dosage was exceeded. Even at 20 mg/lb., this formulation must be administered carefully if excessive muscle inflammation is to be avoided. The maximum volume per injection site should be limited to 10 ml. Care must be taken to avoid reinjection of previously injected areas of muscle. This is best accomplished by injecting a different muscle mass each day, and by limiting the number of treatments to a maximum of four. Because of these limitations, use of erythromycin is restricted to those cases of pneumonia which are refractory to oxytetracycline, sulfamethazine, and penicillin G.

Dihydrostreptomycin was not utilized in the treatment program for two reasons: (1) Most *Pasteurella* bacteria are resistant to it. (2) Multiple daily treatments would be required to maintain inhibitory serum concentrations (Figure 5). Ampicillin was not utilized for the following reasons: (1) Multiple daily injections would be required to maintain inhibitory serum concentrations (Figure 6). (2) Most *Pasteurella* bacteria which are resistant to penicillin G are also resistant to ampicillin. Over a 3-year period 82.8% of 390 penicillin G-resistant isolates were also ampicillin-resistant.

Tylosin was originally rejected because of lack of efficacy for *Pasteurella* bacteria (Figure 7). Subsequently, tylosin was sometimes found to be of value in the treatment of certain conditions, such as

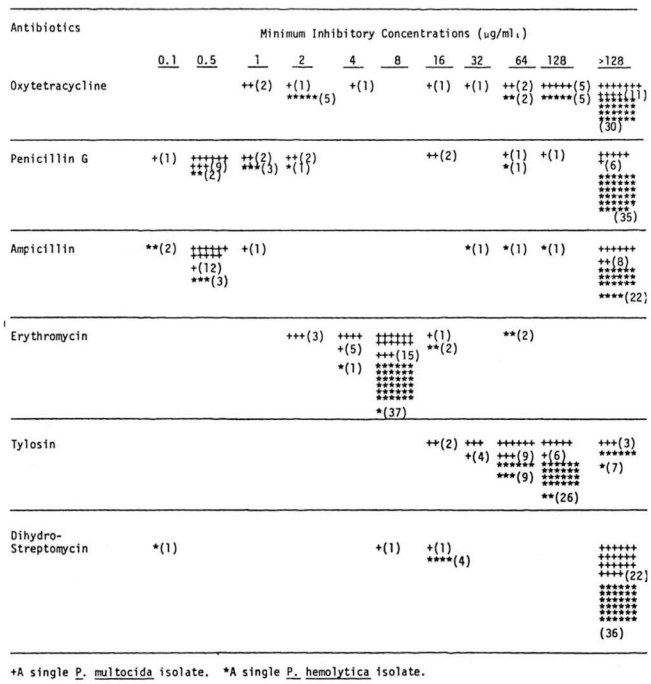
Table 4

Results of Microbiologic Examination of Lungs from 406 Cases of Bovine Bacterial Pneumonia: Influence of Duration of Treatment

Organism Isolated	Duration of Treatment (Days)*							
	Not treated	Less than 7	8-10	11-14	15-21	22-30	31-45	Greater than 45
Mycoplasma	19** (76.0)***	83 (79.8)	30 (83.3)	38 (86.4)	42 (95.5)	28 (93.3)	10 (90.9)	10 (90.9)
P. hemolytica	21 (58.3)	93 (62.4)	32 (65.3)	25 (43.9)	25 (46.3)	12 (35.3)	6 (42.9)	6 (46.2)
P. multocida	4 (11.1)	20 (13.4)	10 (20.4)	17 (29.8)	19 (35.2)	19 (55.9)	8 (57.1)	3 (23.1)
E. coli (non-hemolytic)	4 (11.1)	32 (21.5)	8 (16.3)	7 (12.3)	5 (9.3)	3 (8.8)	–	2 (15.4)
C. pyogenes	3 (8.3)	11 (7.4)	3 (6.1)	9 (15.8)	11 (20.4)	5 (14.7)	4 (28.6)	2 (15.4)
Proteus spp.	–	7 (4.7)	2 (4.1)	2 (3.5)	3 (5.6)	3 (8.8)	1 (7.1)	–
Pasteurella spp.	1 (2.8)	5 (3.4)	1 (2.0)	3 (5.3)	2 (3.7)	–	1 (7.1)	1 (7.7)
E. coli (hemolytic)	2 (5.6)	7 (4.7)	3 (6.1)	1 (1.8)	–	1 (2.9)	–	–
Negative	2 (5.6)	7 (4.7)	–	–	1 (1.9)	–	–	–
S. newport	–	–	2 (4.1)	2 (3.5)	2 (3.7)	3 (8.8)	–	1 (7.7)
H. oakley	2 (5.6)	1 (0.7)	–	2 (3.5)	–	–	–	1 (7.7)
Actinobacillus-like	–	2 (1.3)	–	–	–	–	–	–
Str. viridans	–	1 (0.7)	1 (2.0)	1 (1.8)	–	1 (2.9)	–	–
Alpha streptococci	1 (2.8)	1 (0.7)	1 (2.0)	–	–	–	–	–
All *Pasteurellas*	26 (72.2)	118 (79.2)	43 (87.8)	45 (78.9)	46 (85.2)	31 (94.1)	15 (100.7)	10 (71.4)
No. cases	36	149	49	57	54	34	14	13

*No. of days from the first time the animal was treated until death occurred. **No. of isolations. ***Frequency of isolation (%). All lungs not cultured for mycoplasmas.

Figure 1 -- Minimum Inhibitory Antibiotic Concentrations for Pasteurella hemolytica and Pasteurella multocida



+A single P. multocida isolate. *A single P. hemolytica isolate.

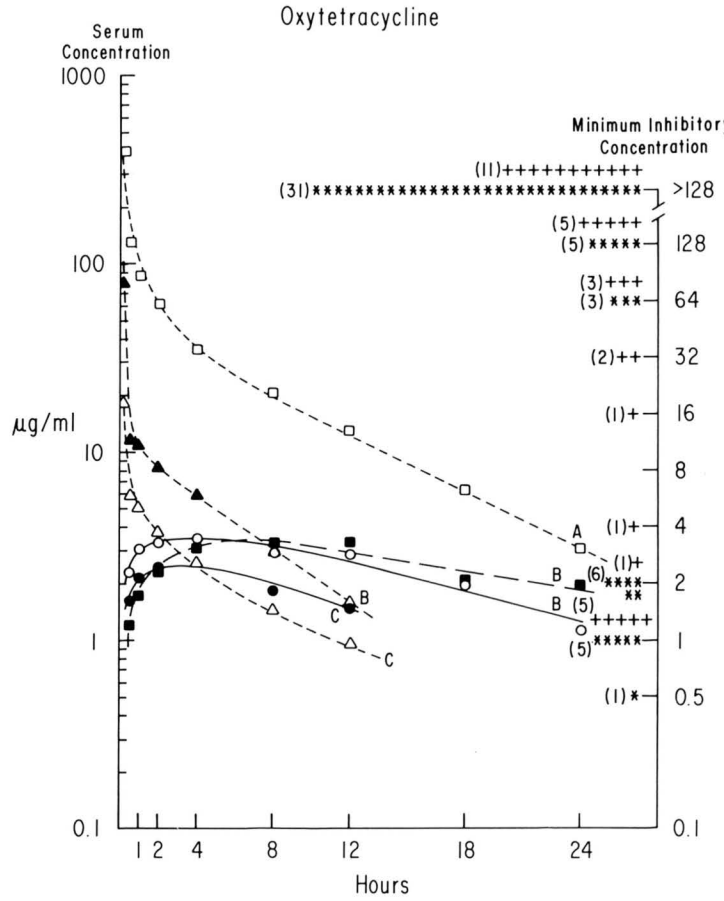


Figure 2. Serum oxytetracycline concentrations in relation to minimum inhibitory concentrations of oxytetracycline for *P. hemolytica* and *P. multocida*. - - - - intravenous administration; – intramuscular administration; – – – subcutaneous administration; A– dosage of 25 mg/lb.; B– dosage of 5 mg/lb.; C– dosage of 2 mg/lb.; *– single isolate of *P. hemolytica;* +– single isolate of *P. hemolytica.*

chronic pneumonia and cellulitis, which are often associated with *C. pyogenes* (Table 11). *C. pyogenes* is a common secondary bacterial invader in chronic pneumonic pasteurellosis (Table 4). These chronic pneumonia cases often show improvement during a course of treatment with antibiotics, only to relapse when therapy is terminated. These exacerbations are thought to originate from pockets of infection which are well-isolated from the blood stream, and into which antimicrobics diffuse with difficuluty. In other words, the problem is often not antimicrobic resistance, but one of ineffective antimicrobic concentrations. We have observed cases of chronic pneumonia which were refractory to treatment with oxytetracycline, sulfamethazine, penicillin G, and erythromycin, which responded favorably to tylosin in a dose of 20 mg/lb., administered by intramuscular injection. In an effort to understand this phenomenon, the minimum inhibitory concentrations of six antibiotics were determined for several *C. pyogenes* isolates. All were of bovine origin and were recovered from a variety of suppurative lesions, including pneumonic lungs. All were sensitive to penicillin G, whereas only about half were sensitive to tylosin (Figure 8). When the minimum inhibitory concentrations of penicillin G and tylosin for sensitive organisms were

Table 5

Antimicrobic Resistance Patterns in 29 Isolates of *P. hemolytica* Recovered During the Period of Prophylactic CTC Feed Medication

No. of Isolates	Antimicrobics												
	Penicillin G	Dihydrostreptomycin	Chloramphenicol	Erythromycin	Neomycin	Tetracycline	Kanamycin	Polymyxin B	Tylosin	Sulfathiazole	Gentamicin	Cephalothin	Ampicillin
7	X*	X		X	X	X	X		X	X	X		X
5	X	X		X	X	X	X		X	X			X
4	X	X		X	X	X	X		X	X	X	X	X
3	X	X		X	X	X	X		X	X		X	X
2	X	X		X	X	X			X	X			X
2	X	X				X			X	X			X
1		X		X	X				X	X			
1	X	X		X		X			X	X			X
1		X		X		X	X		X	X	X		
1	X	X		X		X			X	X		X	X
1		X		X	X	X	X		X	X	X	X	
1		X		X	X		X		X	X			

*Indicates resistance.

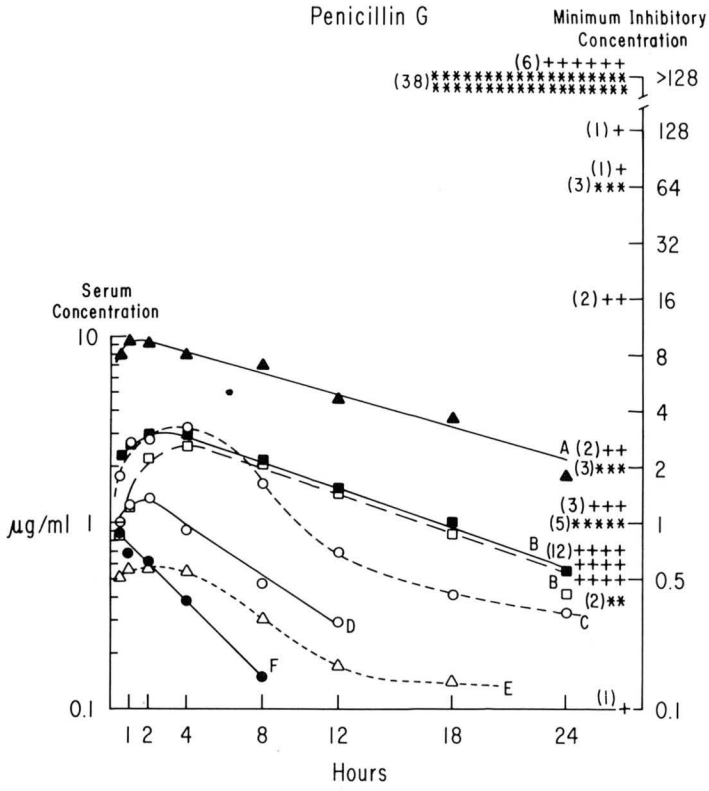


Figure 3. Serum concentrations of penicillin G in relation to minimum inhibitory concentrations of penicillin G for *P. hemolytica* and *P. multocida;* - procaine penicillin G, intramuscular administration; - - - Procaine penicillin G, subcutaneous administration; - - - - bicillin R, subcutaneous administration; A- dosage of 60,000 u/lb.; B- dosage of 20,000 u/lb.; C- dosage of 10 ml/150 lb.; D- dosage of 6,000 u/lb.; E- dosage of 2 ml/150 lb.; F- dosage of 2,000 u/lb.; *- single isolate of *P. hemolytica;* +- single isolate of *P. multocida.*

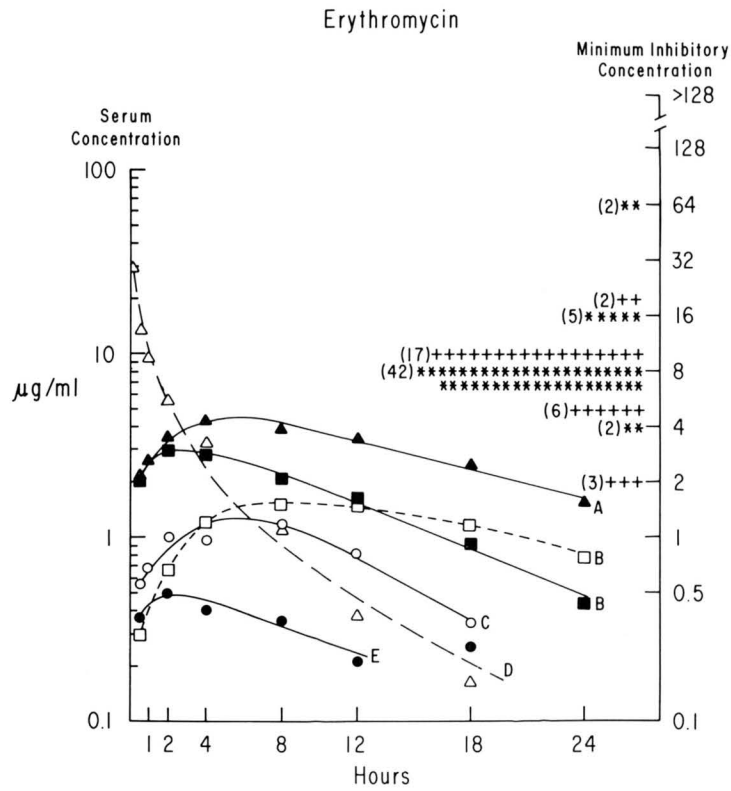


Figure 4. Serum concentrations of erythromycin in relation to minimum inhibitory concentrations of erythromycin for *P. hemolytica* and *P. multocida.* - intramuscular administration; - - - - subcutaneous administration; - - - intravenous administration; A- dosage of 25 mg/lb.; B- dosage of 15 mg/lb.; C- dosage of 5 mg/lb.; D- dosage of 10 mg/lb.; E- dosage of 2 mg/lb.; *- a single isolate of *P. hemolytica;* +- a single isolate of *P. multocida.*

Table 6

Antimicrobic Resistance Patterns in 13 Isolates of *P. multocida* Recovered During the Period of Prophylactic CTC Feed Medication

No. of Isolates	Antimicrobics													
	Penicillin G	Dihydrostreptomycin	Chloramphenicol	Erythromycin	Neomycin	Tetracycline	Kanamycin	Polymyxin B	Tylosin	Sulfathiazole	Gentamicin	Cephalothin	Ampicillin
3	X*	X		X	X	X	X		X	X	X	X	X
1	X	X		X	X	X			X	X	X		
1	X	X				X	X		X	X			
1	X	X		X	X	X	X	X	X	X	X	X	
1	X	X		X	X	X	X		X	X			X
1	X	X				X	X		X				
1	X	X		X	X		X	X	X	X	X		X
1	X	X			X	X	X		X		X		X
1	X			X		X			X	X			
1	X	X		X	X	X	X		X	X			
1		X		X	X	X	X		X	X			

*Indicates resistance.

examined in relation to peak serum concentrations achieved in treatment, a possible explanation for the occasional superiority of tylosin therapy became evident: Peak serum concentration of tylosin (administered intramuscularly in a dose of 20 mg/lb.) would exceed the minimum inhibitory concentration by a factor of 30 to 60 (Figures 7 and 8). The corresponding value for penicillin (administered subcutaneously in a dose of 30,000 u./lb.) would be 10 (Figures 3 and 8). The relatively greater concentrations of tylosin in relation to those required may tend to facilitate achievement of inhibitory concentrations in isolated pockets of infections.

Even before appropriate dosage and administration regimens had been determined, a new treatment system was devised and implemented in the cooperating feedlot. Sick cattle were individually

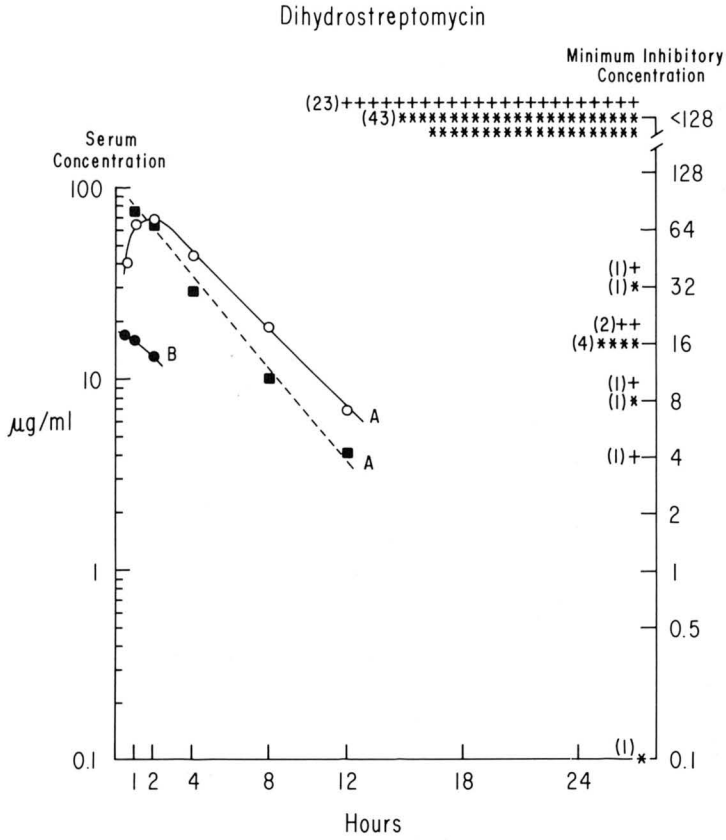


Figure 5. Serum concentrations of dihydrostreptomycin in relation to minimum inhibitory concentrations of dihydrostreptomycin for *P. hemolytica* and *P. multocida*. – intramuscular administration; - - - - subcutaneous administration; A– dosage of 25 mg/lb.; B– dosage of 5 mg/lb.; *– single isolate of *P. hemolytica;* +– single isolate of *P. multocida.*

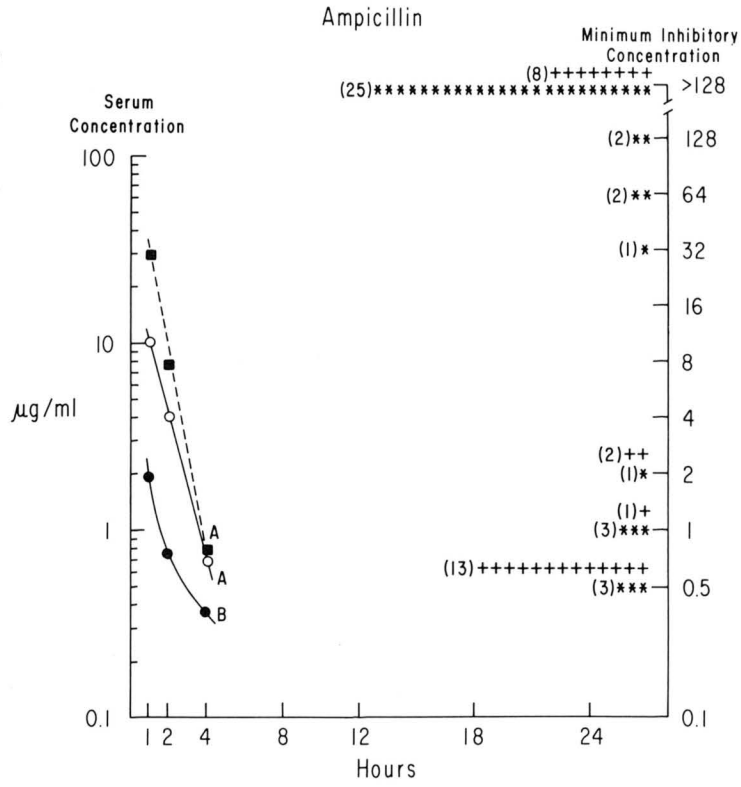


Figure 6. Serum concentrations of ampicillin in relation to minimum inhibitory concentrations of ampicillin for *P. hemolytica* and *P. multocida*. - - - - subcutaneous administration; – intramuscular administration; A– dosage of 10 mg/lb.; B– dosage of 2 mg/lb.; *– single isolate of *P. hemolytica;* +– single isolate of *P. multocida.*

identified and provided with a permanent individual treatment record. The order in which antimicrobics were to be utilized in the management of refractory lung infections was determined by examination of antimicrobic sensitivity patterns in *Pasteurella* bacteria isolated from the nasal secretions of sick cattle between July and December of 1972. Tetracycline, sulfathiazole, penicillin G and erythromycin were ranked in decreasing order of effectiveness (Table 12). The system initially developed for treatment of respiratory disease in this feedlot is presented in detail in Appendix A. Initial treatment was with the antimicrobic to which the infection was most likely to respond. If a favorable response was detectable by 24 hours after treatment, the initial treatment was repeated. Otherwise, the next antimicrobic in the treatment rotation was administered. This was continued until a favorable response was observed. Treatment was ordinarily continued until the rectal temperature and the attitude of the animal were judged to be normal on two consecutive days.

Subsequent to February 1, 1974, when antimicrobic-resistant *Pasteurella* pneumonia (as seen from December 27, 1972 to January 31, 1974) was not a problem, use of this treatment system was associated with reductions in mortality from uncomplicated bacterial pneumonia of 51% in calves (Table 13), and 69% in yearlings (Table 14). The basis for comparison was the period from February 17 to December 26, 1972, prior to initiation of prophylactic CTC feed medication. Mortality from uncomplicated bacterial pneumonia in yearling cattle was limited to 0.11% (Table 14). Reductions of 44% and 41% in total mortality and culling were associated with use of the new treatment system (Table 15). Cost of treatment was increased by 39¢ per animal fed (Tables 15 and 16). The net value of the new treatment system in yearling cattle was estimated to be $3.23 per steer fed (Table 16).

Beginning on August 19, 1975, the treatment system was modified to provide for a 48-hour response evaluation period. Sulfamethazine was substituted for oxytetracycline as the first-choice antimicrobic, based on the results of more recent sensitivity testing of nasal *Pasteurella* isolates (Table 12) and on a superior response rate (Table 17). This modified treatment system is described in detail in Appendix B. The 48-hour response evaluation was initiated because of the observation that pneumonia cases not initially responding to standard antimicrobics (oxytetracycline, sulfamethazine and procaine penicillin G) often responded to them when they were subsequently administered for a 3-day period (Table 17). A preliminary summary of the response patterns in 123 cases of pneumonia treated using this modified system is presented (Table 18). Improved response

Table 7

Mortality from Antimicrobic Resistant* Pasteurella Pneumonia in Feedlot Cattle: Influence of a Prophylactic Chlortetracycline Feed Medication** Program

Time period	Relationship to CTC feeding program	No. of cattle received	Mortality	
			Resistant *P. hemolytica* isolated	Resistant *P. multocida* isolated
2-15-72 to 12-26-72	Before	15,468	7† (0.045)[11]	11 (0.071)
12-26-72 to 3-6-73	During	5,258	38 (0.723)[1]	11 (0.209)[2]
3-7-73 to 3-31-73	After	1,360	1 (0.074)	2 (0.147)
April 1973	After	1,399	17 (1.215)[1]	1 (0.071)
May 1973	After	2,345	6 (0.256)[1]	0 (0.000)
June 1973	After	4,426	25 (0.565)[1]	7 (0.158)
July 1973	After	1,122	7 (0.624)[1]	1 (0.089)
August 1973	After	680	2 (0.294)[2]	2 (0.294)[3]
September 1973	After	733	0 (0.000)	0 (0.000)
October 1973	After	1,174	8 (0.681)[1]	1 (0.085)
November 1973	After	1,172	1 (0.085)	3 (0.256)[3]
December 1973	After	1,578	5 (0.317)[1]	5 (0.317)[2]
January 1974	After	1,617	6 (0.371)[1]	4 (0.247)[3]
February 1974	After	467	0 (0.000)	0 (0.000)
March 1974	After	28	0 (0.000)	0 (0.000)
April 1974	After	25	0 (0.000)	0 (0.000)
May 1974	After	5,817	0 (0.000)	0 (0.000)
June 1974	After	1,484	0 (0.000)	0 (0.000)
July 1974	After	3,569	3 (0.084)	0 (0.000)
August 1974	After	525	0 (0.000)	0 (0.000)

*Resistant to tetracycline, sulfathiazole and penicillin G. **From Dec. 27, 1972, to March 6, 1973, all cattle entering the feedlot were fed a starting ration containing 500 mg of CTC/4.5 kg (10 lb.) for the first 21 days after arrival. †Number of deaths. [11]Mortality (%).
[1] [2] [3]Significantly greater than in cattle received before CTC medication ([1]$P < 0.001$; [2]$P < 0.01$; [3]$P < 0.05$).

Table 8

Deaths by Month from Salmonellosis in Feedlot Cattle

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1972	–	2	1	0	0	0	1	4	4	1	3	12
1973	7	5	6	1	1	1	3	16	3	3	6	7
1974	4	8	1	0	0	0	0	0	0	0	0	0

Table 9

Frequency of Isolation of Penicillin-Resistant *Pasteurella* Bacteria from Cases of Uncomplicated* Bovine Bacterial Pneumonia Unsuccessfully Treated with Procaine Penicillin G: Influence of Dosage

Time Period	No. of Isolates	Frequency of Resistance	
		No.	%
9-15-73 to 12-31-73*	17	16	94.1
1-1-74 to 2-13-74*	18	12	66.7
2-14-74 to 6-6-74**	8	6	75.0
TOTALS	43	34	79.1

*Using a dosage of 20,000 u./lb. b.w. **Dosage increased to 30,000 u./lb. b.w.

Table 10

Results of Treating Non-responsive* Cases of Bovine Pneumonia with Erythromycin**

	No.	%
All pneumonia cases	2,069	100
Non-responsive cases	458	22
Non-responsive cases responding to erythromycin	129	28
Relapses in erythromycin-responsive cases	19	15
Mortality in erythromycin-treated cases	21	5

*Non-responsive to oxytetracycline, sulfamethazine, and procaine penicillin G. **20 mg/lb. b.w., i.m.

rates to sulfamethazine and oxytetracycline resulted in reduced utilization of procaine penicillin G, erythromycin, and tylosin (Tables 17 and 18). Since the latter three are used in dosages which exceed label recommendations and are relatively expensive treatments, the modified system shows promise of reducing treatment costs. An additional benefit was an apparent reduction in the relapse rate (Tables 17 and 18). More definitive evaluation of the modified system must await its use in a larger series of cases.

Questions

Circle the letter preceding the phrase which most accurately completes the opening statement:

1. The most significant bacterial agents recovered from lesions of bacterial pneumonia were: a. *Pasteurella hemolytica, P. multocida* and *E. coli;* b. *P. hemolytica, P. multocida* and mycoplasmas; c. *P. hemolytica, P. multocida* and *Corynebacterium pyogenes;* d. *Pseudomonas aeruginosa, P. multocida* and *Hemophilus somnus;* e. *P. hemolytica, P. multocida* and *H. somnus.*
2. *Corynebacterium pyogenes* is least likely to be resistant to: a. penicillin G, b. dihydrostreptomycin, c. tetracyclines, d. sulfonamides, e. erythromycin, f. tylosin.
3. The pasteurella bacteria associated with bacterial pneumonia in cattle: a. are least likely to be resistant to sulfonamides, b. are least likely to be resistant to tetracyclines, c. are least likely to be resistant to penicillin G, d. are in a dynamic state with respect to antibiotic resistance patterns.
4. The route of administration which was most effective in maintaining inhibitory serum concentrations of oxytetracycline after the 12th hour post-treatment was: a. the intravenous route, b. the intramuscular route, c. the subcutaneous route, d. the oral route.
5. Concentrations of penicillin G, which are inhibitory for all sensitive pasteurella bacteria, can be maintained for 24 hours following subcutaneous or intramuscular administration of procaine penicillin G in aqueous suspension in a dose of: a. 2,000 units per lb. of b.w., b. 6,000 units per lb. of b.w., c. 20,000 units per lb. of b.w., d. 60,000 units per lb. of b.w.

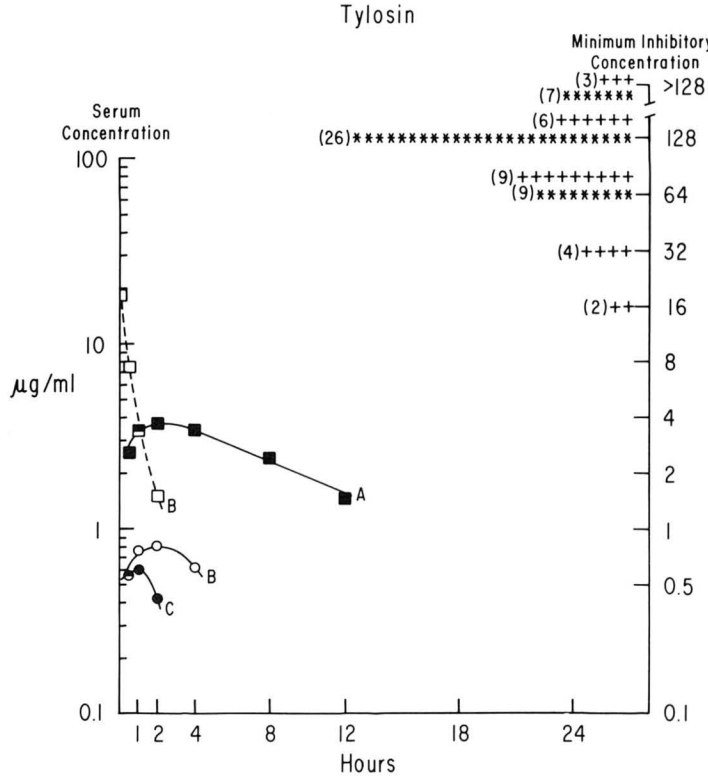


Figure 7. Serum concentrations of tylosin in relation to minimum inhibitory concentrations of tylosin for *P. hemolytica* and *P. multocida.* - - - - intravenous administration; – intramuscular administration; A– dosage 25 mg/lb.; B– dosage of 5 mg/lb.; C– dosage of 2 mg/lb.; *– single isolate of *P. hemolytica;* +– single isolate of *P. multocida.*

Table 11

Results of an Evaluation of Tylosin* in the Treatment Program of a Commercial Feedlot

Disease	No. cases treated	No. cases responding	Response (%)	No. deaths in responding cases	No. deaths in non-responding cases	Antimicrobic providing response: Oxytetracycline	Sulfamethazine	Procaine penicillin G 30,000 u/lb.	Procaine penicillin G 60,000 u/lb.
Acute pneumonia	13	3	23.1		1	3	3	1	1
Chronic pneumonia	8	3	37.5	2	2	1			2
Suppurative pododermatitis	6	4	66.7						1
Cellulitis	4	2	50.0	1	1				
Pharyngeal cellulitis	2	2	100.0						
Peritonitis	2	2	100.0	1					
Traumatic pharyngitis	1	1	100.00				1		
Polyarthritis	1		0.0						
TOTALS	37	17	45.9	4	4	4	4	1	4

*Administered in a dosage of 20 mg/lb. by intramuscular injection.

Antibiotics	Minimum Inhibitory Concentration (μg/ml)												
	.01	.05	0.1	0.5	1	2	4	8	16	32	64	128	>128
Oxytetracycline				*	**	**	*	*		*	***	***	
											***		
											*		
Penicillin G			*	***									
				***									
				***									
				***									
				*									
Erythromycin		***											***
	*	***			*	*					*	*	***
Dihydrostreptomycin													***
			**		*	*			*				***
													***
													***
													*
Ampicillin			***	***	*								
			***	***									
				***									
				**									
Tylosin			**										**
		***	***						*	*	**	*	***

*A single *C. pyogenes* isolate.

Figure 8. Minimum inhibitory antibiotic concentrations for *Corynebacterium pyogenes*.

Table 12

Antimicrobic Sensitivity of Pasteurellae Isolated from Nasal Secretions of Cattle with Feedlot Pneumonia*

Antimicrobic	Date of Isolation			
	1972**		1974***	
	No. tested	Sensitive (%)	No. tested	Sensitive (%)
Tetracycline	73	97.3	97	62.9
Sulfathiazole	73	78.1	53	90.6
Penicillin G	73	63.0	94	77.7
Erythromycin	23	34.8	97	21.6

*Isolated on the first day of clinical illness, prior to initial treatment. **Isolated between July 12, 1972, and December 5, 1972. ***Isolated during July of 1974.

Table 13

Mortality Associated with Bacterial Pneumonia in Feedlot Calves: Influence of Antimicrobic Resistance in Causative Pasteurellae

Time period	Relationship to antimicrobic resistance problem	No. calves received	Mortality Associated with Pneumonia		
			Primary pneumonias	Secondary pneumonias	All pneumonias
2-15-72 to 12-26-72	Before	7,392	65* (0.88)** [1]	29 (0.39)[2]	94 (1.27)[3]
12-27-72 to 1-31-74	During	10,296	217 (2.11)[1 4]	69 (0.67)[2]	286 (2.78)[3 5]
2-1-74 to 8-31-74	After	711	3 (0.42)*** [4]	2 (0.28)	5 (0.70)[11 5]

*No. of deaths. **Mortality (%). ***Reduction of 51% compared with "Before." [11]Reduction of 45% compared with "Before." Values having the same superscript are significantly different ([1 3 5] $P = < 0.001$; [2]$P = < 0.02$; [4]$P = < 0.01$).

Table 14

Mortality Associated with Bacterial Pneumonia in Yearling Feedlot Cattle: Influence of Antimicrobic Resistance in Causative Pasteurellae

Time period	Relationship to antimicrobic resistance problem	No. yearling cattle received	Mortality Associated with Pneumonia		
			Primary pneumonias	Secondary pneumonias	All pneumonias
2-15-75 to 12-26-72	Before	8,076	28* (0.35)** [1 4]	35 (0.43)[2]	63 (0.78)[3]
12-27-72 to 1-31-74	During	12,576	86 (0.68)[4 5]	37 (0.29)[6]	123 (0.98)[7]
2-1-74 to 8-31-74	After	10,931	12 (0.11)*** [1 5]	8 (0.07)[2 6]	20 (0.18)[11 3 7]

*No. of deaths. **Mortality (%). ***Reduction of 69% compared with "Before." [11]Reduction of 77% compared with "Before." Values having the same superscript are significantly different ([1 2 3 5 6 7]$P = < 0.001$; [4]$P = < 0.01$).

Table 15

A Comparison of Mortality, Culling and Medicine Cost in Yearling Cattle Treated with and without Individual Treatment Records

Time Period	Treatment system used	Mortality	Culling rate	Medicine cost*
(2-17 - 12-31-72)**	No individual records	198/10,282 (1.93)*** [6]	372/10,265 (3.62)*** [6]	$5.03 (9,161)[11]
(2-1-74 - 4-30-75)**	Individual treatment records	186/17,174 (1.08)[1 5]	251/11,770 (2.13)[2 6]	$5.42[3] (10,513) $5.26[4] (1,167)

*Includes all prophylactic and therapeutic biologicals and pharmaceuticals. **The time period during which cattle were received. ***Percent. [11]No. of cattle included in the analysis. [1]Reduction of 44% compared with the period from 2-17 to 12-31-72. [2]Reduction of 41% compared with the period from 2-17 to 12-31-72. [3]Medicine cost for 2-1 - 7-31-74 (Kohler treating). [4]Medicine cost for 8-1-74 - 4-30-75 (Gillam treating). Values having the same superscript are significantly different ([5 6] P = < 0.001).

Table 16

An Estimate of the Economic Advantage in Yearling Cattle of an Individual Animal Treatment Record System

Time period	Change in mortality	Net advantage per steer (mortality)	Change in culling rate	Net advantage per steer (culling)	Net advantage per steer (medicine)	Total net advantage per steer
(2-1-74 - 4-30-75)	-0.85%*	+$2.13**	-1.49%*	+$1.49** ***	-$0.39*	+$3.23

*Based on comparisons with the baseline period of 2-17-72 - 12-31-72. **Based on a $250 feeder steer. ***Based on an estimated 40% reduction in value when a cull steer is sold at auction or killed on consignment.

Table 17

A Summary of the Response to Antimicrobics in 406 Cases of Bovine Feedlot Pneumonia Treated Using 24-hour Response Criteria (11-8-74 to 2-7-75)

Antimicrobic	No. cases treated	No. responding	No. of relapses	No. relapsed <30 days*	No. relapsed 8-30 days	No. relapsed < 8 days
Oxytetracycline (5 mg/lb., s.c.)	393 (96.8)**	243 (61.8)	55 (22.6)	16 (6.6)	27 (11.1)	12 (4.9)
Sulfamethazine (1 gr/lb. p.o.)	150 (36.9)	109 (72.7)	21 (19.3)	7 (6.4)	11 (10.1)	3 (2.8)
Procaine penicillin G (30,000 u/lb., s.c.)	53 (13.1)	36 (67.9)	3 (8.3)	1 (2.8)	2 (5.6)	-
Erythromycin (20 mg/lb., i.m.)	14 (3.4)	6 (42.9)	1 (16.7)	-	1 (16.7)	-
Tylosin (20 mg/lb., i.m.)	9 (2.2)	2 (22.2)	1 (50.0)	1 (50.0)	-	-
Procaine penicillin G (60,000 u/lb., s.c.)	7 (1.7)	1 (14.3)	1 (100.0)	-	1 (100.0)	-
Oxytetracycline (3-day minimum)	6 (1.5)	0 (0.0)	-	-	-	-
Sulfamethazine (3-day minimum)	5 (1.2)	4 (80.0)	3 (75.0)	1 (25.0)	2 (50.0)	-
Procaine penicillin G (3-day minimum)	-	-	-	-	-	
TOTALS	406 (100.0)	401 (98.8)	85 (21.2)	26 (6.5)	44 (11.0)	15 (3.7)

*No. of days between last day of initial treatment and first day of relapse. **Percent.

Table 18

A Summary of the Response to Antimicrobics in 123 Cases of Bovine Feedlot Pneumonia Treated Using 48-hour Response Criteria (8-19 to 11-27-75)

Antimicrobic	No. cases treated	No. responding	No. of relapses	No. relapsed <30 days*	No. relapsed 8-30 days	No. relapsed < 8 days
Sulfamethazine (1 gr/lb., p.o.)	122 (99.2)**	106 (86.9)	9 (8.5)	1 (0.9)	4 (3.8)	4 (3.8)
Oxytetracycline (5 mg/lb., s.c.)	14 (11.4)	10 (71.4)	0 (0.0)	-	-	-
Procaine penicillin G (30,000 u/lb., s.c.)	5 (4.1)	2 (40.0)	1 (50.0)	-	-	1 (50.0)
Procaine penicillin G (60,000 u/lb., s.c.)	3 (2.4)	0 (0.0)	-	-	-	-
Erythromycin (20 mg/lb., i.m.)	3 (2.4)	0 (0.0)	-	-	-	-
Tylosin (20 mg/lb., i.m.)	2 (1.6)	1 (50.0)	0 (0.0)	-	-	-
Sulfamethazine (3 days minimum)	1 (0.8)	1 (100.0)	-	-	-	-
Oxytetracycline (3 days minimum)	-	-	-	-	-	-
Procaine penicillin G (3 days min.)	-	-	-	-	-	-
TOTAL	123 (100.0)	120 (97.6)	10 (8.3)	1 (0.8)	4 (3.3)	5 (4.2)

*No. of days between last day of initial treatment and first day of relapse. **Percent.

Appendix A
Treatment Routine for Sick Cattle
(1-1-75)
C. A. Hjerpe, D.V.M.

1. Respiratory Disease and Miscellaneous Infections:

The objectives of the treatment program are to reduce death loss, culling and cost of treatment by starting each sick animal on an effective treatment as promptly as possible, and by keeping the animal on that treatment as long as it is responding to it. This can be efficiently accomplished by using an individual animal record system:

a. As each animal is treated for the first time, a pre-numbered Lone Star tag is placed in the ear. This number is written on the individual cattle medication record card (see appendix) along with the lot number, the diagnosis, the date, the rectal temperature, the degree of sickness, and the medication used.

b. The following symbols are used to designate the diagnosis: No symbol - respiratory and miscellaneous infections; SH - diarrhea cases; CEL - cellulitis; OL - other lameness; HEM - brain disease (Hemophilus); UT - uterine infection; BT - bloater; SW - buller; ABS - abscess; OV - overeating; PIZ - infected sheath; WB - urolithiasis.

c. Under "degree of illness," the animal is assigned a number which designates a degree of severity: 3 - severely ill (weak; very depressed; labored breathing); 2 - moderately ill (moderately depressed; gaunt); 1 - slightly ill to almost normal.

d. The following day, the rectal temperature and the "degree of illness" are again determined, recorded on the animal's card, and used to decide on the treatment for that day. For example: 1) If the animal had a temperature of 104.0°F or greater on the day it was pulled, and if the fever has fallen by two or more degrees, or to less than 104.0°F, the animal should be continued on the same treatment; 2) If the animal did not have a temperature of 104.0°F or greater on the day it was pulled, but if it is less weak, less depressed, less gaunt, it should be continued on the same treatment; 3) If the temperature does not fall two or more degrees and remains above 104.0°F, the next recommended treatment should be started; 4) If the animal did not have a temperature of 104.0°F or greater on the day it was pulled, and the "degree of illness" remains unimproved, the next recommended treatment should be started. In this way, the treatment is changed daily, if necessary, until a definite improvement is observed; 5) Treatment should be continued until fever, depression, weakness, heavy breathing and inappetence are absent on two consecutive examinations.

e. At the time of the initial treatment, the animal should be assigned to either the: 1) moderately sick or 2) very sick categories, and treated accordingly:

1) **Moderately Sick Cattle:** (a) Start treatment with oxytetracycline (Terramycin, Oxyject) injected subcutaneously. See appendix for recommended dosage; (b) If the animal does not respond, change the treatment to sulfamethazine boluses. See appendix for recommended dosages; (c) If the animal fails to respond, change the treatment to penicillin injected subcutaneously. See appendix for recommended dosages; (d) If still non-responsive, change the treatment to erythromycin (Gallimycin) injected intramuscularly. See appendix for recommended dosages; (e) If the animal fails to respond, change to tylosin (Tylan 200) injected intramuscularly. See appendix for recommended dosages; (f) If there is no response, change back to penicillin but increase the dosage to 20 cc/100 lb., injected subcutaneously; (g) If the animal also fails to respond to penicillin (20 cc/100 lb.), proceed as follows: (1) If time permits, continue with the daily observations of temperature and degree of illness. Treat for three days with oxytetracycline. If no response is obtained, treat for three more days with sulfamethazine. If there is still no response, treat for three days with penicillin. Subsequent treatments, if required, should consist of 3-day cycles of sulfamethazine or penicillin; and (2) If time is a factor, discontinue the daily observations of temperature and degree of illness. Place non-responsive cattle in a common pen and treat sequentially with oxytetracycline, sulfamethazine or penicillin in 3-day treatment cycles. Sort the

cattle on the third day of each treatment cycle and send normal-appearing cattle to a convalescent pen.

2) **Very Sick Cattle:** (a) Start treatment with subcutaneous injection of oxytetracycline (Terramycin, Oxyject) and with an intravenous infusion of sulfamethazine (or with oral sulfamethazine boluses). See appendix for recommended dosage; (b) If the animal fails to respond, change the treatment to penicillin injected subcutaneously, and proceed as described in the preceding section; (c) Cattle with labored breathing should, in addition to antibiotic therapy, be treated with Methagon for a maximum of three days. Use a dose of 2 cc/100 lb., given intravenously. Cattle that are thought to have interstitial pneumonia should be treated as described, except that the dose of Methagon should be 10 cc/100 lb. during the first three days of treatment. The dose is then reduced to 2 cc/100 lb. for subsequent treatments, if required. Do not treat for interstitial pneumonia unless difficult breathing is observed within the first seven days after the animal is pulled. Corticosteroids (including Methagon, Azium, Flucort, etc.), should be used sparingly for the following reasons: (1) These drugs impair the ability of body defense mechanisms to fight bacteria and viruses. If used in treating antibiotic-resistant bacterial infections, the infection may quickly spread throughout the lung and even throughout the body; (2) These drugs impair the production of immune antibodies which are helpful in fighting both bacterial and viral infections; (3) These drugs mask (not cure) the signs of infection (fever and depression). As a result, antibiotic treatment may be terminated prematurely, and the infection allowed to spread to the point where permanent recovery is impossible. These drugs should be limited to use during the first few days of treatment of extremely severe pneumonia cases, in order to help keep the animal alive long enough for the antibiotics to do some good. Do not use these drugs in chronic cases, as there is nothing to be gained and they are relatively expensive medicine. Always continue antibiotic treatment for two days after Methagon therapy is terminated; (d) Cattle that relapse within 30 days after a previous illness should be started out on the treatment to which they previously responded. If more than 30 days have elapsed since previous illness, start out treating in the usual way; (e) Antibiotics should be used in the following sequence when treating cattle for respiratory disease that have been in the feedlot for 90 days or more: (1) penicillin (2) oxytetracycline (3) sulfamethazine (4) erythromycin (5 cc/200 lbs.) (5) tylosin (6) penicillin (20 cc/100 lb.). Note that erythromycin dosage is reduced to 5 cc/200 lbs. in this situation. This is done to minimize packer complaints about injection lesions.

2. Enteritis Cases (salmonellosis, BVD, etc.):
Cattle with a normal temperature and a diarrhea that has obviously resulted from a feeding problem should not be treated, but simply fed liberal quantities of oat hay until they firm up. Others should be wormed with Tramisole and treated in the same way as pneumonia cases.

3. Lameness Cases are Separated into Two Categories:
a. Lameness with Swelling Up and Down the Leg(s) (cellulitis), Footrot, and Miscellaneous: Start treating with penicillin. If the animal has an elevated rectal temperature, use it as an indicator of favorable response to antibiotic therapy. If there is no response, change to tylosin. If there is no response to tylosin, change to sulfamethazine.

Cattle Medication Record

Lot No. 1		Diagnosis - R				Tag No. 101		
Date	Temp.	Degree of illness	Terra	Sulfa sol	Sulfa bolus	Pen	Gall	Tylan	Other Methagon	Other Treatment
6-15	106.2	50								
6-16	105.0	2			3					
6-17	105.5	2				50				
6-18	106.4	2					50			
6-19	105.0	2						50		
6-20	105.5	2				100				
6-21	103.8	2				100				
6-22	102.4	1				100				
6-23	102.6	1				100				

A Condensed Summary of Recommended Antimicrobial Rotations
for Treating Common Feedlot Diseases

Respiratory Miscellaneous Enteritis Arthritis, Metritis, Bloat and Bullers	Respiratory after 90 days on feed	Cellulitis, Footrot and Miscellaneous	Sheath Infections	Urolithiasis and Urinary Infections
	penicillin	penicillin	penicillin	penicillin
oxytetracycline	oxytetracycline	tylosin		
sulfamethazine	sulfamethazine	sulfamethazine		
penicillin				
erythromycin	erythromycin (¼)	erythromycin (¼)	erythromycin (¼)	
tylosin	tylosin			
penicillin (2x)	penicillin (2x)			
Maintenance schedule		oxytetracycline		
oxytetracycline (3 days)				
sulfamethazine (3 days)				
penicillin (3 days)				
sulfamethazine (3 days)				
penicillin (3 days)				

Appendix B
Treatment Routine for Sick Cattle
(8-19-75)
C. A. Hjerpe, D.V.M.

1. **Respiratory Disease and Miscellaneous Infections:**

The objectives of the treatment program are to reduce death loss, culling and cost of treatment by starting each sick animal on an effective treatment as promptly as possible, and by keeping the animal on that treatment as long as it is responding to it. This can be efficiently accomplished by using an individual animal record system:

a. As each animal is treated for the first time, a pre-numbered Lone Star tag is placed in the ear. This number is written on the individual cattle medication record card (see appendix) along with the lot number, the diagnosis, the date, the rectal temperature, the degree of sickness, and the medication used.

b. The following symbols are used to designate the diagnosis: No symbol - respiratory and miscellaneous infections; SH - diarrhea cases; CEL - cellulitis; OL - other lameness; HEM - brain disease (Hemophilus); UT - uterine infection; BT - bloater; SW - buller; ABS - abscess; OV - overeating; PIZ - infected sheath; WB - urolithiasis.

c. Under "degree of illness," the animal is assigned a number which designates a degree of severity: 3 - severely ill (weak; very depressed; labored breathing); 2 - moderately ill (moderately depressed; gaunt); 1 - slightly ill to almost normal.

d. Twenty-four hours later, the rectal temperature and the "degree of illness" are again determined, recorded on the animal's card, and the initial treatment repeated.

e. Forty-eight hours after initial treatment, the rectal temperature and "degree of illness" are again determined and recorded. The 24-hour and 48-hour findings are then compared with the initial rectal temperature and "degree of illness" in order to determine whether or not a favorable response has occurred. If the animal is definitely better, the original antimicrobic is readministered daily (as long as improvement continues) until fever, depression, weakness, heavy breathing and inappetence are absent on two consecutive examinations. In most cases absence of fever will mean a rectal temperature of 103.0°F or less. The following criteria are indicative of a favorable response to treatment, and will ordinarily dictate continued treatment with a given antimicrobic: 1) If the initial rectal temperature was greater than 104.0°F, a reduction to 103.5°F or less by the 48th hour is indicative of a favorable response; 2) If the initial rectal temperature was between 103.0°F and 104.0°F, a progressive reduction toward 103.0°F is indicative of a favorable response. However, if the rectal temperature remains above 103.1°F on three consecutive days with no tendency to decline toward 103.0°F, the treatment should be changed; 3) If during treatment with a given antimicrobic the rectal temperature should fall to 103.0°F or less, that antimicrobic should always be administered again on the following day, even though the rectal temperature may rebound. On the day following the rebound, the treatment should be changed unless there has been a reduction in the fever to 103.5°F or less; 4) If the initial rectal temperature was less than 103.0°F, a reduction in the degree of illness rating is indicative of a favorable response; 5) If evidence of a favorable response (as previously defined) is lacking after the mandatory number of treatments with a particular antimicrobic, the treatment should be changed; 6) When treating cases: a) which have relapsed two or more times, or; b) in which response to treatment does not occur within the first three days after treatment is started, treatment should be continued until fever, depression, weakness, heavy breathing and inappetence are absent on three to five (or more) consecutive examinations, depending on the general health and past history of the individual.

f. At the time of the initial treatment, the animal should be assigned to either the: 1) moderately sick or 2) very sick categories, and treated accordingly:

1) **Moderately Sick Cattle:** (a) Start treatment with sulfamethazine boluses, administered orally; (b) If the animal does not respond within two days, change the treatment to oxytetracycline injected subcutaneously. See appendix for recommended dosages; (c) If the animal fails to respond after two days of oxytetracycline therapy, change the treatment to penicillin, injected subcutaneously in a dose of 10 cc/100 lb.; (d) If there is no response within two days, increase the dosage to 20 cc/100 lb., injected subcutaneously; (e) If still non-responsive after two days of treatment at this increased dosage, change the treatment to erythromycin (Gallimycin), injected intramuscularly. See appendix for recommended dosages; (f) If the animal fails to respond to two days of erythromycin treatment, change to tylosin (Tylan 200), injected intramuscularly. See appendix for recommended dosages; (g) If the animal also fails to respond after two days of treatment with tylosin, proceed as follows: (1) If time permits, continue with the daily observations of temperature and degree of illness. Treat for three days with sulfamethazine. If no response is obtained, treat for three more days with oxytetracycline. If there is still no response, treat for three days with penicillin. Subsequent treatments, if required, should consist of 3-day cycles of sulfamethazine or penicillin; (2) If time is a factor, discontinue the daily observations of temperature and degree of illness. Place non-responsive cattle in a common pen and treat sequentially with sulfamethazine, oxytetracycline or penicillin in 3-day treatment cycles. Sort the cattle on the third day of each treatment cycle and send normal-appearing cattle to a convalescent pen.

2) **Very Sick Cattle:** (a) Start treatment with subcutaneous injection of oxytetracycline (Terramycin, Oxyject) and with an intravenous infusion of sulfamethazine (or with oral sulfamethazine boluses). See appendix for recommended dosage; (b) If the animal fails to respond after two days, change the treatment to penicillin injected subcutaneously, and proceed as described in the preceding section; (c) Cattle with labored breathing should, in addition to antibiotic therapy, be treated with Methagon for a maximum of three days. Use a dose of 2 cc/100 lb., given intravenously. Cattle that are thought to have interstitial pneumonia should be treated as described, except that the dose of Methagon should be 10 cc/100 lb. during the first one to three days of treatment. The dose is then reduced to 2 cc/100 lb. for subsequent treatments, if required. Do not treat for interstitial pneumonia unless difficult breathing is observed within the first seven days after the animal is pulled. Always continue antimicrobic therapy for two days after termination of corticosteroid therapy. Corticosteroids (including Methagon, Azium, Flucort, etc.) should be used sparingly for the following reasons: (1) These drugs impair the ability of body defense mechanisms to fight bacteria and viruses. If used in treating antimicrobiotic-resistant bacterial infections, the infection may quickly spread throughout the lung and even throughout the body; (2) These drugs impair the production of immune antibodies which are helpful in fighting both bacterial and viral infections; (3) These drugs mask (not cure) the signs of infection (fever and depression). As a result, antimicrobic treatment may be terminated prematurely, and the infection allowed to spread to the point where permanent recovery is impossible. These drugs should be limited to use during the first few days of treatment of extremely severe pneumonia cases in order to help keep the animal alive long enough for the antimicrobics to do some good. Do not use these drugs in chronic cases as there is nothing to be gained and they are relatively expensive medicine.

g. Cattle that relapse within 30 days after a previous illness should be started out on the treatment to which they previously responded. If more than 30 days have elapsed since previous illness, start out treating in the usual way.

h. Antimicrobics should be used in the following sequence when treating cattle that have been in the feedlot for more than 90 days for respiratory disease: (1) penicillin (2) sulfamethazine (3) oxytetracycline (4) penicillin (20 cc/100 lb.) (5) erythromycin (5 cc/200 lb.) (6) tylosin. Note that erythromycin dosage is reduced to 5 cc/200 lb. in this situation.

2. **Enteritis cases (salmonellosis, BVD, etc.):**
Cattle with a normal temperature and a diarrhea that has obviously resulted from a feeding problem should not be treated, but simply fed liberal quantities of oat hay until they firm up. Others should be wormed with Tramisole and treated in the same way as pneumonia cases.

3. **Lameness Cases are Separated into Two Categories:** a. Lameness with Swelling Up and Down the Leg(s) (cellulitis), Footrot, and Miscellaneous: Start treating with penicillin. If the animal has an elevated rectal temperature, use it as an indicator of favorable response to antimicrobic therapy. If there is no response within two days, double the dosage. If there is still no response after two more days, change to tylosin. If there is no response after two days of tylosin therapy, change to sulfamethazine. If there is no response after two days, change to erythromycin, using ¼ the dosage recommended for pneumonia (5 cc/200 lb. b.w.). If two days of erythromycin treatment is unsuccessful, change to oxytetracycline for at least two days. If there is no fever but the animal appears sick, treat sequentially in 3-day cycles until improvement (less depression, swelling and lameness) is noted. Then keep the animal on that treatment as long as it continues to respond.

Cattle Medication Record

Lot No. 1		Diagnosis - R			Tag No. 101				
Date	Temp.	Degree of illness	Terra	Sulfa sol	Sulfa bolus	Pen	Gall	Tylan	Other Meth-agon	Treat-ment
6-15	106.2	2			3.5					
6-16	105.0	2			2.5					
6-17	105.5	2	50							
6-18	106.4	2	50							
6-19	105.0	2				50				
6-20	105.5	2				50				
6-21	103.8	2				100				
6-22	102.4	1				100				
6-23	102.6	1				100				
6-24	102.5					100				

A Condensed Summary of Recommended Antimicrobial Rotations for Treating Common Feedlot Diseases

Respiratory Miscellaneous Enteritis Metritis Bloat and Bullers	Respiratory after 90 days on feed	Cellulitis, Footrot and Miscellaneous	Urolithiasis, Urinary and Sheath Infections	Arthritis
	penicillin (2)*	penicillin (2)*	penicillin (2)*	oxytetracycline (2)*
		penicillin - 2x (2)		
		tylosin (2)		
sulfamethazine (2)*	sulfamethazine (2)	sulfamethazine (2)		
oxytetracycline (2)	oxytetracycline (2)			
penicillin (2)				
penicillin - 2x (2)	penicillin - 2x (2)			
erythromycin (2)	erythromycin - ¼ (2)	erythromycin - ¼ (2)	erythromycin - ¼ (2)	
tylosin (2)	tylosin (2)			
		oxytetracycline (2)		
Maintenance schedule				
sulfamethazine (3)*				
oxytetracycline (3)				
penicillin (3)				
sulfamethazine (3)				
penicillin (3)				

*The mandatory minimum number of days of treatment.

Appendix B
Recommended Dosages

I. **Terramycin, Oxyject (oxytetracycline)**
   A. Subcutaneous use in cattle with respiratory disease, diarrhea, arthritis, uterine infections, bloat, bullers. Use 10 cc/100 lb. (5 mg/lb). Inject no more than 10 cc per site.
   B. Intravenous use in brain infections. Use 50 cc/100 lb. (25 mg/lb). Dilute with three parts saline solution to one part antibiotic before using. **Do not sell or slaughter for 20 days after the last treatment with oxytetracycline.**

II. **Sulfamethazine**
   A. Intravenous use (24% solution)
      1. Use a dose of 40 cc/100 lb. for the initial treatment (1½ gr/lb.).
      2. Retreat once daily with 25 cc/100 lb. (1 gr/lb.).
   B. Oral Use (15 gm boluses)
      1. Use 1½ boluses for every 225 lbs. for initial treatment (1½ Gr./lb.).
      2. Re-treat once daily with one bolus for every 225 lbs. (1 gr/lb.).

The following precautions should be observed in using sulfamethazine:
1. Do not overdose. Sulfas may be injurious to the kidneys. Closely follow recommended dosages.
2. Don't treat with sulfamethazine for longer than a 7-day period.
3. Avoid use of sulfamethazine in severely dehydrated cattle (sunken eyes) or in cattle that are not drinking.
4. The cost of treating with the 24% solution is twice the cost of treating with boluses. Reserve intravenous use for

the initial treatment of severely sick cattle. Repeat treatment of severely sick cattle and all treatment of moderately sick cattle should be with boluses. **Do not sell or slaughter for 10 days after the last treatment with sulfamethazine.**

III. **Procaine Penicillin G**
Use 10 cc/100 lbs. (30,000 units/lb.) or 20 cc/100 lbs. (60,000 units/lb.) injected subcutaneously. There is no limit on the volume used per injection site. **Do not sell or slaughter for 20 days after the last treatment with penicillin.**

IV. **Gallimycin (erythromycin)**
Use 10 cc/100 lb. (20 mg/lb.) in treating respiratory disease in new cattle. Use 5 cc/200 lb. (5 mg/lb.) in treating respiratory disease in cattle that have been in the feedlot for 90 days or more, and in treating cellulitis and sheath infections. Inject deep into the muscles of the rump or thigh. Use no more than 10 cc per injection site when treating with Gallimycin. **Do not sell or slaughter for 20 days after the last treatment with Gallimycin.**

V. **Tylan 200 (tylosin)**
Use 10 cc/100 lb. (20 mg/lb.) injected into the muscles of the neck. Use no more than 10 cc per injection site. **Do not sell or slaughter for 20 days after the last treatment with Tylan 200.**

Panel Discussion

Dr. A. A. Ardans
Dr. B. I. Osburn
Dr. C. A. Hjerpe

Question–Dr. Jim Turboc from Deckerville, Michigan. Dr. Hjerpe, I don't know if I missed it or it wasn't given, tell me the route and the form of the sulfamethazine that you were using.

Answer–I probably didn't mention it. It is almost all given by oral route and we use the boluses.

Question–Dr. Herb Talc from Mechanicsburg, Ohio. Dr. Hjerpe, I have another question. I wonder if you've ever tried any combinations such as sulfas and tetracyclines in the first treatment or if you just strictly stick with one drug?

Answer–I think that combinations can be effectively used. I don't thank that a combination is any more effective than either drug used alone if the organism is sensitive to both of the antimicrobics used in combination. The advantage of the combination is in the fact that, let's say you are treating 10 animals and you treat them with a combination of sulfamethazine and oxytetracycline. We would expect only nine out of the 10 to respond to sulfamethazine, but the chances are that in the individual in which the infection is resistant to sulfamethazine, it is probably going to be sensitive to oxytet. By using both you get a response in all 10 animals. The only reason we have not used it this way is an attempt to minimize cost of treatment, and we feel we can get virutally the same results in terms of culling rates and death loss by treating the way we do as we would if we started using combinations. Initially we did use lots of combinations before we got into our record system. Before we were treating with records, we almost never treated except with combinations. But, when you consider this one fairly small feedlot by California standards the cost of medicine is $150,000 per year, and 23% of all the yearling cattle that pass through this feedlot get sick at least once and 53% of all the calves get sick at least once, that I probably saved this company two to three times what they pay the school in terms of reduced costs of treatment by using these things one at a time.

Question–Dr. Don Williams, Oklahoma. Dr. Hjerpe, do you see any evidence of so-called drug fever from any of the antibiotics?

Answer–I think we occasionally do. I presume what you are talking about is an animal running a fever when you cannot acutally determine where the infection is localized, then when you stop the treatment, the fever goes away. We do see some of that type of thing. I try to minimize this. I'm in this feedlot four times a week, and I am in the sick pens every time and I am looking at the cattle and taking notes on them. If I see animals that look normal I write the ear tag number down and I check their treatment record to find out why they are treating them. If we are going on excessively on those animals, we will pull them off treatment, or we will examine them and try to find out why they are sick. If we can't find a reason for them to be sick, we will pull them off treatment. I think it takes a veterinarian, working with a feedlot, to make this system work. I think it is too complicated for them to really use them effectively. There are too many questions that come up that have to have solutions for this to be just something that any large feedlot can take over without supervision and make it really do anything for them.

Question–Do you know of any of the antibiotics that are particularly capable of causing hyperthemia?

Answer–I'm going to have to pass on that. I say that I believe we see this at times, but I can't really say. Somebody else might have a better idea than I have. I think maybe I should comment on our withdrawal periods. We use a withdrawal period of 10 days for sulfa which is the recommended withdrawal period; 20 days for oxytetracycline which is the recommended period; and on all the others we use 20 days. With penicillin, five days is the recommended period. With Tylan the recommended period is eight and we're using 20 with erythromycin (the recommended period is 14 but we are using 20). The FDA knows what we are doing because they have been running around the country for two years telling everybody about it. They are checking our cattle and they are not finding residues. I think the biggest problem with residues in the animal is not identified. They don't know when it was treated. It gets sent to a sale and ends up being boned out when you thought it was going back out on pasture where no withdrawal period at all was observed. I don't feel that I am contributing to a residue problem. In fact I think we probably have less of that