Effects of Cold Stress on Cattle Performance and Management Factors to Reduce Cold Stress and Improve Performance

Donald G. Wagner, *Ph.D.*
Animal Science Department
Oklahoma State University
Stillwater, Oklahoma 74078

Cold Stress. It happens almost every year in many locations. Maintaining top performance of cattle during very cold or inclement winter weather conditions is a challenge, particularly in certain parts of the United States or in other countries. If feed intakes aren't maintained or increased during such time and cold stress isn't managed or reduced, performance may suffer greatly.

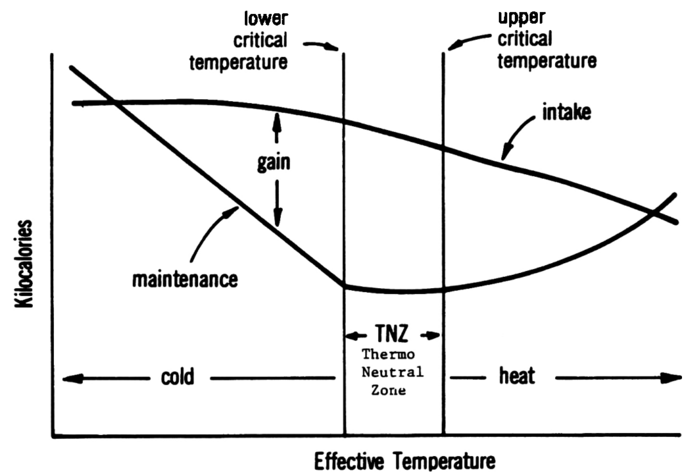
In this article, a few thoughts are presented which may be helpful in either improving or, more realistically, maintaining good feed intake and performance during cold weather. In many instances, it may be difficult to greatly increase feed intake, so perhaps the focus should be on maintaining and/or acquiring top energy/feed intakes during such times. During severe stress, intake will drop, perhaps greatly, compromising performance.

Most of the discussion herein will pertain to feedlot or confinement cattle, but some thoughts about pastured cattle will be included. The same principles generally apply to both confinement and pastured cattle, except in that pastured cattle need to search over greater distances and may incur more difficulties in procuring feed. Therefore, total grazing/feeding time must be extended for grazing cattle, compared to confinement cattle, for them to acquire adequate feed. Moreover, they may face a variety of difficulties with regard to adequate shelter or protection to reduce the strong elements of winter weather or with regard to the availability of feed and/or water, especially if the water is frozen and/or snow is unavailable for consumption (Degen and Young, 1984).

Changes Noted During Cold Stress

Some of the general changes noted in animals during temperature stress are graphically shown in Figure 1. This excellent figure was composited by David Ames of Colorado State University from a variety of research studies (Ames, 1988). Changes are noted in the figure for both cold stress and heat stress, but the discussion herein will be limited to the effects of cold. Top animal performance

Figure 1. Effect of temperature on intake, maintenance energy requirements and energy gain (adapted from Ames, 1988).



occurs in the thermoneutral zone (TNZ) which is the zone of optimal comfort. The TNZ might be viewed much as an elastic zone of animal comfort with flexible boundaries. The lower critical temperature represents the lower limit of the TNZ. The lower critical temperature is the temperature at which the animal begins to "feel cold" and must increase heat production to stay warm. Moreover, it is the point at which performance begins to decline as the temperature decreases and/or the animal becomes colder. The same concept applies to the upper critical temperature, although this point deals with heat, not cold. The point at which the lower critical temperature is reached may be variable and does not necessarily occur at a specific temperature. The actual temperature at which the lower critical temperature is reached may be quite variable and will depend upon such things as wind speed, length of hair coat, wet or dry hair, level of animal activity, dietary heat production or heat increment as influenced by type of diet or level of feed intake, etc. Hence, the line or point representing the lower critical temperature can be moved to the left or right on the temperature scale depending upon conditions. The same is true for the point of upper critical temperature during hot conditions. In this sense, the TNZ has elasticity.

See Also Maintaining or Improving Performace of Cattle During Hot Weather by Dr. Wagner in the 1987 issue (No. 22) of the Bovine Practitioner, p. 71-75.

As noted in Table 1, the lower critical temperature for a beef animal might be as high as 59°F for an animal which has a summer coat of hair (i.e. short or shed off) or a haircoat which is wet from rain or snow; whereas, it could be as low as 18°F for an animal which has a heavy winter coat of hair that is dry. This illustrates how the point for the lower critical temperature can be moved to the left or right, as is also true for the upper limit. In other words, the limits of the TNZ are elastic and not fixed points. If one thinks about this in the context of providing animal comfort, one often can make environmental or other changes to widen or enhance the zone of thermoneutrality, and thus, animal comfort under diffficult circumstances. For example, when it is hot, increasing air movement via fan or by providing a location with breezy conditions or increased wind speed will raise the upper limit or temperature of the TNZ. Surface wetting would too.

TABLE 1. Projected lower critical temperature for beef cattle.[a]

Coat Description	Critical temperature
Summer coat or wet	59°F
Fall coat	45°F
Winter coat	32°F
Heavy winter coat	18°F

[a]Adapted from Ames (1980, 1981).

As temperature declines below the lower critical temperature, cold stress on an animal increases (Figure 1). Maintenance energy requirements increase as well to provide additional warmth. Thus, feed requirements for maintenance will increase. Or, in maintenance or sub-maintenance situations, weight loss will increase if additional food is not consumed.

TABLE 2. The effect of type of cattle and diet on relative feed intake at different temperatures. (Adapted from Young, 1987)

Ambient temp. °C	Relative intake[a]					
	6-10	10-15	15-20	20-25	25-30	30-35
Growing, 1 to 12 mo.[b]			1.00		.92	
B. taurus, 5 to 7 mo.[c]			1.00		.86	
B. indicus, 5 to 7 mo.[c]			1.00		.89	
B. taurus, conc diet[d]	1.30		1.00			.83
B. taurus, rough diet[d]	1.10			1.00		
B. indicus, conc diet[d]	1.38		1.00			.88
B. indicus, rough diet[d]	1.07		1.00			.87

[a]Ratio of food intake to intake at thermoneutrality.
[b]Johnson et al., 1960.
[c]Colditz and Kellaway, 1972.
[d]Olbrich et al., 1973.

Feed intake normally increases at colder temperatures (Table 2) and during cold stress (Figure 1), but the increase in feed intake usually is not as great as the increase in the maintenance requirement. Thus, gain usually decreases in finishing animals during cold stress or weight loss increases in animals which are under maintenance or sub-maintenance conditions. In beef cows or grazing animals which may be gaining little or nothing, gains are further reduced, or losses are increased—whichever the case may be. Although not depicted in Figure 1, under severe cold stress, intakes will decline. Such a situation is more likely in grazing animals which may temporarily place a higher priority in seeking comfort than food.

Wind Chill and Cold Stress

The importance of hair coat on lower critical temperature is illustrated in Tables 1 and 3. Maintenance energy requirements can increase dramatically with increasing coldness below the comfort of TNZ (Table 3). Wind chill factors developed by Ames at varying temperatures and wind speeds are illustrated in Table 4.

TABLE 3. Increase in maintenance energy costs per degree (F) of coldness.[a]

Coat Description	Weight (lb) 800 Percentage per degree
Summer coat or wet	2.0
Fall coat	1.4
Winter coat	1.1
Heavy winter coat	.7

[a]Adapted from Ames (1980, 1981).

TABLE 4. Wind-Chill factors for cattle with winter coat.[a]

Wind speed (mph)	Temperature (°F)				
	-10	0	10	30	50
Calm	-10	- 0	10	30	50
10	-21	-11	- 1	18	38
20	-30	-20	-10	9	20
30	-46	-36	-26	- 6	13
40	-78	-68	-58	-38	-18

[a]Adapted from Ames (1980, 1981).

Studies by Bourdon et al. (1984) indicate that maintenance requirements may increase by more than 24% during cold stress and metabolic requirements may increase by more than 24% during cold stress and metabolic acclimatization to cold in commercial Colorado feedlot cattle. In fact, an increase of 37% was noted during November, December and January. The most common animal responses were relatively normal intakes, but depressed gains during the winter. A poorer feed efficiency will follow. Gains were usually depressed by one-half pound or more per day during January, with about one pound more feed being required per pound of gain. On the average, gains were depressed

.019 lb per °C of coldness below 17 to 20°C. Johnson (1984) suggested maintenance energy requirements increased 1.3% for each °C of wind chill exposure below 20°C. Cold will increase maintenance requirements due to metabolic acclimatization as well as the effects of immediate cold stress (NRC, 1981, Figure 1).

Climatic Factors Which Influence Intake

Many factors influence intake including environment. Intake is not constant as many often believe. Climate is one important factor. Some climatic or environmental factors result in conflicting and/or confounding stimuli to the animal. According to studies by Young (1987), there are important phtoperiod, thermal and atmospheric pressure effects. Food intake in cattle usually increase with an increasing photoperiod or increasing day length. In contrast, shorter photoperiods generally depress intake. Domestication of animals appears to have reduced the magnitude of the photoperiod effect, but it is still important. According to Young, usually there is delay or lag phase of 6 to 10 to 16 weeks before the photoperiod response is observed. Concommitently, resting metabolism increases during shorter photoperiods (cold months) and decreases with longer day length. The magnitude of change in resting metabolism can be as much as 20-30%. Commercial feedlots located in the Southern Plains areas or in the Southwest usually note higher mean feed intakes during the months of most light. In these sections of the country, the intake response is probably dominated by the photoperiod effect, not thermal.

Temperature also has an important effect on intake. Resting metabolism increases with colder temperatures. Generally, increased intakes are noted in feedlot cattle during the winter months in Northern states. This is in contrast to that in the Southern Plains and Southwestern areas. Plegge (1987) reported that in a summary of 14,999 cattle, intake averaged 8% higher in the winter months than in the summer months in Minnesota. In these areas, temperature appears to have the dominant effect on feed intake, overriding the photoperiod effect. According to Young (1987), the effects of cold are, in addition to increasing resting metabolism or maintenance, to increase rate of food passage, decrease digestibility, increase intake and to alter feeding behavior. This would concur with the observation of Plegge.

Management Considerations to Maintain or Improve Performance During Cold Stress

Acquiring top performance often means observing some helpful rules or guidelines during cold weather. No particular order of importance or priority is intended. The rank may differ from one locale or operation to another. The itemizations which follow may look more like a listing of **Do's** and **Don'ts**, although the list probably doesn't include all the items which deserve mention. Additionally, there may be a little room for some difference of opinion on a few items, depending upon locale, feeds available, etc.

Keep the snow out of the bunks.

This must receive major attention and be a top priority. This means removing snow, if needed, prior to adding feed. If the snow is not removed, the cattle will make ice out of it when eating, resulting in reduced intake. Moreover, some feed may be trapped below the snow and/or ice. Usually, it will be less fresh and not consumed. In most commercial yards, bunks are "read" before most feedings to determine the amount which should be added at the next feeding. When there is snow and ice plus some feed in the bunk, it is very difficult to properly read the bunk. If one estimates that a bunk still has 1000 lb left in it, one may not be sure if there is 900 lb feed and 100 lb of snow or 100 lb of feed and 900 lb of snow—or some other figure. Hence, feeding the correct amount is difficult, resulting in more erratic intakes, reduced performance and, potentially, more health problems.

Scrape the snow and ice off the pad in front of the bunks.

In more Northern States where there is a lot of snow and little or no thawing between snows, immense build-up of snow, ice and manure can occur on a concrete pad during a feeding period. If the pad is not cleaned periodically, by March or April, the cattle might be standing on a pad one or two feet above the bottom of the bunk. Does this facilitate top intake and performance? The answer should be obvious, but such a management practice can be easy to overlook. Problems also can exist if cattle have difficulty gaining access to the concrete pad because of excess manure, holes in front of the pad or whatever.

Don't Limit Water.

If freezing or borderline freezing problems are incurred with waterers, water intake will be reduced. Declines in feed intake will follow. In some free flowing water systems, problems with freezing or partial freezing can occur. If the same waterer or waterers in certain pens are freezing over each morning, concern and steps to correct the problem should be noted. Otherwise, it will be most difficult to maintain top intakes. The cattle may be able to drink water during the day, but not what they want when they want it. Consequently, feed intake patterns may be altered. Additionally, problems can occur during competitive watering, risking more injury. Logically, a larger drink than usual of near freezing water by a thirsty animal may also increase the feeling of cold stress on the animal. If water intake is restricted, feed intake will decline. This is true for confinement or pasture environments. The effects of water intake on feed intake are illustrated in Table 5.

TABLE 5. Dry matter (DM) intake in steers receiving either snow, ice, cold water (CW) or warm water (WW) (Degen and Young, 1984).

	Snow	Ice	CW	WW
Weight (kg)	457.0	451.5	456.2	463.0
DM intake (kg/day)				
Barley grain	3.09	3.09	3.09	3.09
Bromegrass hay	2.36	2.54	2.77	3.03
Water intake	8.5[a]	7.9[a]	18.4[b]	16.4[b]
Heat required (MJ)	4.44[a]	3.97[a]	3.10[b]	0.67[c]
Rumen Contents (kg)	33.0[a]	33.0[a]	45.0[b]	46.4[b]
Dry matter (kg)	4.51[a]	4.54[a]	5.14[b]	5.73[b]
Dry matter (%)	13.8[ab]	14.2[a]	11.6[c]	12.3[bc]

*Estimated heat required to raise ingested water to body temperature, including latent heat of melting of ice and snow.
[abc]Means in the same rows with different letters are different.

Ingesting ice or snow will require more heat. Additional, if only snow or ice is available, total water intake may decline which also may decrease total dry matter intake.

Don't overfeed; keep bunks clean and the feed fresh.

When trying to encourage intake, it is tempting to put out too much feed. This compromises "cleaning-up" of the bunks by the cattle and can result in a build up of "fines" in the bottom of the bunk. A build up of fines will reduce intake and present a variety of intake problems, including more irregularity in intake.

Don't use feeds or commodities of marginal quality or at least consider reducing their amount in the ration.

Most cattle can generally be adapted to or will get use to eating a variety of different feeds. But, feeds which are moldy, musty or unpalatable can create problems when conditions are such that it is difficult to maintain good intakes anyway. So, try to keep feeds fresh, appealing and appetizing. Most cattle get used to what you feed them and accept it, but this item shouldn't be overlooked. Moreover, periods of cold stress may not be good times to make dramatic changes in a ration.

Keep wet feeds from freezing in the bunk.

Although this may not be a serious problem for many feeders, some high silage grower rations or even very wet finishing rations may be prone to freezing in the bunk in some northern states. Reducing the amount of feed at one feeding and increasing the frequency of feeding can be helpful. Additionally, feeding drier silages (e.g. 60-65% moisture corn silage rather than 68% moisture or wetter silages, etc.) or adding some dry feeds will usually be helpful in allowing cattle to eat all of the feed before it freezes.

Adding a little extra roughage may be useful.

How much? Increasing roughage 1 to 2, perhaps 3%, during the winter may be helpful if a low roughage ration (7 to 9% roughage) is being fed during warmer months. Not very long ago, it was common for most high concentrate finishing rations in many areas of the country to contain about 15% (or perhaps 12 to 18%) roughage. In areas of the country where roughages are either in short supply or expensive relative to grains, (e.g. in the Southern High Plains) it is now common for finish rations to contain only 7 to 9% roughage during most months of the year. In such cases, increasing roughage by 1 to 2 to 3% during the winter is usually beneficial in maintaining good, consistent intakes and reducing risk of acidosis.

Problems with maintaining high, consistent intakes and minimizing health problems in the winter are usually storm related. Experience has shown that feedlot cattle usually eat fairly well, maybe even higher amounts than normal—tending to "tank up" on feed—*just prior to and during the early part* of a storm. Higher than normal intakes at this point may set the stage for mild or even more severe acidosis. But, the major problem usually occurs largely during the latter stages of, or more likely *immediately after,* a storm when it warms up. At that point, the cattle are usually tired, lie down, rest and may not eat for a while. Then when they do eat, they may be hungrier then usual, overeat and will then subsequently back off on feed intake. For example, if cattle were normally eating an average of 22 lb of dry matter, some of them may back off to no more than 17-18-19 lb and *never recover* to previous or desirable intake levels.

In research with stocker cattle grazing wheat pasture, Horn et al. (1976) has shown that cattle are indeed good weather predictors. Interestingly, when atmospheric pressure starts to drop prior to a storm, cattle will begin to greatly increase grazing time and intake, do little or no grazing during the storm, and then again show a big increase in grazing activity after the storm is over. This sets the stage for more potential problems with bloat, etc. in stockers grazing very high quality roughages. Although perhaps somewhat different in feedlot cattle, a change is also noted in eating behavior or patterns. There is an increase in feeding activity prior to and during the initial stages of a storm, followed by a lull and then again another increase. Changes are noted not only in total feed intakes but also in the amounts consumed at one feeding and in the frequency of eating (i.e., instead of e.g. eating 3.0 lb per feeding 8 times per day, the cattle may eat 8 or 9 lb per feeding 3.0 times per day). The potential for creating rumen distress is apparent. For the above reasons, some nutritionists even recommend backing cattle up by one ration for the first feeding during and/or immediately after the storm. Backing up one ration means that instead of feeding the finish ration which contains 9 to 10% roughage, the next step-up or intermediate ration in the sequence may be used. It may contain perhaps 18-20% roughage. However, not all do this. In some sense, the inclusion of

1 to 2 to 3% more roughage in the finish ration during cold weather represents some compromise in procedure.

Occasionally, some problem cattle may need to be marketed several weeks to a month earlier than projected.

If cattle in a pen have been eating, e.g., an average of 22 lb before a severe storm, then back off, and never recover to eat more than perhaps 17-18-19 lb on the same finish ration—when you are trying to pick them up in feed intake again later—you may need to think about marketing them a little early. This may be best in the long run even if some discount is incurred because they aren't quite ready. Some pens of cattle will do this. This problem is more likely to be noted with cattle that a) have been on feed quite a few days already (> 120 to 130 days) because they were started at a light weight and b) cattle which are fairly fat, but perhaps not quite ready. These are the best candidates for "quitting," never recovering to previous intakes. In such cases, it may simply be better to get rid of them. Why? Because the final closeouts, if kept until normally readily, will usually be *quite poor, maybe disastrous,* and *even less profitable.*

If cattle have poor cold tolerance, they may need to be fed or finished on a higher level of roughage (e.g. perhaps 20 to 25% instead of 8-9-10%).

Poor cold tolerance can be due to either genetic factors (e.g. too much Zebu breeding for the winter conditions) and/or inadequate time for acclimatization (e.g. southern cattle, predominantly of British or European breeding, shipped to Nebraska or Minnesota during cold weather) (Table 2). Cattle with poor cold tolerance usually have less hair, a thinner skin, less flesh and/or simply haven't had adequate time to acclimate.

The traditional school of thinking has been that higher levels of roughage not only provide less risk of acidosis, but also more heat increment or heat production to help keep cattle warm (Blaxter, 1962). Yet, in the vast majority of cases, high concentrate finish rations, containing 8-10% roughages, probably produce sufficient heat to keep cattle warm if intakes are adequate. Exceptions might be when wind chills approach -25 to -30° where most cattle will show discomfort and evidence of cold stress. With shorter hair, thinner hide, less time for acclimatization, greater wind chills because of the environmental conditions, etc., inadequate heat production may be a problem, however, even with much less effective wind chills than mentioned above. In these instances, more roughage should be helpful. Additionally, certain kinds of cattle appear to have an inherent genetic tendency to being more prone to acidosis and founder. These would be easier to finish on a higher roughage (e.g. 20-25%)) ration.

Adding a little fat, perhaps 1-2%, may be useful in raising dietary energy level and hopefully energy intake during cold weather.

The addition of fat will not increase feed intake, but may raise energy intake. Moreover, in some rations, the addition of perhaps 3% molasses may be helpful in temporarily raising intakes.

Provide an environment which is as comfortable as possible.

A comfortable environment means a variety of things—a wind break as necessary; a dry place to lie down; an absence of minimum of mud; adequate ventilation if housed inside in Northern areas, etc. Failure to provide any or any combination of these will reduce performance and/or increase health problems. Tired or weary animals do not eat well. Interesting research at the University of Nebraska some years ago clearly showed the very depressing effect of mud on intake, gain and efficiency. A "mud index" was developed to depict the degree of mud, and the resulting depression in intake, gain and efficiency. If cattle have to wade through mud or do not have a dry place to lie down, performance will decline sharply.

Use somewhat drier feeds or rations when using high moisture or wet feeds to increase intake and/or improve regularity of intake during periods of severe cold stress.

High moisture feeds include silages and high moisture grains. For instance, drier corn silages (i.e. 60-65% moisture) may offer better DM intakes than wetter corn silage (i.e. 68% moisture or greater). The same would apply to wetter haylages or grass silages. With regard to grains, wetter high moisture corn grain (i.e. 28 to 30% moisture or greater) often presents more difficulty in maintaining intake than drier high moisture grains (i.e. 24-26% moisture). Unfortunately, the potential conflict, however, is that research shows best feed efficiencies are usually noted with the wetter grains—if adequate intakes can be maintained. Another alternative would be to include some dry feed in the ration mixture. Examples could include alfalfa, dry grain, steam flaked grain, etc.

Another alternative some may use is to temporarily decrease Rumensin levels (e.g. from perhaps 30 down to 20 or 25g per ton) to aid intake. But, often any such effects are probably temporary. Most cattle will usually return to their previous level of net energy consumption—whatever that might be. Moreover, the real question is "Are cattle merely eating more in lieu of a poorer feed conversion?" To a large degree, this may be what happens if one increases roughage or decreases Rumensin levels simply to increase intake. Yet, some cold weather situations may dictate an advantage for doing so.

Pasture Cattle

Most of the fundamental concepts noted previously can be adapted to cattle on pasture (e.g. cows or stocker calves). Their behavioral and eating patterns will be modified in much the same manner as in confinement cattle. Several important considerations come to mind. Increased cold or wind chill can greatly increase maintenance and thus feed requirements (Ames, 1980; 1981). If feed intake isn't increased, weight loss will increase. If cattle have short and/or wet hair, cold stress is much more severe. Moreover, thin cattle will incur cold stress much more quickly. Feed intakes will need to increase to prevent loss of weight or condition. If harvested roughages are fed, more will need to be fed, and intakes will usually rise during such times. For pasture cattle, increased intake may not occur. Secondly, grazing time may decrease with strong wind chills, increasing duress and loss of condition. Providing wind breaks can partially alleviate cold stress.

References

1. Ames, D.R. 1980. Livestock nutrition in cold weather. Animal Nutrition and Health, October. 2. Ames, D.R. 1981. Thermal feeding has potential benefits. Better Beef Business, Agr/May. 3. Ames, D.R. 1988. Effect of climate on rate and efficiency of performance. Beef Cattle Science Handbook, International Stockmen's School, Vol. 2:55. 4. Blaxter, K.L. The Energy Metabolism of Ruminants. 1962. CC Thomas Publishing. Springfield, Illinois. 5. Bourdon, R.M., D.E. Johnson and D.R. Ames. 1984. Simulated effects of cold stess on maintenance requirements of beef cattle. Colorado State University Beef report 1-6. 6. Colditz, P.J. and R.C. Kellaway. 1972. The effect of diet and heat stress on feed intake, growth and nitrogen metabolism in Friesian, F_1 Brahman X Friesian and Brahman heifers. Aust. J. Agri. Res. 23:717. 7. Degen, A.A. and B.A. Young, 1984. Effects of ingestion of warm cold and frozen water on heat balance in cattle. Can. J. Anim. Sci. 64:73. 8. Horn, F.P., G.W. Horn, H.R. Crookshank, W. Jackson, H.J. Muncrief and R. Osborne. 1976. Influence of periods of starvation on blood ammonia and plasma urea concentrations of steers grazing wheat pastures. Oklahoma State Univ. Agri. Sta. MP96:48. Oklahoma State Univ. and USDA. 9. Johnson, D.E. 1984. Rate of energetic efficiency of production by ruminant during climatic stress. W-135. Colorado State Univ. Handbook. 10. Johnson, H.D., A.C. Ragsdale, R.G. Yeck and J.F. Jones. 1960. The effects of constant environmental temperatures 50 to 80°F on the feed and water consumption of Holstein, Brown Swiss and Jersey calves. Mo. Agr. Exp. Sta. Res. Bull No. 786. 11. N.R.C. 1981. Effect of environment on nutrient requirement of domestic animals. National Academy of Sciences-National Research Council, Washington, D.C. 12. Olbrich, S.E., F.A. Marty and E.S. Hildebrand. 1973. Ambient temperature and ration effects on nutritional and physiological parameters of heat and cold tolerant cattle. J. Anim. Sci. 37:574. 13. Plegge, S. 1987. Intake equations for feedlot cattle. Proc. Int. Feed Intake Symp. Oklahoma State University, Stillwater, p 232. 14. Young, B.A. 1987. Food intake of cattle in cold climates. Proc. Int. Feed Intake Symposium. Oklahoma State University, Stillwater. p 328.