DAIRY DAY 1992

Report of Progress 666

Agricultural Experiment Station
Kansas State University, Manhattan
Marc A. Johnson, Interim Director

FOREWORD

Members of the Dairy Commodity Group of the Department of Animal Sciences and Industry are pleased to present this Report of Progress, 1992. Dairying continues to be a viable business and contributes significantly to the total agricultural economy of Kansas. Annual farm value of milk produced (1.23 billion lb) on Kansas dairy farms was $144 million in May, 1992, with an impact on the economy of Kansas amounting to $720 million. Wide variation exists in the productivity per cow, as indicated by the production testing program (Dairy Herd Improvement Association or DHIA) in Kansas. Nearly one-half of the dairy herds (n = 1,273) and dairy cows (n = 95,000) in Kansas are enrolled in DHIA. Our testing program shows that all DHI-tested cows average 17,329 lb milk compared with approximately 12,680 lb for all nontested cows. Dairy herds enrolled in DHIA continue to average more income over feed cost ($1,010/cow) than nontested herds ($549/cow) in 1991. Most of this success occurs because of better management of what is measured in monthly DHI records. In addition, use of superior, proven sires in artificial insemination (AI) programs shows average predicted transmitting ability (PTA) of AI bulls in service to be +1,111 lb compared to non-AI bulls whose average PTA is only +317 lb milk. More emphasis should be placed on furthering the DHIA program and encouraging use of its records in making management decisions.

With our herd expansion program, which was begun in 1978 after we moved to the new Dairy Teaching and Research Center (DTRC), we peaked at about 210 cows. The herd expansion was made possible by the generous donation of 72 heifers and some monetary donations by Kansas dairy producers and friends. Herd expansion has enabled our research efforts to increase, while making the herd more efficient. Our rolling herd average was 19,052 lb in August, 1992, despite many research projects that do not promote production efficiency.

We are proud of our new 72-cow tie stall barn that was constructed in 1991 through the generous support of The Upjohn Company, Clay Equipment Company, and Monsanto Company and under the able direction of Dr. John Shirley. This new facility will give us the ability to expand our research efforts in various studies involving nutrition and feeding, reproduction, and herd management. The excellent functioning of the DTRC is due to the special dedication of our staff. Appreciation is expressed to Richard K. Scoby (Manager, DTRC), Donald L. Thiemann (Asst. Manager, DTRC), Michael V. Scheffel (Research Assistant), Daniel J. Umsheid, Mary J. Rogers, Charlotte Kobiskie, Kathleen M. Cochran, Becky K. Pushee, Robert Reeves, Tamara K. Redding, and Lloyd F. Manthe. Special thanks are given to Neil Wallace, Natalie W. Brockish, Eddie L. Knoppel, Lois M. Morales, and Cheryl K. Armendariz for their technical assistance in our laboratories.

As demonstrated, each dollar spent for research yields a 30 to 50 percent return in practical application. Research is not only tedious and painstakingly slow but expensive. Those interested in supporting dairy research are encouraged to consider participation in the Livestock and Meat Industry Council (LMIC), a philanthropic organization dedicated to furthering academic and research pursuits by the Department. More details about LMIC are provided at the end of this Report of Progress. Appreciation is expressed to Charles Michaels (Director) and the Kansas Artificial Breeding Service Unit (KABSU) for their continued support of dairy research in the Department. Appreciation also is expressed to the College of Veterinary Medicine for their continued cooperation. This relationship has fostered cooperative research and established an exemplary herd health program.

J. S. Stevenson, Editor
1992 Dairy Day Report of Progress

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WASTE MANAGEMENT: REGULATIONS AND PROBLEMS IN KANSAS

J. P. Harner and J.P. Murphy[1]

Summary

The dairy industry is receiving greater pressure to reduce its potential pollution to the environment. As the demand grows for cleaner streams, dairy operations will need to reduce and control the nutrient and sediment loading of the runoff leaving the farm vicinity. Existing dairy operations will need to evaluate the impact of manure storage and management on the environment. Costs of controlling the runoff must be weighed against new lot construction in an alternate location. Future dairy facilities will need to address current regulations and be designed for compliance with future and more stringent regulations.

(Key Words: Waste Management, Kansas Regulations, Manure Production.)

Overview of Manure Production in Kansas Dairy Herds

The Kansas dairy industry includes 98,000 milk cows. A 1,400 lb cow produces 115 lbs of manure/day. Over 5,635 tons/day and over 2 million tons/yr of manure are produced by dairy cows in Kansas. Storm water runoff from dirt lots and concrete slabs on dairy farms is estimated at 400 acre-ft of water/yr. Without proper control structures, the storm water runoff transfers the nutrients to streams or neighboring property. The volume of wash water from milk parlors is over 550 acre-ft of water/yr. Additional manure production and runoff result from the replacement heifer lots. The manure from one cow is equal to that from 16 people. On a daily basis, the dairy industry in Kansas is responsible for handling sewage or manure equivalent to that from a population of 1.5 million people, or about 60% of the population in Kansas.

Annual manure production from Kansas dairy cows contains approximately 10,200 tons of nitrogen (N), 4,150 tons of potassium (K), and 8,200 tons of phosphorus (P). Fifty percent of the N is lost to the soil through leaching or to the air as ammonia. The remaining N, 5,100 tons, is available for utilization on cropland or pasture. If the manure is not properly stored and applied to land, then the N leaves the property in the storm runoff. The K and P will not break down as quickly as the N and will remain in the solid portion of the manure. About 30% of the K and P can be lost by runoff and leaching.

The N available for land application is equal to about 1/3 of 1% of the total fertilizer used in Kansas. Conservatively, its value is $1 million or about $10 per cow. Although the return economic value per cow for handling the manure may seem low, proper management and control of the runoff from the vicinity can help avoid nuisance complaints, lawsuits, or environmental problems such as fish kill or groundwater contamination. The cost of controlling problems is relatively small compared to the cost of correcting a problem at a later date. Later correction not only includes the cost of developing proper waste handling facilities and management practices, but may also include cost of cleaning up damage to the environment.

[1]Department of Agricultural Engineering.

Research has found that runoff from beef cattle feedlots has a biochemical oxygen demand (BOD_5) eight times the concentration found in raw domestic sewage. Increased levels of BOD_5 result in oxygen being depleted in waterways and potential fish kill. Feedlot runoff can contain 100 times more N and P than runoff from grazing land. Similar results would be expected from lots utilized in the dairy industry.

Current Kansas regulations relate to confined livestock facilities and not to livestock maintained on pastures. The amounts of nutrients transported from grazed pasture land range from 0.5 to 8.7 lb for N/acre/yr and 0.04 to 4.1 lb for P/acre/yr. Nutrient levels in runoff from livestock pastures often do not exceed those in runoff from ungrazed pasture, forest, or dryland farms. Overgrazed pastures have higher nutrient runoff than properly managed pasture. Unconfined livestock may decrease vegetative cover and increase runoff, erosion, transport of sediment, plant nutrients, and oxygen demand. This is particularly true in high impact feeding and watering sites. Bunks in a pasture should be at least 200 feet from the nearest stream. Improvements can also be made at watering sites to minimize the stream bank erosion and pollution problems.

Kansas Regulatory Agency

Kansas Department of Health and Environment (KDHE) is responsible for administering Kansas regulations related to runoff from confined livestock facilities and other agricultural waste-control facilities. The Kansas regulations became effective on July 1, 1967. The laws are designed to minimize the pollution or nutrients leaving the vicinity of a confined feeding operation, such as a dairy operation, with everyday manure production and normal rainfall or intensive storms. Each year, KDHE collects over 1,500 surface water samples, 150 groundwater samples, and 60 fish tissue samples to monitor the quality of water in Kansas.

Present Kansas Laws

KDHE administers the registration permit and certification requirements for dairy facilities in Kansas. The Kansas regulations require any operation with 300 head or more of livestock in confinement to be registered. Operations located so no potential problems are created by the runoff from dirt or concrete lots and manure stacks or leaching into groundwater are issued a certificate of operation rather than a permit. Normally, a permit will require the construction and maintenance of some type of waste management control system and a plan for utilizing the nutrients. In Kansas, 2,664 livestock operations are registered, and 1,031 operations are certified.

Runoff from a dairy operation is no longer under the operator's control once it leaves the property or enters a stream. Dairy producers need to be concerned about the shortest distance from a manure stack, freestall barn, dirt lot, or concrete feeding slab to either the property line or the stream, NOT just the distance to the nearest stream. The soil type and depth of groundwater must also be considered. The runoff must meet the following conditions:

1. The water cannot be acutely toxic to aquatic life, wildlife, plants, livestock, or humans;

2. The water cannot be a health hazard to humans who come in contact with it;

3. The water must not cause water quality standard violations in any "classified" streams or lakes;

4. The water must be of a quality that will not degrade any groundwater it might recharge.

Who Needs a Permit?

Confined feeding is defined as confinement of animals in lots or pens that are not normally used for raising crops and have no presence of vegetation. Confined feeding facilities can be located indoors (freestall barns) or outdoors (dirt lots). Even if dairy cows remain in a freestall barn without access to dirt lots, the operation is still considered to be confined feeding. Operators need to be registered if any one of the following criteria are met:

1. The operation has a capacity of 300 or more head of beef cattle, dairy cows, hogs, or sheep or a combination of all four;

2. The operation, irrespective of size, utilizes wastewater control facilities such as manure pits, ponds, or lagoons;

3. The operation is located near a stream or other aspects of the operation, such as improper disposal of dead animals present a potential water pollution problem; and

4. The operator(s) elects to come under the regulations.

Dairy producers should recognize that the 300-head capacity applies only to the livestock kept in confinement. Livestock that are maintained on pastures or crop stubble are not included. The total capacity is number of cows plus other confined fed livestock, such as the number of head in a beef backgrounding operation. The regulations do not allow for adjustments based on animal weight, age, or type. Weight or size will influence the size of the system needed to handle the manure. The Kansas laws do not have a minimum number of days in confinement before registration is required. In Kansas, if more than 300 head of livestock are held in confinement for 1 day, then registration is legally required.

Most Kansas dairy operations are less than 300 cows, with an average of 70 cows per farm. However, the regulations apply to these operations, because any runoff control, manure storage, or wash water structures are required to be registered, regardless of herd size. The present laws require most dairies to be registered because of the regulations for manure and wash water control structures.

State and Federal Guidelines?

Dairies having between 300 and 750 cows are required to follow the regulations established for Kansas and directed through KDHE's Division of Environment. However, if a dairy has less than 300 head and is considered to have pollution potential, it can still be required by KDHE to come under compliance with the existing laws. Operations with 750 or more cows are required to meet the regulation established by the Environmental Protection Agency (EPA). EPA guidelines basically apply to operations with over 1 million lb of livestock confinement/day. When the larger operations meet EPA requirements, they are issued a National Pollutant Discharge Elimination System (NPDES) permit. Presently, 296 livestock operations in Kansas have NPDES permits.

Discharging and Nondischarging Systems

The regulations for dairy operations between 300 and 750 cows allow for either discharging or nondischarging systems, depending on the size of operation and location of lots in relationship to waterways and potential problems. A discharging system separates the solids from the liquid by using settling basins, terraces, grass filter strips, sedimentation structures, or mechanical separators. After separation, the water is then discharged into a grassed waterway, pasture, or cropped field. No mechanical pumping is required with discharging control systems. A nondischarging system may include a method for separating the liquid and the solids, but the liquid portion of the runoff is contained in a structure. Normally, the pond is later pumped, and the water is dispersed onto cropland or pasture.

Any water draining from adjacent fields through a lot must be controlled using either a discharging or nondischarging pollution control system. Therefore, it is important to divert runoff from cropland or pasture around the lots using terraces or channels. In some cases, it may be easier to relocate the lots rather than control the excess runoff. For new operations, lots should be located on upland rather than bottomland to minimize the drainage and potential pollution problems.

Production units with a capacity of 750 or more cows are required to contain all runoff from lots in a holding pond, where there is little or no breakdown of the solids prior to dispersing onto cropland. The function of a holding pond is to contain the runoff from a lot until the nutrients are dispersed on farmland.

An operation with capacity of less than 300 head may require registration if it has pollution potential, a complaint is issued by a neighbor, or a pond is used to contain the runoff or wash water. Smaller operators are not allowed to have dirt or concrete lots straddling, adjoining, or draining into a road ditch, creek, or other channels without adequate control, because of the pollution potential. In addition, streams or waterways should not run through dirt lots. A water tank and pump system should be used for watering the cows.

Operations with less than 300 cows should maintain a distance between property lines or streams and the lots of at least 150 ft. KDHE requires a release form to be signed by any neighbors living within a quarter of mile of a dairy operation with 30 or more cows, if the operation is registered. The release form does not prevent neighbors from issuing complaints, should mismanagement occur.

Kansas laws allow for maximum flexibility for dairy operators to choose the type of waste management control facility. Options available include: holding ponds, lagoons, sedimentation structures, terraces, waterways, infiltration ponds, evaporation ponds, or concrete storage structures. With each of the systems, certain restrictions will apply and design specifications have to be met. Some of the criteria are:

1. Lots and runoff control facilities cannot be within 100 feet of the property line;

2. Water pollution control facilities must be able to handle the runoff generated by a 24-hr rainfall equal to 10-yr or 25-yr averages, which is about 5" in western Kansas, 6" in central Kansas, and 7" in eastern Kansas;

3. Lowest elevation of the feeding area or waste control facilities must a minimum of 10 ft above groundwater aquifers or seasonal perched tables;

4. The lots must be located a minimum of 100 ft from wells or reservoirs (preferably downslope of water sources) and 50 ft from rural water district lines;

5. Sedimentation structures are needed, with the type being dependent upon the drainage area;

6. If a holding pond or lagoon is used, then provisions for pumping the water, including certain land requirements and pumping equipment, must be available;

7. Release forms must be signed by neighbors within a certain distance of operations; and

8. A plan must be developed for utilizing the nutrients contained in the runoff.

Holding ponds and lagoons must be pumped down in 120 hr, if a nondischarging system is constructed. Often, irrigation equipment is more feasible and practical than tank wagons. An acre-ft of water (43,560 cu ft or 1,600 cu yd) contains 325,828 gallons of water. A 3,000 gallon tank wagon would have to make 108 trips to haul an acre-ft of water. A 300-gallon/min irrigation pump would be able to pump an acre-ft of water in 18 hr. Therefore, during the design stage, an operator needs to consider how a pond is going to be pumped. Additional details are also provided for pumping regulations, fencing, maintenance, and inspection in KDHE design standards.

A crop consultant should be considered in developing a nutrient utilization plan for applying the water onto farmland. KDHE limits the application rates to 3 acre-in/acre/day and 6 to 12 acre-in/acre/yr. The water in a pond should be sampled and tested for nutrient levels prior to application. Annual soil sampling in the application areas should be done to monitor the levels of N, K, or P in the soil. Fertilizer and other nutrients should then be applied according to the crop's needs.

Conclusions

The type of actual system that may receive approval by KDHE is dependent upon the site, drainage area, proximity of the streams or groundwater, number of cows, etc. Because of the variability between dairies, it is difficult to state exactly what will work in all situations. However, dairy producers should not locate new or expand existing facilities near streams or running water or in areas such as a ravines, where cropland or pasture may drain through the lots. Existing dairy operations will need to evaluate the impact of the manure storage and management on the environment. Costs of controlling the runoff must be weighed against new lot construction in an alternate location. Future dairy facilities will need to address and be designed for compliance with future and more stringent regulations.

WASTE MANAGEMENT IN THE PRODUCTION DAIRY INDUSTRY

C. Fulhage[1]

Summary

The impact of environmental regulation on livestock production enterprises is, inevitably, an increase in production costs. Producers should recognize that these are the costs of doing business and will probably have to be incurred by all producers who stay in business and remain viable. With proper input to the regulation process and implementation of practical and effective methods of manure management, most producers should be able to maintain viable enterprises.

Introduction

The late 1960's and early 1970's marked the beginning of significant changes and developments in the manner in which wastes were handled and managed in production operations involving livestock. Prior to that time, most livestock operations (other than a few, large cases) did not need to be greatly concerned about the path taken by manure or manure nutrients after it was voided by the animal. Most waste management activities were implemented for the convenience of the operator or animal/human health and sanitation reasons, rather than concern for surface and/or groundwater contamination. As long as nobody complained, manure "going to the creek" was generally ignored or simply not addressed by the regulatory agencies.

With the advent of the National Pollutant Discharge Elimination System, state and federal regulatory agencies became much more involved in scrutinizing sources and potential sources of pollution in agriculture as well as other industries. This increased attention from the regulatory sector coincided with an era of generally increasing size of individual operations. The 20-cow dairy that father or grandfather started grew into the 100-cow or larger dairy of today, often in the same location and utilizing many of the same facilities that were in use years ago. This increasing growth/manure production and increased regulatory activity have caused difficulty for many livestock producers as they attempt to comply with environmental requirements, while maintaining a viable production enterprise.

Review and analysis of the livestock waste/regulatory developments of the past 20 years identifies three factors that determine the degree of difficulty a particular livestock operation may perceive regulations as causing.

1. **Compliance**. Livestock producers, traditionally and characteristically independent types, must accept that compliance with environmental regulations is in their best interests and will be required by public perception and scrutiny. Experience suggests that attempts to delay, circumvent, or seek political relief from compliance requirements are nonproductive and, in many cases, ultimately make compliance more painful and difficult, because the regulatory agency perceives an attitude of noncooperation and disregard for the environment. Hence, a positive attitude toward compliance and recognition that public perception and scrutiny require all waste generators (agricultural as well as industrial, municipal, etc.) to comply with

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environmental regulations are important to the dairy producer in maintaining a viable production enterprise.

2. **Regulatory Input**. Although environmental regulations and their associated impact appear to be (and probably are) inevitable, livestock producers should take an active role in shaping and influencing the nature of those regulations. Most regulation development is conducted in a manner designed to allow input from those that the regulation impacts. This input may be accomplished in a variety of ways, including public hearings, written commentary, review of a proposed regulation in a public register, writing your congressman, etc. Agricultural commodity and issue organizations (Farm Bureau, Cattleman's Association, etc.) can and should be active participants in regulatory development. The objective in supplying input to regulations should not be to seek exempt or "special favored" status, but rather to find reasonable and practical methods of reaching the goal and intent of the regulation.

3. **Cost**. Waste management is, and probably always will be, a net cost item in the production enterprise. Although utilization of nutrients in manure may offset some costs, compliance-management of manure, in most cases, will result in a net cost to the operation. Because this cost does not usually contribute to or increase production (as does feed cost, for example), there is a strong tendency to attempt to "sidestep" this cost in order to enhance the capital cost/cash flow picture. Given that compliance-management of manure, sooner or later, will be required in all operations, it is extremely important that the producer view the cost of compliance as a cost of doing business. This cost should be viewed as valid and necessary as feed cost, facility costs, and other commonly accepted operating expenses. If a production enterprise cannot operate "in the black" with those costs accounted for, then that enterprise probably does not have a long-term, viable future. The contention that "compliance-waste management costs will put me out of business" generally elicits little sympathy or relaxation from the regulatory agencies. And indeed, the record shows that very few operations go out of business solely because of waste management costs. In such cases, other factors generally contribute to the nonviability of the operation.

Problems of Waste Management

Experience suggests that certain circumstances and conditions are often present in cases in which the regulatory agency initiates action regarding producer compliance with environmental regulations. Some of these circumstances are as follows:

1. **Dirt Lots/No Runoff Control**. In these cases, manure-laden runoff often enters a dry, intermittent, or losing stream or a flowing stream. Most regulatory agencies will regard this as a discharge of contaminants to waters of the state and, hence, a violation. Runoff discharges to other areas such as a pond or lake, sinkhole, neighbor's property (with or without associated complaints), and public rights-of-way such as road ditches also may be considered violations.

2. **Manure Storage Facilities Overflowing**. Overflow and subsequent runoff from manure storage facilities, as with runoff from dirt lots, can draw the attention of the regulatory agency. Movement of manure nutrients from a storage facility to any of the receiving areas described above will probably be perceived as a violation.

3. **Odor/Emissions**. Up to now, most regulatory agencies have played a rather passive role in regulating or addressing odors of agricultural origin. However, odors have, in recent years, been sources of many controversies and litigation in the courts. Agricultural odor cases generally are not initiated and pursued by the regulatory agency. Many cases are initiated by citizen

plaintiffs, usually citing nuisance law as a basis for the complaint. However, the regulatory agency usually does become involved, even though it has not documented or even addressed the possibility of an odor violation or nuisance. The involvement usually is a result of one side or the other attempting to show that the plaintiff is negligent, or conversely, exemplary in his other waste management practices. In the past, regulatory activity in the livestock waste area has focused primarily on water pollution. With the passage of the Clean Air Act, focus also will be directed toward atmospheric emissions (carbon dioxide, methane, ammonia, dust, particulates, etc.) as well. Because livestock waste systems are significant generators of these materials, future system designs must be developed with such regulatory impacts in mind.

4. **Manure Spreading**. Experience has shown that manure spreading activities can be a source of problems because of odor as well as being potential sources of surface or groundwater contamination. Odor problems often arise when untreated manure is surface spread in an area in which potential odor receptors live too close to the spreading site. Runoff problems can arise when too much manure is spread on too little ground. This often happens as the operator attempts to reduce the amount of time spent hauling manure. Manure stockpiled on a field for subsequent spreading also can cause nutrient runoff problems, if significant rainfall leaches material from the stockpile. Irrigation equipment used to distribute dilute lagoon effluent can suffer malfunctions such as pipe disconnection/breakage, or gun/sprinkler malfunction (i.e., traveling gun stopping or upsetting on uneven terrain or stationary sprinklers left operating in one place tool long). These types of failures typically result in high rates of runoff to the nearest stream, pond, or lake with associated fish kills, water quality degradation, etc.

5. **Neighbor Complaints**. Poor relationships or antagonistic feelings among neighbors are often expressed as complaints about the livestock waste management system or its operation. The root of the problem may actually lie elsewhere, but, for whatever reasons, waste management is used as a vehicle for expression. Most regulatory agencies are required by law to investigate complaints alleging the occurrence of water pollution. In such complaint cases, the regulatory agency becomes involved when it might not have otherwise had the complaint not been made.

6. **Dead Animal Management**. As livestock operations become larger, management of the mortalities that inevitably occur becomes more of a problem. Many states have enacted legislation to prohibit traditional methods of dead animal disposal. Such traditional methods may include burial, dragging, or hauling off to an isolated (or not so isolated) area to "feed the coyotes", improper (brushpile) burning, dumping into a sinkhole, or floating in a lagoon. Any of these practices, often reported by a neighbor's complaint, may result in regulatory action, depending upon the laws and statutes in place and their degree of enforcement.

Solutions to Problems

Solutions to waste management problems are many and varied, limited only by the ingenuity of the problem solver and, perhaps, by the regulation structure/framework itself. Experience indicates that only a very small percentage of waste management problems may not be solved within the economic framework of the production enterprise. However, in a few cases, operators may elect to cease production rather than pay costs of compliance that are required in their individual cases.

The single, most important factor that can prevent, reduce, or eliminate livestock waste management problems is site selection. Successful prevention or resolution of nearly all the problems discussed above can be enhanced by good site selection. Unfortunately, many livestock operations are located on sites where little consideration was given to waste management, usually because the site was selected in an earlier era when the operation was small and environmental concerns were minimal. Years ago, livestock operations were sometimes located on or near streams to take advantage of the "natural flushing" associated with such a location. On such sites, especially when the operation has significantly increased in size over the years, it can be very expensive and difficult to protect the stream that was the original waste-receiving area. The operator is then faced with the dilemma of moving to a new, more acceptable site, with the associated costs, or taking costly preventative measures on the original site, which may not support expansion into the future.

The most important factor to consider in site selection is maximization of distance to sensitive or critical features. These features can include streams (dry or flowing), ponds, lakes, sinkhole areas, public roads, property lines, and nonowned dwellings. Providing maximum distance between the facility site (manure source) and a sensitive feature, such as a stream, reduces the possibility of manure nutrients degrading that stream. This distance, in addition to providing a grassed filter area, allows room for the construction of runoff control structures, manure storages, lagoons, etc.

Traditional site selection criteria include access (close to the public road), utilities (locate or expand where water and electricity are already available), and existing support facilities (i.e., the hay barn or feed storage is already there). In the present era of environmental concern, these traditional criteria should be considered secondary to the question, "Can the livestock waste produced be successfully managed on this site?"

Some site selection criteria to be considered ahead of the traditional criteria of access/utilities/support facilities include the following.

1. Room for a grassed buffer area between the manure source and a sensitive receiving area (stream, etc.). Such an area also provides needed room to construct waste storage/treatment facilities, solids separation devices, runoff control structures, filter strips, and any other components needed to maintain compliance.

2. Adequate land for spreading manure. Most regulatory agencies require that manure be spread on land at agronomic rates. Hence, it is extremely important that a site be selected in which sufficient land is available to receive the amount of manure expected to be produced in the facility.

3. Proper soil material for constructing the needed waste management components. Many waste management systems can be most economically developed utilizing earthen storage for waste. However, it is very critical that the soil material available for constructing these components have sufficient clay content to attain the degree of impermeability required by an applicable regulation.

4. Odor movement. Any production unit involving livestock will produce some odor. In selecting a site, consideration should be given to the direction odors will travel from the facility. Prevailing wind direction and distance to downwind receptors should be noted. Of equal or greater importance is the travel of odors during damp, humid conditions with little or no wind. In these cases, odors travel, essentially undiluted by wind, in a "drainage" path similar to that water would follow. In such conditions, odors can travel relatively long distances, while retaining most of their original concentration. Separation distance to property lines and nonowned dwellings should be maximized to reduce the possibility of odor complaints by neighbors.

When a site is to be selected for a livestock production facility, an orderly procedure of addressing and evaluating the above factors and/or any other applicable factors should be followed and documented. In addition to ensuring that the best possible site is selected, this documented procedure will be evidence that all available recommendations and regulations were considered should the site location ever be challenged in legal proceedings.

Possible solutions to the specific problems outlined above are as follows.

1. **Dirt Lots/No Runoff Control**. As noted above, the impact of runoff from dirt lots can often be reduced by selecting a site further away (uphill or upslope) from the affected stream. On small operations, a simple solids separation device such as a porous (picket) dam can hold and store solids, and the liquid runoff can be received by a filter strip or grassed buffer area. Grassed terraces or waterways can be used to intercept runoff and provide sufficient flow distance to absorb manure nutrients in some cases. Lagoons and holding ponds are also effective means of interrupting and storing waste flows for subsequent land application. Sometimes dirt lots can be rotated and "farmed" to maintain a vegetative cover most of the time. Regulatory agencies usually consider livestock on a vegetated area to be a "nonpoint" source and, thus, not subject to the usual "feedlot" regulations.

2. **Manure Storage Facilities Overflowing**. Again, selecting a site away from streams, ponds, property lines, public roads, etc., can reduce the impact of a manure storage facility overflowing. However, it is obviously more ideal to prevent the overflow in the first place through good management. This usually involves pumping or hauling manure from storage facilities as needed and preferably in the summer/fall season, so storage volume is available for the cold and wet winter and spring months. Storage facilities should be designed with a realistic storage period in mind, so that the operator can manage the system in accordance with climatic conditions, tillage/planting/harvesting schedules, and his own time constraints. The operator must have the resources to dedicate the required equipment, labor, and management to manure land application needs. As noted initially, the operator must consider waste management a cost of doing business.

3. **Odor/Emissions**. As always, site selection can play an important part in preventing or reducing odor problems. Adequate separation distance from property lines and nonowned dwellings allows dilution of odors before they reach receptors who might be offended. Consideration of prevailing winds and air drainage patterns in relation to the location of neighbors' houses can prevent odor problems from developing. Good housekeeping and sanitation measures are important in minimizing odor generation. Waste management systems should be designed to minimize contact of raw manure with the atmosphere. Systems employing frequent collection and transport of manure to storage/treatment facilities (such as flushing systems) generally have significantly lower odor production than systems in which manure is collected infrequently.

4. **Manure Spreading**. Again, good site selection can be instrumental in reducing or eliminating manure spreading problems. Selecting a site where adequate land area is available within a reasonable distance from the manure source will allow the operator to apply nutrients at an agronomic rate within a time frame that he can manage. Spreading sites should be selected to minimize impact on streams, lakes, property lines, and non-owned dwellings. Manure storage facilities should be designed so that manure does not have to be spread when soil and/or climatic conditions are unfavorable (i.e., wet or freezing conditions). Spreading or irrigating equipment should be properly maintained and continuously monitored to ensure proper operation.

5. **Neighbor Complaints**. It is very important to eliminate reasons for neighbor complaints before they start. Once complaints are generated, they are very seldom resolved to the satisfaction of both parties. Again, site selection is instrumental in reducing the possibility of neighbor complaints. Remote locations that reduce visual and "smell" exposure help minimize the impact on neighbors. Vegetative screening such as tree lines can be effective. Practicing good public relations; donating commodity products to neighbors, charity, schools, and public functions; and generally being a good neighbor by following the golden rule are methods of reducing complaint probabilities.

6. **Dead Animal Management**. Most states require that animal carcasses be disposed of within 24 hours of time of death. Producers should become familiar with and follow the applicable laws and statutes regarding dead animal disposal. Acceptable methods may include rendering, incineration, sanitary landfill, burial, and composting. Rendering plants are becoming increasingly isolated, and transport of carcasses over long distances is expensive. Hence, rendering is not an attractive option to many producers. Incineration or burning of carcasses is usually regulated by air quality laws or statutes. Equipment and fuel costs are generally quite high to incinerate carcasses in compliance with air quality statutes. Landfills licensed to receive dead animals may refuse to accept them for their own reasons. Additionally, landfills are becoming increasingly filled, and it is difficult to locate and start new landfills. Hence, landfills are not alternatives of dead animal disposal for most producers. Burial may be an accepted method of dead animal disposal, if certain conditions are met. These conditions might include a limit on the number that may be buried per acre per year, requiring burial in a certain soil type, and specifying acceptable burial depth and soil cover requirements. Composting with subsequent land spreading of the compost is a relatively new practice in dead animal disposal. However, this practice has proven to be highly effective and attractive in the poultry industry, because it allows ultimate disposal in a manner similar to that used for handling the poultry litter. With this technique, poultry carcasses are layered with straw and poultry litter in a bin and allowed to compost in a two-stage process. After about a month of composting, the material can be spread on the land with little evidence of the original poultry carcasses detectable. Experiments are being conducted to determine the applicability of composting to other animal species.

Environmental regulations will be an integral factor in livestock operations in the future. Livestock operations must operate in compliance with regulations. Costs of production will increase, but it is imperative that waste management costs be considered as valid and necessary to doing business. This approach will be essential for long-term viability of the operation as a production unit.

EVALUATION OF MILK REPLACERS CONTAINING NEW PROTEIN SOURCES AND A PROBIOTIC

J. L. Morrill, J. F. Laster[1],
J. M. Morrill[2], and A. M. Feyerherm[3]

Summary

The objectives of this experiment were to evaluate bovine and porcine plasma proteins as sources of protein for calf milk replacers and to evaluate a commercial probiotic. Four replacers were compared; an all milk protein control, two replacers with 25% of protein from bovine plasma protein or porcine plasma protein, and a replacer identical to the control except that it contained a probiotic (Biomate FG, Chr. Hansen's Laboratory) instead of antibiotic. The 120 bull calves (7 ± 3 days of age) were divided into four equal groups, and calves from each group were fed 4 quarts per day of one of the replacers until weaned and all of a commercial starter they would eat. For the control, porcine plasma, bovine plasma, and probiotic replacer groups, respectively, during the 6-wk period, the weight gains were 23.8, 29.5, 27.9, and 22.2 lb. Starter consumptions were 53.7, 67.8, 58.7, and 54.6 lb, respectively. Deaths were 2, 1, 3, and 0, respectively. Increases in wither height were similar among diets. Increases in weight gains and starter consumed by calves fed the plasma proteins compared to controls approached significance (P = .10); differences between control and probiotic replacer groups were not significant.

(Key Words: Milk Replacers, Calves, Plasma Proteins, Probiotics.)

Introduction

Milk replacers are fed to calves when milk is not available, because it might be more economical, or for other reasons. Because the very young calf is limited in its ability to utilize proteins, it has been difficult to find proteins, other than those from milk products, that can be used in milk replacers. Some products from soybeans (soy flour, soy protein concentrate, soy protein isolate) are used in calf milk replacers with varying degrees of success. Recently, improved plasma proteins (which are by-products of the cattle and swine slaughter industries) have become available and have shown promise as protein sources for pigs. Research is needed to evaluate these products as protein sources for baby calves.

Many of the microorganisms that are found in the intestines of animals are beneficial. Theoretically, increasing the quantity of these microorganisms will benefit the animal, especially if some condition had existed that caused a decrease in quantity. Probiotics are products that contain one or more of these beneficial microorganisms and when administered to animals, will be beneficial. Several of these products are on the market, but most have not been tested adequately.

Our objectives were to determine the effect of replacing milk protein in calf milk replacers with plasma proteins from both porcine and bovine sources on growth and performance of

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dairy calves and to determine the efficacy of one commercial probiotic.

Procedures

Holstein bull calves (n=120) approximately 7 days of age were purchased in Wisconsin and transported to Cottonwood Farms, a commercial calf growing facility at McLouth, Kansas. Upon arrival they were unloaded into individual hutches bedded with straw. The calves were weighed and assigned to four equal groups. Each group was assigned to receive either an all-milk protein milk replacer (control), a replacer in which 25% of the protein came from porcine plasma protein, one containing 25% bovine plasma protein, or a replacer identical to the control except that it contained .25% Biomate FG (Chr. Hansen's Biosystems, Milwaukee, WI) instead of antibiotic. The milk replacers were fed twice daily until the calves were weaned, which was when they consumed at least 1.5 lb of starter daily. A commercial calf starter was always available.

Body weights were recorded weekly, and wither heights were recorded at the beginning and end of the experiment.

All calves received electrolytes on arrival, vaccinations, and were castrated 20 days after arrival. Blood samples were collected from a subsample of each group at 1 and 10 days of age and analyzed for 16 metabolites to determine if differences existed.

Results and Discussion

Overall health and mortality rate of the calves were acceptable for calves that had been collected from various farms and shipped long distance, considering also that they were subjected to the unusual early storm of fall 1991. The deaths per group (control = 2, porcine plasma = 1, bovine plasma = 3, probiotic = 0) were not different enough to be considered conclusive.

Weekly cumulative weight gains of the calves are shown in Table 1. All gains were somewhat low, partly because the protein content of the milk replacers was kept low to allow expression of differences in protein quality and partly because of the experimental stresses. The differences in gains were not significant, but the difference between gains of calves fed either plasma protein and those fed the control milk replacer approached significance (P=.10).

Starter consumption (Table 2) did not differ by treatment. As expected, calves that tended to gain more tended to eat more starter. Age at weaning did not differ significantly by treatment.

Increases in wither height were 5.8, 5.3, 6.9, and 5.8 inches for the control, porcine plasma, bovine plasma, and probiotic replacers, respectively, and were similar. When there were significant differences in blood metabolites, by treatment, there were no apparent explanations for why those metabolites (or measurements) should have been affected by treatment.

These results demonstrate that plasma proteins can successfully supply up to one-fourth of the protein in a milk replacer. Further research is needed to determine if the extra gain by calves fed plasma proteins, especially porcine protein, is repeatable and if feeding the plasma protein results in any benefits to health of calves.

Results from use of the probiotic were inconclusive. If there were benefits from use of the antibiotic in the control replacer (the experiment was not designed to measure that), then those same benefits were realized from use of the probiotic. More research is needed to evaluate the possible benefits from using the probiotic under different conditions, especially when disease is a major problem.

Table 1. Cumulative Weight Gains of Calves[a]

	Week					
Replacer	1	2	3	4	5	6
	lb					
Control	-.9	-2.4	2.6	10.3	20.9	23.8
Porcine plasma	-.2	-.9	5.5	15.0	25.3	29.5
Bovine plasma	-.2	-.9	5.1	13.2	24.0	27.9
Probiotic	.2	-1.3	3.5	11.7	19.8	22.2
SE	.7	.9	1.3	1.8	2.2	2.4

[a]Differences between treatments were not significant

Table 2. Cumulative Consumption of Starter by Calves[a]

	Week					
Replacer	1	2	3	4	5	6
	lb					
Control	.1	1.1	4.2	13.6	30.6	53.7
Porcine plasma	.2	1.5	6.6	18.7	38.9	67.8
Bovine plasma	.1	1.5	5.9	15.6	33.2	58.7
Probiotic	.2	1.5	5.5	15.6	31.2	54.6
SE	.1	.2	.9	2.0	3.3	4.4

[a]Differences between treatments were not significant

FISH MEAL AS A PROTEIN SOURCE FOR HOLSTEIN STEER CALVES

J. L. Morrill, J. F. Laster[1], J. M. Morrill[2], and A. M. Feyerherm[3]

Summary

Holstein steer calves (n = 96) were on experiment from 8 to 18 wk of age. Control calves were fed a diet in which all supplemental protein was from soybean meal; in the experimental diet, part of the soybean meal was replaced by fish meal. Both feeds were readily consumed, and consumption did not differ between treatments. Gains of calves fed fish meal were greater (P = .10) during the first 8 wk of the experiment; however, over the entire experiment, the difference was not significant. Overall results suggest that fish meal may improve weight gains and feed efficiency of younger and smaller calves.

(Key Words: Calves, Grower Diets, Fish Meal, Protein Source.)

Introduction

Approximately one-half of all calves born are bulls and, because of the widespread use of artificial insemination, few of these are needed for breeding purposes and, therefore, are available for production of meat. In recent years, large calf-feeding ranches have been developed that specialize in growing Holstein calves to a weight at which they are shipped to feedlots and finished on full feed. In this type of program, the calves essentially are on full feed from birth to slaughter. If properly fed and managed, the Holstein steer produces meat that is lean, tender, and flavorful.

The period from weaning to about 3 mo of age is still a high risk time for calves, with respiratory problems being especially serious. There is little information concerning optimum feeding programs for weaned Holstein calves that are kept on full feed. Specifically, the rumen undegradable protein requirement of this age animal is not known. Fish meal is a good source of high quality undegradable protein and may contain other special nutritional properties as well. The objective of this experiment was to evaluate fish meal as a partial replacement of soybean meal as a protein source for Holstein calves from 8 to 18 wk of age.

Procedures

Holstein steer calves (n = 96), 8 wk of age, were divided by body weight into two groups (heavy and light weight). Within each group, calves were assigned to two treatments, fish meal or soybean meal supplements. After assignment and placement in lots, the animals were weighed on 2 consecutive days, and the average of these weights was used as the beginning weight. The calves were weighed at 12 and 16 wk of age and on 3 consecutive days at the end of the experiment at 18 wk of age. Wither height was recorded at the beginning and end of the experiment.

The diets (Table 1) consisted of 1 part pelleted supplement (Table 2) and 3 parts whole shelled corn. Feed was added daily to ensure ad libitum consumption, and orts were

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measured weekly to allow calculation of weekly feed consumption.

Table 1. Analysis of Finished Feeds

Item	Fish Meal	Soybean Meal
Dry Matter, %	90.2	90.2
Crude Protein, %	16.3	17.1
Calcium, %	.72	.83
Phosphorus, %	.41	.42

Results and Discussion

All animals in the heavy group fed fish meal completed the experiment. Two calves in the light group on fish meal, five calves in the heavy group on soybean meal, and three calves in the light group on soybean meal were removed because of poor health, primarily respiratory problems.

Feed consumption is shown in Table 3. Both feeds were readily consumed, and consumption did not differ between treatments.

Body weights and gains are shown in Tables 4 and 5, respectively. Gains were greater on fish meal diets during the first 4 wk of the experiment, but the differences were not significant. Variability among animals is high at this age, as is shown by the large standard deviations. Differences between treatments from the fifth through the eighth wk of the experiment, as well as throughout the first 8 wk, were significant (P = .10).

Over the entire experiment, differences between treatments were not significant; weight gains were higher for the heavy group of calves fed diets containing soybean meal and for the light group of calves fed diets containing fish meal. It should be noted that calves removed from an experiment are often the ones that are not doing as well; thus, average gains of remaining calves are increased. The result of this would be that average gains of calves fed soybean meal would be inflated, because more calves were culled from that group.

Feed efficiency, expressed as amount of feed required per pound of gain, is shown in Table 6. Less feed was required when animals were fed fish meal during wk 1 to 4 and 5 to 8. During the last 2 wk of the experiment, the results depended on the group, with the light group benefitting more from the fish meal diet.

Heights at the withers at the beginning and at the end of the experiment and changes in wither height are shown in Table 7. Differences by treatment were not significant.

The results of this experiment suggest that fish meal may improve weight gains and feed efficiency in young calves, with more benefit likely for younger and smaller calves. The number of animals removed from the experiment may have been too small to draw conclusions; however, the possibility that fish meal may have provided some protection should be considered. More information is needed concerning the benefit of fish meal in rations for young dairy calves and for stressed animals.

Table 2. Composition of Supplement Pellets

Ingredients	Fish Meal	Soybean Meal
	---------- % ----------	
Soybean Meal	64.08	87.68
Fish Meal	14.00	
Wheat Middlings	11.45	
Limestone, ground	4.15	5.20
Alfalfa, dehydrated	2.50	2.50
Salt, mixing	2.00	2.00
Dicalcium phosphate		1.30
Potassium chloride	.90	.35
Trace mineral supplement	.38	.38
Vitamin supplement	.25	.25
Vitamin E supplement	.25	.30
Lasalocid	.05	.05
Calculated nutrient content and, in parentheses, analyzed content		
Crude protein, %	39.00 (38.54)	39.01 (39.05)
Undegraded protein, %	13.84	11.75
Metabolizable energy, Mcal/lb	1.08	1.08
Fat, %	2.18	.53
Acid Detergent Fiber, %	8.62	8.90
Neutral Detergent Fiber, %	13.31	12.32
Calcium, %	2.75 (3.16)	2.74 (2.53)
Phosphorus, %	.92 (.98)	.85 (.83)

Table 3. Average Daily Feed Consumption per Animal, lb

		Weeks of experiment					
Diet	Group	1	2	3	4	5	6
Fish meal	Heavy	5.1	5.5	6.4	6.6	7.3	8.8
	Light	4.4	5.3	5.7	5.9	6.8	7.9
Soybean meal	Heavy	4.0	4.6	5.7	6.2	6.6	8.1
	Light	4.2	5.1	5.7	6.4	6.4	7.7

		Weeks of experiment				
Diet	Group	7	8	9	10	1-10
Fish meal	Heavy	9.7	10.8	10.8	12.3	8.4
	Light	9.5	10.1	9.9	11.2	7.7
Soybean meal	Heavy	9.9	10.6	11.0	13.0	7.9
	Light	9.5	9.5	10.8	11.9	7.7

Table 4. Body Weights (lb) of Animals, (± Standard Deviation)

		Weeks of experiment			
Diet	Group	0	4	8	10
Fish meal	Heavy	159 ± 10	211 ± 26	305 ± 42	341 ± 49
	Light	140 ± 9	193 ± 29	285 ± 40	323 ± 45
Soybean meal	Heavy	156 ± 11	200 ± 39	296 ± 50	345 ± 47
	Light	140 ± 10	188 ± 35	265 ± 50	310 ± 50

Table 5. Gain (lb) in Body Weight of Animals (± Standard Deviation)

		Weeks of experiment				
Diet	Group	1-4	5-8	1-8	9-10	1-10
Fish meal	Heavy	52 ± 23	94 ± 20	146	36 ± 11	182 ± 45
	Light	53 ± 24	89 ± 17	142	38 ± 8	183 ± 41
Soybean meal	Heavy	43 ± 35	87 ± 25	130	39 ± 12	186 ± 45
	Light	47 ± 34	74 ± 23	121	39 ± 14	169 ± 48
	P[a]	.53	.09	.096	.71	.57

[a]P = Probability of difference between treatments, within initial weight groups.

Table 6. Feed Efficiency (Pounds Feed/Pounds Gain)

		Weeks of experiment		
Diet	Group	1-4	5-8	9-10
Fish meal	Heavy	3.17	2.73	4.45
	Light	2.81	2.70	3.86
Soybean meal	Heavy	3.30	2.84	4.29
	Light	3.16	3.13	4.07

Table 7. Withers Height and Increases in Withers Height, Inches

		Weeks of Experiment		
Diet	Group	0	10	Change (± standard deviation)
Fish meal	1	32.0	37.1	5.1 ± 1.5
	2	30.9	36.6	5.7 ± 1.5
Soybean meal	1	32.0	37.6	5.6 ± 1.3
	2	31.1	36.3	5.2 ± 1.5

EVALUATION OF ROASTED SOYBEANS FOR DAIRY CALVES

P. V. Reddy, J. L. Morrill, and L. S. Bates[1]

Summary

Diets containing soybeans roasted at different temperatures were fed to calves to investigate effects on growth and feed consumption. A growth trial was conducted using 84 Holstein calves from birth to 8 wk of age. The diets were formulated to contain 18% CP using soybeans roasted at 270 degrees F, 295 degrees F, or 325 degrees F. The overall feed consumption was greater for calves fed the diet containing beans roasted at either 270 or 295 degrees F than those fed the diet containing 325 degrees F beans. A similar trend was observed in weekly feed consumption. Gains were higher for calves fed the diet containing 295 degrees F beans, and these calves were more efficient in converting feed and energy to gain than the others. Rumen undegradable intake protein increased with increasing roasting temperature, but unavailable protein was high for 325 degrees F beans. Superior calf performance resulted when corrected undegradable intake protein (undegradable intake protein "minus" indigestible intake protein) was 56% and trace lipase activity remained.

(Key Words: Calves, Starter Diets, Soybeans, Roasting Temperatures.)

Introduction

Young calves, like high milk-producing cows in early lactation, require a feed high in protein and energy. Full fat soybeans contain, on a dry basis, approximately 19% fat and 39% CP, but raw soybeans contain several antinutritional factors (trypsin inhibitors, urease, hemaglutinins, etc.) that may lower their feed value. Heat treatment is the most commonly used method to minimize activity of these factors and can be accomplished by extrusion or by roasting. Results of our previous studies indicated that when roasting temperature was increased up to 290 degrees F, calf performance was increased. However, we did not have information on beans roasted at temperatures above 290 degrees F. The industry needs a simple, reliable method for determining when soybeans have been properly processed. This experiment was conducted to answer some of these questions.

Procedures

Performance Trial

Eighty-four Holstein calves were used from birth to 8 wk of age. They were fed colostrum for 3 d, then whole milk at 8% of birth weight daily in two equal feedings. All calves were housed in outdoor hutches and bedded on straw.

Calves were blocked by date of birth, then calves within blocks were assigned randomly to each of three pelleted calf starter diets (Table 1). The diets were formulated to contain 18% CP using soybeans roasted at 270 degrees F, 295 degrees F or 325 degrees F with a Jet-Pro Roaster® (Jet-Pro Co., Atchison, KS). Calves could consume calf starter and water free choice and were weaned when they consumed at least 1.5 lb starter per day for 2 consecutive days.

Amount of starter consumed and body weight of calves were recorded weekly. Calves were observed daily for deviations from normal health. At birth and at 8 wk of age, wither height,

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body length (from point of shoulder to posterior edge of pin bone), and heart girth were recorded.

In Vitro Evaluation of Roasted Soybeans

A laboratory method was used to determine the extent of protein degradation in the roasted soybeans. Indigestible intake protein content of roasted soybeans was calculated from analyzed values of acid detergent insoluble nitrogen. Lipase activity of the soybeans roasted at different temperatures was determined by using a PRO-CHEK test kit (ALTECA Ltd., Manhattan, KS).

Results and Discussion

Feed consumption and weight gains are presented in Table 2. The overall feed consumption was greater for calves fed the 270 or 295 degrees F diets than those fed 325 degrees F roasted beans. A similar trend of weekly feed consumptions was observed from wk 4 through 8. However, the weight gains of calves fed the 295 degrees F diet were higher than those of calves fed the 270 or 325 degrees F diets.

Average daily gain, gain to feed ratio, and energy efficiencies were calculated using the data for calves (n = 80) from 6 to 8 wk of age (Table 3). Calves fed the diet containing beans roasted at 295 degrees F gained more weight and tended to be more efficient in converting feed and energy to gain than those fed the 270 or 325 degrees F diets.

The increases in height for the 8-wk period were 3.4, 4.1, and 2.6 inches, and the increases in length were 4.0, 4.6, and 3.3 inches for the 270, 295, and 325 degrees F diets, respectively. Calves fed the 295 degrees F diet grew more than calves in other groups.

Rumen undegradable intake protein contents of soybeans roasted at 270, 295, and 325 degrees F were 53, 60, and 69% and lipase activities were medium, trace, and none, respectively.

Use of soybeans roasted at 295 degrees F resulted in superior calf performance. This temperature sufficiently increased the protein undegradability and probably allowed more efficient utilization in the small intestine. The low gains on the diet containing 325 degrees F beans may have been related to palatability or heat damaged protein that was indicated by severe scorching and burning of the seed coat and by a high proportion of indigestible intake protein (13%) in comparison to soybeans processed at 270 or 295 degrees F (4%).

In conclusion, performance of calves fed soybeans roasted at 295 degrees F was superior to those fed soybeans roasted at 270 or 325 degrees F. Rumen undegradable intake protein increased with increasing roasting temperature, but unavailable protein was high for 325 degrees F beans. Lipase activity can be used to predict protein undegradability, provided that the beans are uniformly cooked.

Table 1. Ingredient and Chemical Composition of Calf Starters

	Diets[1]		
Item	270^0F	295^0F	325^0F
Ingredient		%	
Alfalfa, ground	19.4	19.9	19.9
Corn, cracked	40.3	39.4	39.5
Oats, rolled	14.5	15.1	15.1
Molasses, liquid	6.0	6.0	6.0
Soybeans, roasted	18.5	18.3	18.2
Trace-mineralized salt	.22	.22	.22
Dicalcium phosphate	.46	.46	.46
Limestone	.54	.54	.54
Vitamin ADE premix[3]	.05	.05	.05
Coccidiostat[4]	.03	.03	.03
Chemical analysis, %			
DM	89.6	89.8	90.5
CP[5]	17.9	18.2	18.4
ADF[5]	9.9	10.1	9.5
NDF[5]	14.4	14.6	15.0

[1]Diets identified by temperature at which soybeans were roasted.
[2]As-fed basis.
[3]Provided 1000 IU vitamin A, 140 IU vitamin D, and 32 IU vitamin E per lb feed.
[4]Provided 30 mg of decoquinate per lb feed.
[5]DM basis.

Table 2. Average Feed Consumption and Weight Gains of Calves Fed Roasted Soybeans

		Week								
Item	Diets[1]	1	2	3	4	5	6	7	8	Overall
						lb				
Feed consumption	270^0F	.2	.6	2.9	8.5[a]	14.8[a]	18.7[b]	23.3[b]	28.1[a]	96.3[a]
	295^0F	.1	.7	2.8	8.1[a]	15.7[a]	22.2[a]	26.1[a]	30.5[a]	103.3[a]
	325^0F	.2	.5	2.1	5.4[b]	11.1[b]	15.0[c]	19.9[c]	23.1[b]	81.3[b]
	SEM	.2	.1	.2	.4	.5	.5	.5	.5	1.9
Weight gain	270^0F	.6	-.8	5.3	8.3[a]	7.6[ab]	8.2[ab]	9.9[b]	12.3[ab]	51.3[b]
	295^0F	1.0	1.0	6.3	6.6[b]	9.4[a]	10.7[a]	12.5[a]	14.7[a]	61.1[a]
	325^0F	.7	-.9	5.9	6.0[b]	5.4[b]	7.6[b]	8.1[b]	10.5[b]	44.2[c]
	SEM	.2	.3	.3	.3	.4	.4	.4	.4	1.2

[a,b,c]Means within a column within feed consumption or weight gain with different superscripts differ ($P<.05$).
[1]Diets identified by temperature at which soybeans were roasted.

Table 3. Average Daily Gain (ADG), Gain to Feed Ratio, and Energy Efficiency of Calves from 6 to 8 wk of Age

Diets	ADG, lb	lb gain/lb feed	Mcal ME/lb gain
270^{0}F	.22[b]	.33	4.37
295^{0}F	.27[a]	.36	4.24
325^{0}F	.18[c]	.36	4.54

[a,b,c]Means within a column within a trial with different superscripts differ ($P<.05$).
[1]Diets identified by temperature at which soybeans were roasted.

LEUKOCYTE FUNCTION IN VITRO AFTER ADDING VITAMINS A, E, AND β-CAROTENE

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Summary

Blood neutrophils and pulmonary alveolar macrophages isolated from calves at 3 and 6 wk of age were cultured in medium without added vitamins or supplemented with vitamin A, vitamin E, vitamin A and vitamin E, or ß-carotene and vitamin E. Macrophage bactericidal activity improved with A-E supplementation compared to ß-carotene-E supplementation at wk 3. Neutrophil bactericidal activity decreased with all vitamin E treatments at wk 3 and with vitamins E and A-E at wk 6. Neutrophil phagocytosis improved at wk 3 with A, E, and A-E supplementations. The chemotactic index improved at wk 3 with ß-carotene-E compared to vitamin E alone and at wk 6 with vitamin E compared to vitamin A and control treatments. The retinol content of neutrophils at wk 3 was variable, but by wk 6, cells supplemented with A, E, or A-E had higher retinol concentrations than control cells. Neutrophil α-tocopherol concentrations at 3 wk increased over controls with vitamin E or ß-carotene-E supplementation, but at wk 6, vitamin E-supplemented cells were different only from vitamin A-supplemented cells. These data suggest that there are optimum plasma concentrations of vitamins A and E for leukocyte functions.

(Key Words: Retinol, α-Tocopherol, ß-Carotene, Neutrophils, Macrophages, Calves.)

Introduction

Neonatal calf loss from enteric and respiratory illness is a major problem in the dairy industry. The young animal's first immune defenses are antibodies absorbed from colostrum and phagocytic cell activity. Vitamins A and E have been implicated in enhancement of phagocytic functions of leukocytes. In previous research, increased supplemental vitamin E enhanced the chemotactic index, but had no effect on antibody-dependent cellular cytotoxicity. Increased supplementation of vitamins A and E together improved bactericidal responses more than with either vitamin alone. The vitamin E concentrations used in that research were below recommendations for improved immune functions, thereby limiting possible benefits. Mastitis research with dairy cows has suggested a role in the immune response for ß-carotene, independent of vitamin A.

The objectives of this study were to determine the effects of supplemental vitamins A, E, or ß-carotene on blood neutrophil and pulmonary alveolar macrophage functions in vitro and to determine concentrations of vitamins A and E in neutrophils supplemented in vitro with vitamins A, E, or ß-carotene.

Procedures

Twelve Holstein bull calves were fed a milk replacer containing 5 IU/lb vitamin E and 3636 IU/lb vitamin A. At 3 and 6 wk of age, blood samples and pulmonary alveolar macrophages were collected. Neutrophils and

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macrophages were separated and resuspended in medium with no additional vitamin supplementation (0) or containing the following vitamin supplementation: 100 ug/dl retinyl palmitate (A), 1000 ug/dl þ-tocopherol acetate (E), 100 ug/dl retinyl palmitate and 1000 ug/dl þ-tocopherol (AE), or .25 IU/dl ß-carotene and 1000 ug/dl α-tocopherol (BC). Neutrophils were used in a migration assay to measure movement toward a chemoattractant, in a phagocytosis assay to measure the cell's ability to ingest *S. aureus*, and in a bactericidal assay to measure the cell's ability to kill *S. aureus*. The macrophages were also used in the bactericidal assay. Neutrophils were analyzed for α-tocopherol, retinol, and retinyl palmitate.

Results and Discussion

Neutrophil chemotactic index (directed:random migration) at wk 3 was less with vitamin E added to the medium than with ß-carotene and vitamin E added, but neither treatment was different from the control (Table 1). However, by wk 6, the chemotactic index of neutrophils supplemented with vitamin E was higher than that of control cells or those supplemented with vitamin A, but was not different from that of cells treated with AE and CE. Thus, the chemotactic function of neutrophils from 3-wk-old calves responded differently to vitamin supplementation than did that of neutrophils from the same calves at 6 wk.

Neutrophils of 3-wk-old calves had a greater phagocytic capacity than the control cells when supplemented with vitamins A, E, or A and E together (Table 1). However, supplementation with ß-carotene and vitamin E had no beneficial effect. No differences were seen in the phagocytic functions at wk 6, suggesting that the animals had sufficient vitamin stores in those cells for this function prior to use in this experiment.

Neutrophil bactericidal activity responded negatively to vitamin supplementation in the medium at both 3 and 6 wk (Table 1), with the exception of the wk 3 and 6 A treatment and wk 6 CE treatment. At wk 3, activities of all vitamin E-supplemented treatments were significantly decreased compared to the control. ß-carotene and vitamin E supplemented together decreased bactericidal activity compared to the vitamin A supplementation and the control. After observing similar trends in other species, other researchers have suggested that increased phagocytosis and decreased bactericidal activity may have been due to the antioxidant reducing the free radicals and increasing membrane stability. The more stable membrane improved the cell's phagocytic capacity, but the antioxidant effect that was preserving the cell's membrane probably reduced the superoxide in the cell and, therefore, the cell's capacity to destroy bacteria after ingestion. However, at wk 6, only the vitamin E and AE treatments reduced bactericidal activity compared to controls. Neutrophils responded similarly to vitamin E supplementation in the medium at 3 and 6 wk, with the exception of the CE treatment.

Macrophage bactericidal activity (Table 1) was affected by vitamin supplementation at wk 3, but not at wk 6. At 3 wk, differences occurred between AE treatment and the E or CE treatments. None of those treatments differed from the A treatment and the control. Therefore, neutrophils and macrophages responded differently to vitamins supplemented in the medium at both 3 and 6 wk. For example, at wk 3, vitamins A and E together tended to improve bactericidal activity of macrophages, but decreased bactericidal activity of neutrophils. At wk 6, vitamin E tended to increase neutrophil bactericidal activity, but all supplemental vitamins had no effect on macrophage bactericidal activity.

The vitamin A and E contents of neutrophils are shown in Figure 1. Retinol content of cells at wk 3 was variable between calves. One calf had large values of retinyl palmitate, but others had little or no retinyl palmitate and smaller increases of retinol acetate (data not shown). The vitamin A-supplemented cells were not different from the control cells.

In contrast, the α-tocopherol content of the cells reflected supplementation of that vitamin alone or in conjunction with ß-carotene. When neutrophils were supplemented with retinyl palmitate or retinyl palmitate and α-tocopherol, their α-tocopherol content was not different from that of the controls. Retinyl palmitate tended to inhibit the incorporation of α-tocopherol into the cells, but ß-carotene increased cellular α-tocopherol at wk 3.

At wk 6, α-tocopherol content differed only between the vitamin A-supplemented cells and the vitamin E-supplemented cells. In contrast, the retinol content of neutrophils at wk 6 was increased compared to the control by supplementation with vitamins A, E, or A and E, but not with ß-carotene.

In conclusion, these data suggest that there are optimal plasma concentrations of vitamins A and E for leukocyte function. More research is warranted to determine the exact range that is most beneficial for these leukocytes.

Table 1. Function of Neutrophils and Macrophages from Calves at 3 and 6 Weeks of Age after Incubation in Medium with Vitamin Supplementation

	Vitamin supplementation[1]					
Function	0	A	E	AE	CE	SE
			Week 3			
Neutrophil						
Chemotaxis (directed:random migration)	2.6[ab]	3.5[ab]	1.5[b]	2.9[ab]	3.9[a]	1.0
Phagocytosis (% ingestion)	29.7[b]	50.3[a]	46.8[a]	47.3[a]	35.3[b]	4.6
Bactericidal kill (%)	43.4[a]	38.2[ab]	32.6[bc]	32.9[bc]	29.2[c]	3.5
Macrophage						
Bactericidal kill (%)	36.9[ab]	39.5[ab]	34.5[b]	47.5[a]	30.3[b]	5.1
			Week 6			
Neutrophil						
Chemotaxis (directed:random migration)	2.6[b]	3.0[b*]	4.6[a]	3.0[ab*]	3.6[ab]	.7
Phagocytosis (% ingestion)	36.6	32.9	39.1	32.9	34.7	6.6
Bactericidal kill (%)	57.7[a]	53.8[ab]	46.9[bc]	40.6[c]	51.3[ab]	4.1
Macrophage						
Bactericidal kill (%)	39.3	44.8	37.5	33.3	36.8	5.3

[1]0 = no vitamin supplementation, A = 100 ug/dl vitamin A, E = 1000 ug/dl vitamin E, AE = 100 ug/dl vitamin A and 1000 ug/dl vitamin E, and CE = .25 ug/dl ß-carotene adn 1000 ug/dl vitamin E.

[abc]Means within the same row with different letters differ (*P*<.10).

[*]Equal values with differing superscripts are a result of decimal rounding.

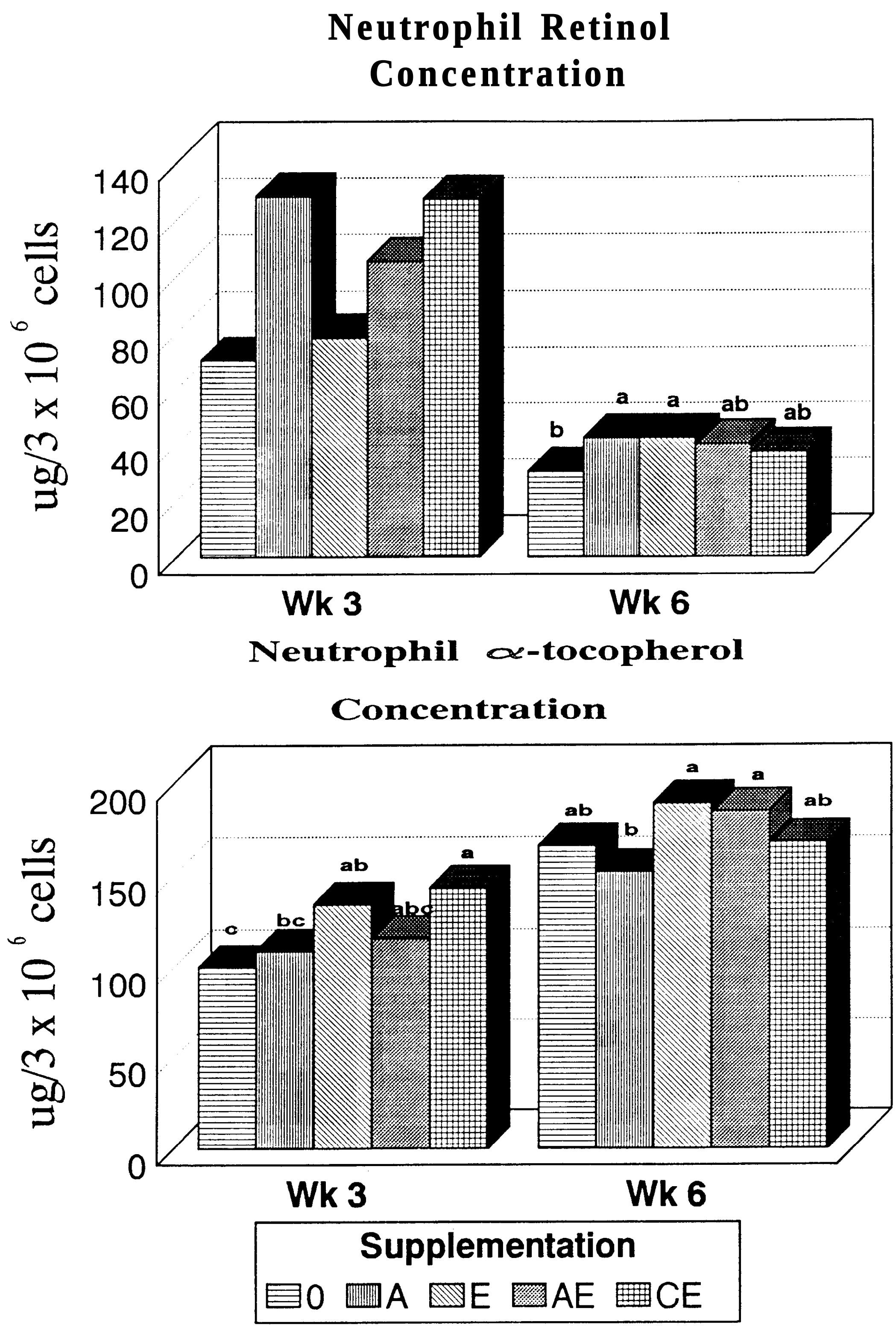

Figure 1. **Retinol and α-tocopherol contents of blood neutrophils following incubation in medium without supplemented vitamins (0) or supplemented with 100 ug/dl vitamin A (A), 1000 ug/dl vitamin E (E), 100 ug/dl vitamin A and 1000 ug/dl vitamin E (AE), or .25 ug/dl ß-carotene and 1000 ug/dl vitamin E (CE). Means with different letters differ (*P* < .10).**

SOMATIC CELL COUNT INVERSELY RELATED TO POTENTIAL PROFITS IN DAIRYING

J. R. Dunham

Summary

Somatic Cell Count (SCC) affects productivity of a dairy herd and, thus, potential profit. Almost all SCC problems can be solved by management. The DHIA SCC program is very useful for evaluating the situation in a dairy herd to solve such problems.

(Key Words: Somatic Cell Count, Mastitis, Rolling Herd Average.)

Introduction

Herd average Somatic Cell Count (SCC) is inversely related to potential profit in a dairy herd because of the relationship of SCC to mammary infections. As SCC increases, more mastitis occurs, resulting in lower milk production, higher treatment costs, more dumped milk, and more cows culled. A recent summary indicated that SCC average and Rolling Herd Average (RHA) are inversely related, and most SCC problems can be resolved with improved management.

Procedures

Data were collected from Dairy Herd Improvement Association (DHIA) summaries for 463 dairy herds in Kansas in 1991. Herds were divided into four production groups (quartiles) based on RHAs for milk production.

Results and Discussion

A DHIA summary of Kansas Holstein herds grouped according to RHA in Table 1 shows that SCC, SCC Linear Score, and dollar loss/day from SCC decrease as RHA increases. Table 2 contains more summary information that is useful in evaluating the potential causes of higher SCC in lower producing herds.

First lactation SCC averages are good indications of the incidence of mastitis in heifers entering the herd. Heifers should be free of mastitis at freshening, with an SCC average of less than 200,000. Lower producing herds exceed this level, which indicates that many herd SCC problems are related to too many heifers freshening that are already infected with mastitis.

Table 2 also demonstrates that SCC average is lowest in first lactation cows in all production groups. If first lactation SCC is too high, then the herd average SCC will likely be too high because the SCC increases in succeeding lactations. Many herds could markedly reduce their SCC, if the heifers entered the herd with low SCC.

The most likely reasons for freshening heifers to have high SCC are heifers 1) becoming infected in a farm pond during late gestation, 2) becoming infected because of poor sanitation in the springer pen, and/or 3) becoming infected because of poor control of flies.

A similar sort of a problem is indicated by the high SCC of all early lactation cows (Table 2). In many herds, bred heifers and dry cows are kept together in a pasture, and the springing cows and heifers are in the same springer pen. Some managers could go a long ways toward solving their SCC problem by improving the environment for the bred heifers and dry cows.

All production groups have lower SCC averages when in milk <50 days compared to >300 days in milk. This might indicate that some reduction in mammary infection is occurring because of dry cow treatment. However, SCC in lower producing herds is still too high, indicating that too many cows are becoming reinfected with mastitis-causing bacteria near the time of freshening.

Another conclusion that can be drawn from the summary in Table 2 is that SCC does not increase as much during lactation in higher producing herds as in lower producing herds. This indicates that increased rate of mammary infections are due to 1) poor milking techniques, including sanitation; 2) milking equipment operating inadequately; 3) poor environmental conditions; and/or 4) damage to teat ends caused by warts. Any herd experiencing an increase of more than 150,000 SCC as cows go from early lactation to late lactation should review these conditions.

Table 1. Comparison of Rolling Herd Average Groups to Somatic Cell Count, Linear Score, and Losses in Dairy Herds

RHA	SCC	Linear score	Loss/cow/day
13,084	483,000	3.9	$0.37
15,737	402,000	3.5	$0.31
17,762	317,000	3.2	$0.24
20,187	262,000	2.9	$0.18

Table 2. Comparison of Rolling Herd Average Groups to SCC Averaged by Lactation Number and Stage of Lactation

	SCC averages (× 1,000)							
	Lactation number			Stage of lactation (days)				
RHA	1	2	3+	<50	51-100	101-200	201-300	>300
13,084	277	375	647	423	431	463	588	588
15,737	255	333	541	297	356	400	519	473
17,762	205	268	440	273	296	322	346	400
20,187	183	227	354	212	240	273	287	328

EFFECT OF YEARLY MILK PRODUCTION ON AVERAGE DAYS OPEN

E. P. Call

Summary

Although there is a genetic antagonism between yearly production per cow and reproduction, analysis of Kansas Holstein herds suggests that managers of higher producing herds overcome this inverse relationship. Higher producing herds have fewer cows open at any given time, and those cows that are open average fewer days since last freshening. When open cows are categorized by days open, higher producing herds have fewer cows open more than 60 days, and especially fewer cows open more than 120 days.

(Key Words: Milk Production, Days Open, Dairy Cattle.)

Introduction

Evaluating reproductive efficiency in the dairy enterprise is a complex problem. Most losses are "hidden" or insidious and after the fact. For example, calving interval cannot be determined until the cow has calved twice. Although all herds will have a group of cows categorized as OPEN -NOT YET BRED, the average days open for this group may have a marked influence on the overall reproductive loss in the herd. Considering the negative genetic correlation that exists between production and reproduction, higher producing herds may have greater losses from the percentage of cows open and average days open.

Procedures

Kansas Holstein herds (n = 463) cooperating in the Dairy Herd Improvement program (DHIA) were evaluated using the Kansas State University Dairy Herd Analyzer (KSU-DHA). The herds were ranked by rolling herd average (RHA) for milk and categorized by quartile. In addition to calculating losses associated with the various management areas, the percentage of cows open and cows open stratified by average days open were determined to evaluate the possible effect of yearly milk per cow (RHA) on the number of cows OPEN -NOT YET BRED.

Results and Disscussion

The economic effect of yearly milk production per cow (RHA) on various management areas is shown in Table 1. The evaluation assumes that all producers are capable of reaching the goals of the KSU-DHA. The losses depicted represent income-over-feed cost, in that feed cost per cwt milk is included in the calculations. As noted, reproductive losses are second only to nutrition (production) losses in the average herd included in the analysis.

Table 1. Average Losses per Cow Associated with Various Management Areas in 463 Kansas Holstein Herds (1991)*

Management area	Loss/cow $	Loss/cow %
Nutrition	153	40
Reproduction	134	34
Milk Quality	69	18
Genetics	33	8
Total	389	100

*KSU Dairy Herd Analyzer.

Table 2 evaluates the four factors included in reproduction management. Elongated calving interval accounts for 58% of the reproduction losses. Long calving interval is primarily a function of "elective waiting period" to first service, which averaged 82 days in this study. The importance of reproductive efficiency associated with yearly milk per cow is illustrated in Table 3. Although higher producing herds are more efficient, reproductive losses make up a considerably larger portion of total losses realized.

Table 2. Average Losses per Cow Associated with Reproductive Parameters in 463 Kansas Holstein Herds (1991)*

Reproduction area	Actual	Loss/cow $	Loss/cow %
Calving interval, d	411	78	58
Days dry	60	15	11
Services/conception	2.1	8	6
Age at calving, L-1	27	33	25
		134	100

*KSU Dairy Herd Analyzer.

Table 3. Reproduction Losses in Kansas Holstein Herds Grouped by Rolling Herd Average (RHA) (1991)*

RHA (lb)	Yearly losses/cow Reproduction ($)	Yearly losses/cow % of Total (%)
12,715	164	23
15,924	141	27
17,580	128	30
19,978	118	42

*KSU Dairy Herd Analyzer.

Table 4 indicates little effect of RHA on average days open for cows in the pregnant group. However, higher producing herds have a marked advantage, with lower percentages of herd bred and especially of average days open for cows not yet serviced since calving. Although most herds practice an "elective waiting period" before servicing cows after calving, Table 5 shows an inverse relationship between RHA and percentage of cows open beyond 60 days fresh and especially beyond 120 days.

Although a negative relationship exists between production and reproduction, managers of higher producing herds apparently overcome this inverse effect by initiating procedures to get cows serviced earlier in the postpartum period. Synchronization programs are available to minimize cows open that should be bred.

Table 4. Average Days Open in Pregnant and Open Cows and Percent of Herd Not Bred in Kansas Holstein Herds Grouped by Rolling Herd Average (RHA) (1991)

	Group		
RHA	Pregnant	Not bred	
(lb)	Days open	% of herd	Days open
12,715	135	41	138
15,924	130	32	90
17,580	130	34	87
19,978	128	30	70

Table 5. Percent of Herd Open by Average Days Open in Kansas Holstein Herds Grouped by Rolling Herd Average (RHA) (1991)

RHA (lb)	Percentage of cows open < 60 d	> 60 d	> 120 d
12,715	43	57	35
15,924	57	43	22
17,580	54	46	19
19,978	60	40	12

OVARIAN FOLLICULAR WAVES AND SECRETION OF FOLLICLE-STIMULATING HORMONE AFTER ADMINISTRATION OF GnRH AT ESTRUS

J. R. Pursley and J. S. Stevenson

Summary

An experiment was conducted to examine the effects of GnRH on the secretion of FSH, LH, estradiol, and progesterone in serum and changes in ovarian structures. Dairy cows were assigned randomly to receive either 100 µg of GnRH or saline 12 hr after estrus (day 0) was detected. Blood was collected daily to assess changes in serum estradiol and progesterone and every 12 min for 8 hr on days 8 and 15 after estrus to assess concentrations of FSH and LH. Diameter and number of follicles were determined daily by real-time ultrasonography. Two patterns of follicular development were observed. The day of peak diameter of each dominant follicle (three or four per cycle) was synchronous with increases in estradiol in serum. The dominant follicle grew at a faster rate in all GnRH-treated cows. We concluded that administering GnRH at estrus increased the pulse frequency of FSH on days 8 and 15 of the cycle, altered follicular dynamics of dominant follicles of the subsequent estrous cycle, and tended to increase concentrations of progesterone in serum of cows.

(Key Words: GnRH, Ovarian Follicles, FSH, Estradiol, Progesterone.)

Procedures

Nine mid- to late-lactation dairy cows were used in a crossover experiment in which 13 estrous cycles were studied. These cows had failed to conceive to earlier inseminations and were classified as repeat-breeders. During the first part of the study, one-half of the cows received 100 µg of GnRH (Cystorelin, Sanofi Animal Health, Inc., Overland Park, KS), and the remainder received saline at 12 hr after estrus was detected. The cows were monitored during one estrous cycle, with a second intervening estrous cycle serving as a rest cycle. At the estrus before the third estrous cycle, the cows received the alternate treatment at 12 hr after estrus was detected and were studied as in the first cycle. During the first and third estrous cycles, blood was collected daily to assess concentrations of progesterone and estradiol-17β, and both ovaries were scanned by ultrasonography to measure and record the number and diameter of all ovarian follicles. In addition, cows were fitted with jugular catheters, in order to collect blood samples on days 8 and 15 of the cycle (every 12 min for 8 hr) to monitor characteristics of gonadotropin (LH and FSH) secretion. These days were selected because they correspond to days of the estrous cycle when the last two dominant follicles begin to enlarge in diameter.

Results and Discussion

Two patterns of follicular growth were observed. During six of the cycles, three dominant follicles emerged, whereas in the remaining seven cycles, four dominant follicles were detected. Figure 1 illustrates the increasing diameters of three dominant follicles in one cow on days 1, 11, and 15 of the cycle, along with corresponding increases in serum concentration of estradiol produced by those large follicles. The last follicle (labelled DOF in Figure 1) was the one that ovulated after the subsequent estrus.

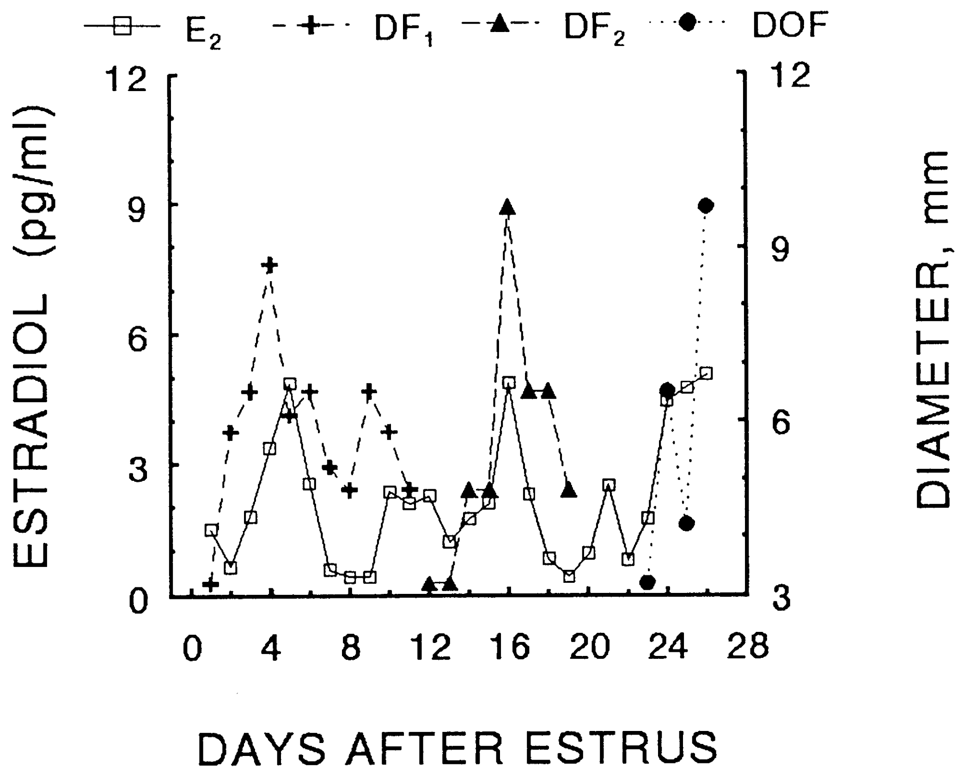

Figure 1. Concentrations of estradiol-17β in serum and diameter of two dominant follicles (DF_1 and DF_2) and the dominant ovulatory follicle (DOF) during the estrous cycle of one cow.

As shown in Figure 1, the day each dominant follicle reached its peak in diameter, concentrations of estradiol in serum were at their highest level in the blood serum, indicating that the dominant follicles were estrogenic. The dominant follicle that eventually ovulated grew at a faster rate in all cows treated at the previous estrus with 100 *μg* of GnRH.

The percentage of cows with pulses of FSH were greater ($P < .05$) on days 8 and 15 of the estrous cycle in GnRH-treated cows (Table 1). Although concentrations of FSH in serum were unaffected by treatment with GnRH at estrus, cows having three follicular waves tended to have lower FSH than those having four follicular waves (measured on days 8 and 15; Table 2). However, cows with three waves averaged up to sixfold more pulses of FSH on days 8 and 15. There were no differences in LH secretion among treatment groups or among cows with three or four follicular waves.

Concentrations of progesterone in serum of cows having three follicular waves, but not four waves, tended to be higher after treatment with GnRH. We concluded that administration of GnRH at estrus altered follicular dynamics of dominant follicles during the subsequent estrous cycle and tended to alter secretion of progesterone as we observed in our earlier studies (1991 Dairy Day, Report of Progress 640, pp 36-39).

Table 1. Percentage of Cows with Pulses of FSH on d 8 and 15 of the Estrous Cycle after Treatment with 100 µg GnRH or Saline at Estrus (d 0)

	Treatment		
Item	GnRH	Saline	Wave %
Number of follicular waves[b]			
Three	100.0[c] (n = 4)	33.3 (n = 3)	66.7[e]
Four	66.6[c] (n = 3)	0 (n = 3)	33.3
Treatment %	83.3[d] (n = 7)	16.7 (n = 6)	

[a]Response was identical on d 8 and 15 of the estrous cycle.
[b]Synchronous development of a group of follicles greater than or equal to 3 mm in diameter, which includes a dominant follicle and several subordinate follicles.
[c]Different (P < .05) from saline.
[d]Different (P = .01) from saline.
[e]Different (P < .10) from corresponding four-wave cows.

Table 2. Concentrations and Number of Pulses of FSH in Serum on d 8 and 15 of the Estrous Cycle[a] in 13 Cows with either Three or Four Follicular Waves after Treatment with 100 µg of GnRH or Saline at Estrus (d 0)

	Treatment[a]		
Item	GnRH	Saline	Wave means
Concentrations of FSH, ng/ml			
Three follicular waves	.9 ± .1	.9 ± .1	.9[d] ± .1
Four follicular waves	1.2 ± .1	1.1 ± .1	1.1 ± .1
Treatment means	1.0 ± .1	1.0 ± .1	
No. of pulses of FSH			
Three follicular waves	2.1 ± .7	1.8 ± .8	2.0[c] ± .5
Four follicular waves	.5 ± .8	0 ± .8	.3 ± .6
Treatment means	1.3 ± .5	.9 ± .5	

[a]Means represent the average response across d 8 and 15 of the estrous cycle.
[b]Synchronous development of a group of follicles greater than or equal to 3 mm in diameter, which includes a dominant follicle and several subordinate follicles.
[c]Different (P < .01) from corresponding four-wave cows.
[d]Different (P = .07) from corresponding four-wave cows.
[e]Different (P < .001) from corresponding four-wave cows.
[f]Different (P = .05) from corresponding four-wave cows.

INDUCTION OF ESTRUS IN THYROIDECTOMIZED-OVARIECTOMIZED, NONLACTATING, HOLSTEIN COWS

R. E. Stewart, J. S. Stevenson, M. O. Mee, and I. Rettmer

Summary

Low thyroid activity (hypothyroidism) has been reported to decrease sexual behavior associated with reproduction in several species. Using estradiol benzoate (EB) and progesterone (P_4), we attempted to induce estrus in hypothyroid cows. Thyroid glands (thyroidectomy) and ovaries (ovariectomy) were removed surgically from nonlactating and nonpregnant Holstein cows that were culled from the Kansas State University dairy herd. Eight cows were thyroidectomized and ovariectomized (THYOVEX) and another four cows were ovariectomized only (OVEX). Starting 9 hr after injection of EB, cows were continuously observed for estrus for 36 hr. Frequencies of mounting activity and standing behavior were recorded for each cow. The percentage showing standing estrus was greater in cows that had no thyroid glands or ovaries than in cows without ovaries (78 vs 31%). Manifestation of estrus was identical in cows treated with EB or EB+P_4 (62%). Interval from EB injection to onset of standing estrus, frequency of mounting activity, and duration of standing estrus were similar among treatment groups and unaffected by the type of hormonal treatment. Thyroidectomized cows can exhibit estrous behavior, which is similar to that in ovariectomized cows treated with EB or P_4+EB.

(Key Words: Thyroidectomy, Ovariectomy, Estrous Behavior, Cattle.)

Introduction

Loss of thyroid gland activity (hypothyroidism) has been reported to affect behavior associated with reproductive function. Hypothyroidism caused decreased sexual drive in bulls without affecting sperm production and obliterated estrous behavior in cows without altering development of follicles and eggs. Orally administered thyroprotein restored sexual behavior in both sexes. During estrus, thyroid activity was increased and concentrations of thyrotropin (a hormone secreted by the pituitary gland that stimulates function of the thyroid gland) were decreased compared to cows in midcycle. In the same study, anestrous cows had low levels of thyroid activity and thyrotropin. Based on these observations, an optimal level of thyroidal hormones appears to be necessary for the manifestation of estrous behavior in cattle. Our objective in the present experiment was to determine if estrus could be induced in thyroidectomized-ovariectomized, nonlactating cows using estradiol benzoate and progesterone.

Procedures

Eight, nonlactating and nonpregnant, Holstein cows were thyroidectomized (leaving the parathyroid glands intact) and ovariectomized (THYOVEX), and a similar set of cows (n = 4) was ovariectomized only (OVEX) in March. Animals were housed in a drylot and fed a maintenance diet of hay and concentrate. During August, all cows were treated with estradiol benzoate (EB) or progesterone plus EB (P_4+EB) to induce estrus. A crossover design with two replicates was used to allow complete balancing of potential carryover effects from hormonal treatment. The study was conducted over 4 consecutive wk. The estrous induction scheme was initiated on a Monday (0800 hr), at which time a progesterone-releasing intravaginal device (PRID) containing 1.5 g crystalline progesterone was inserted into the vagina of half of the cows in each group for 72 hr. Twelve hr after PRID removal (or at a similar time in cows not receiving PRIDs), all cows received injections (i.m.) of EB (.5 mg/2 ml of safflower oil) to induce estrus. Continuous observations for estrous behavior began 9 hr after injection of EB and lasted for 36 hr. Individual estrous behavior was quantified by measuring the frequency of occurrence of mounting activity and whether or not the animal stood to be mounted by another cow.

Percentage of cows in heat was the number of cows demonstrating standing estrus divided by the total number of cows in the replicates of each treatment. Duration of estrus was the duration of time from the first to the last observed standing estrus. Estrous behavior was divided into four categories. An attempted mount (AMT) was recorded when one cow attempted to mount another, without the recipient standing immobile (attempted mount received; AMTR). A standing mount (SMT) was recorded when one cow mounted another, with the recipient standing immobile (standing mount received; SMTR).

Results and Discussion

The percentage of cows showing standing estrus, interval from injection of EB to onset of standing estrus, and duration of standing estrus are summarized in Table 1. The percentage of cows that exhibited standing estrus was higher ($P < .01$) in the THYOVEX group compared to the OVEX group. However, one cow in the latter group showed little estrous activity during the 4-wk period. Two other OVEX cows were very active in mounting behavior and other estrous activity during the experiment, even though they failed to stand to be mounted. The last OVEX cow exhibited high frequencies of all estrous activity recorded. One THYOVEX cow failed to show estrous behavior, other than several attempts at mounting other cows. Interval from injection of EB to onset of standing estrus, duration of standing estrus, and behavioral traits indicative of estrus (Table 2) were similar between the THYOVEX and OVEX groups and also between the EB and P_4+EB treated cows. There were no interaction effects between physiological status and hormonal treatment. Pretreatment with P_4 in EB-treated ovariectomized heifers did not affect the percentage in estrus, interval from EB to estrus, or behavioral signs of estrus.

Induction of estrous behavior in thyroidectomized cows demonstrates that low thyroid activity or hypothyroidism does not inhibit or diminish estrous behavior. Animals that are hypothyroid or in the low range of normal thyroid activity, such as early postpartum, lactating cows or heat-stressed cows, may not exhibit estrous behavior for other physiological reasons.

Table 1. Characteristics of Estrus in Thyroidectomized and Ovariectomized (THYOVEX) and Ovariectomized (OVEX) Cows Treated with Estradiol Benzoate (EB) or Progesterone and EB (P_4+EB)

Status or treatment	Percentage of cows exhibiting standing estrus[a]	Interval from EB to first stand, hr	Duration of standing estrus, hr
THYOVEX	78.1 (25/32)**	15.4 ± .8	7.2 ± .6
OVEX	31.1 (5/16)	12.7 ± 1.8	9.5 ± 1.5
EB	62.5 (15/24)	13.8 ± 1.3	7.4 ± 1.1
P_4+EB	62.5 (15/24)	14.4 ± 1.5	9.4 ± 1.2

[a]Numbers in parentheses are observations of standing estrus and total number of observations during the experiment.
**(P < .01)

Table 2. Characteristics of Estrous Activity during 36 hr after Treatment with Estradiol Benzoate (EB) or Progesterone and EB (P_4+EB)

Status or treatment	Frequency of estrous behavior[a]			
	AMT	AMTR	SMT	SMTR
THYOVEX	12.4 ± 2.7	8.9 ± 2.5	15.5 ± 3.6	21.2 ± 6.3
OVEX	12.9 ± 3.9	8.8 ± 3.5	20.1 ± 5.1	8.2 ± 8.9
EB	11.5 ± 3.3	7.8 ± 3.0	16.0 ± 4.4	12.2 ± 7.7
P_4+EB	13.7 ± 3.3	10.0 ± 3.0	19.7 ± 4.4	17.3 ± 7.7

[a]AMT = attempted mounts; AMTR = attempted mounts received; SMT = standing mounts; and SMTR = standing mounts received.

ADMINISTERING A GnRH AGONIST (RECEPTAL) AFTER INSEMINATION FAILS TO IMPROVE PREGNANCY RATES AT FIRST SERVICE

J. S. Stevenson, I. Rettmer, and R. E. Stewart

Summary

Two experiments were performed to determine the influence of administering a highly potent agonist of gonadotropin-releasing hormone (Receptal) on various reproductive characteristics in dairy cows. In Experiment 1, lactating Holstein cows were treated with either saline (n = 51) or 8 µg of receptal (n = 50) on d 11 to 14 after estrus (d 0) and first service. Peak concentrations of LH, FSH, and progesterone, but not estradiol-17β, in blood serum were increased during 6 to 12 h after injection of Receptal. Pregnancy rates were unaffected by treatment. Concentrations of progesterone in blood serum were increased in nonpregnant and pregnant cows after injection of Receptal. Return to estrus in Receptal-treated cows increased by 2.5 ± .8 days compared to controls. The number of follicles >10 mm in diameter, assessed by transrectal ultrasonography, were reduced and follicular development was altered after Receptal. In Experiment 2, various doses of Receptal were tested in eight dairy herds, including 1,013 inseminations at first service. Cows were given a single injection of either saline or 4, 8, or 12 µg of Receptal on days 11 to 14 after first service. Pregnancy rates were not improved consistently in all herds and failed to increase across all herds. We concluded that administering a potent GnRH agonist altered number and distribution of ovarian follicles, increased cycle length, and increased concentrations of progesterone, without a consistent increase in fertility.

(Key Words: GnRH Agonist, Pregnancy Rates, Hormones, Cattle.)

Procedures

In Experiment 1, lactating dairy cows (n = 101) were assigned to receive either a single injection of saline or 8 µg of Receptal (a GnRH agonist also known as buserelin acetate; Hoechst-Roussel Agri-Vet Company, Somerville, NJ) on days 11 to 14 after first service. Blood was collected daily from estrus and insemination until 10 days after treatment injection and during 12 hr after the injection of either saline or Receptal (10 to 16 cows/group). Hormones were measured by radioimmunoassay. Both ovaries were scanned by ultrasonography (10 cows/group) for 10 consecutive days beginning the day of injection. Number and diameter of follicles and luteal structures (corpus luteum) were measured and recorded.

In Experiment 2, a double-blinded, dose-pregnancy rate response procedure was used in eight dairy herds. Dairy cows were observed for estrus and inseminated at the first eligible heat after 50 days postpartum. Upon insemination, cows were assigned randomly to receive a single injection containing either saline or 4, 8, or 12 µg of Receptal. One herd was located in Chino, California, five herds in the upper San Joaquin valley of central California, one herd in northern California, and one herd in northeastern Kansas. Pregnancy status after first service and treatment injections was confirmed by return to estrus and/or by palpation of the uterus and its contents 40 or more days after insemination.

Results and Discussion

In Experiment 1, pregnancy rates at first service were unaffected by injections of Receptal (19/51 or 37%) or saline (17/50 or 34%). However, in cows not conceiving at first service, the duration of the estrous cycle was increased ($P < .05$) by 2.5 ± .8 d after treatment with Receptal. Peak concentrations of LH, FSH, and progesterone, but not estradiol-17β, in blood serum were increased during 6 to 12 hr after injection of Receptal (Table 1).

Concentrations of progesterone were increased for 3 days in nonpregnant cows and for 12 days in pregnant cows beginning 2 to 3 days after injection of Receptal compared to controls of similar pregnancy status (Figure 1).

Using daily transrectal ultrasonography, we determined that number of ovarian follicles during 10 days after Receptal was reduced, specifically those with antral diameters of greater than or equal to 10 mm. The dominant follicle in both groups began to decrease in diameter on the day following treatment, but the first new dominant follicle began to increase in diameter 2.3 ± .7 days later in Receptal-treated cows compared to controls, accounting for the increase in cycle duration (Table 2). Four of 10 cows given Receptal had induced corpora lutea compared to none of 10 controls.

In Experiment 2, pregnancy rates were improved in one herd (Herd A) at all doses of Receptal, but inconsistent responses were observed in the remaining herds at various doses (Table 3). A greater proportion of cows given Receptal returned to estrus after 24 days compared to controls. We concluded that administering a potent GnRH agonist altered number and distribution of ovarian follicles, increased cycle duration, and increased concentrations of progesterone, without a consistent increase in pregnancy rates.

Table 1. Peak Concentration and Interval to Peak for LH, FSH, Progesterone, and Estradiol-17β in Blood Serum during 12 h after a Single Injection of Saline or Receptal on Days 11 to 14 after Estrus (10 Cows/Treatment)

	Peak concentration[1]		Interval to peak	
Hormone	Saline	8 µg	Saline	8 µg
	----------------ng/mL----------------		---------------min----------------	
LH	.6 ± .9	12.6 ± .9[a]	355 ± 43	172 ± 45[a]
FSH	1.0 ± .2	1.7 ± .2[b]	161 ± 22	180 ± 23
P_4[2]	6.7 ± 1.1	12.1 ± 1.1[a]	8.8 ± .9	5.3 ± .9[b]
E_2[2,3]	7.0 ± 1.5	10.1 ± 1.5	2.6 ± .9	5.5 ± .9[c]

[a]Different ($P < .001$) from saline.
[b]Different ($P < .01$) from saline.
[c]Different ($P < .05$) from saline.
[1]Highest concentration during 12 h after treatment.
[2]Interval to peak in hours.
[3]Concentration in pg/mL.

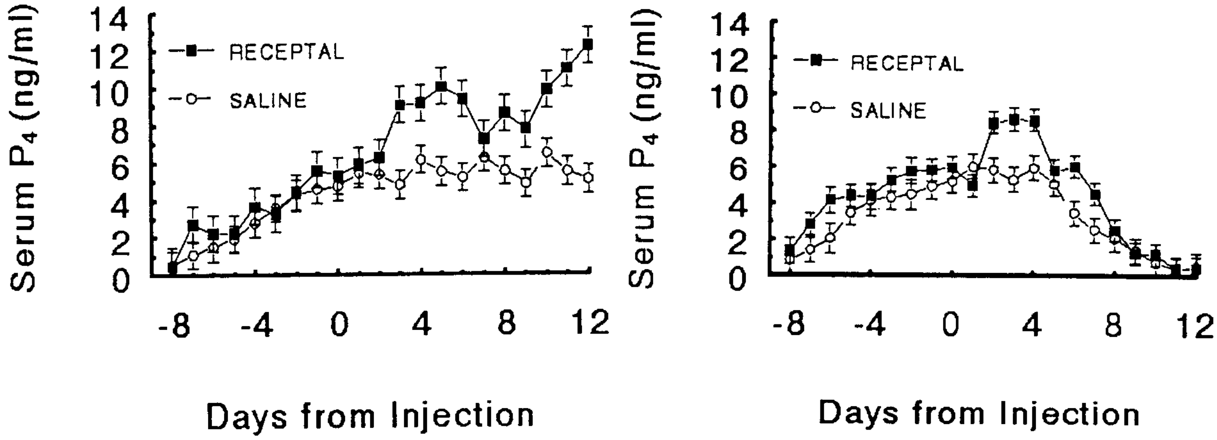

Figure 1. Concentrations of progesterone in serum of 11 pregnant (left; seven saline and four Receptal) and 20 nonpregnant (right; nine saline and 11 Receptal) cows after a 8-μg injection of Receptal (GnRH agonist) or saline.

Table 2. Number of Follicular Waves, and Diameter and Characteristics of Dominant Follicles during 10 d after an Injection of Saline or Receptal on Days 11 to 14 after Estrus[1]

Item	Saline	8 μg	P
No. of cows	10	10	
Antral diameter of dominant follicle[2], mm	10.9 ± 1.0	13.7 ± 1.2	.11
Regression of dominant follicle[3], d	13.2 ± .4	13.1 ± .4	.94
Appearance of first new dominant follicle[4], d	14.4 ± .7	16.7 ± .7	.04
Antral diameter of first new dominant follicles, mm	12.2 ± .8	11.4 ± .8	.48
Regression of first new dominant follicle[6], d	19.4 ± 1.1	21.7 ± 1.1	.17
No. of follicular waves[7]	1.6 ± .2	1.2 ± .2	.24

[1]Based on transrectal ultrasonography during 10 d after treatment on d 11 to 14 of the cycle (estrus = d O).

[2]Peak diameter of the largest follicle on either ovary on the day of treatment with saline or Receptal.

[3]Day of estrous cycle when the dominant follicle first identified on the day of treatment began to regress in size.

[4]Day of estrous cycle when the first new dominant follicle began to increase in diameter after treatment.

[5]Peak diameter of the first new dominant follicle after treatment.

[6]Day of estrous cycle when the first dominant follicle first identified after treatment began to regress in size.

[7]Number of follicular waves after treatment.

Table 3. First-Service Pregnancy Rates after a Single Injection of Saline or Receptal on Days 11 to 13 after Estrus and AI

			Dose of Receptal, µg			Dose χ^2
Herd	n	Saline	4	8	12	by herd
		----------	----------	%	----------	
A	192	48.0	70.2	69.2	60.5	.08
B	44	50.0	45.4	45.4	50.0	.99
C	101	37.2	–	30.3	41.2	.71
D	140	35.9	51.7	35.0	43.7	.48
E	179	54.3	54.6	60.0	50.0	.82
F	119	51.6	44.4	58.1	60.0	.64
G	188	57.1	50.0	52.2	35.6	.19
H	50	30.8	38.5	15.4	54.6	.23
	Mean[a]	46.7	53.9	50.2	49.1	
	n	291	219	271	232	

[a]Herd effect (χ^2 = 21.2; P = .001) and dose effect (χ^2 = 1.1; P = .775).

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BIOLOGICAL VARIABILITY AND CHANCES OF ERROR

Variability among individual animals in an experiment leads to problems in interpreting the results. Although the cattle on treatment X may have produced more milk than those on treatment Y, variability within treatments may indicate that the differences in production between X and Y were not the result of the treatment alone. Statistical analysis allows us to calculate the probability that such differences are from treatment rather than from chance.

In some of the articles herein, you will see the notation "P<.05". That means the probability of the differences resulting from chance is less than 5%. If two averages are said to be "significantly different", the probability is less than 5% that the difference is from chance or the probability exceeds 95% that the difference resulted from the treatment applied.

Some papers report correlations or measures of the relationship between traits. The relationship may be positive (both traits tend to get larger or smaller together) or negative (as one trait gets larger, the other gets smaller). A perfect correlation is one (+1 or -1). If there is no relationship, the correlation is zero.

In other papers, you may see an average given as 2.5 ± .1. The 2.5 is the average; .1 is the "standard error". The standard error is calculated to be 68% certain that the real average (with unlimited number of animals) would fall within one standard error from the average, in this case between 2.4 and 2.6.

Using many animals per treatment, replicating treatments several times, and using uniform animals increase the probability of finding real differences when they exist. Statistical analysis allows more valid interpretation of the results, regardless of the number of animals. In all the research reported herein, statistical analyses are included to increase the confidence you can place in the results.

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