A STUDY OF SOME FACTORS AFFECTING OPERATIONAL COSTS OF AN ARTIFICIAL BREEDING UNIT

by

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INTRODUCTION

Mass improvement of dairy cows through breeding is the primary objective of organized artificial breeding. It has provided a means of greatly extending the use of high quality dairy bulls. Although other advantages such as safety, reduced breeding costs, and control of bovine venereal diseases are important, dairy cattle improvement is the most fundamental justification for the program. The program became acceptable to dairymen of the United States when techniques and equipment were developed that made breeding efficiency comparable to that of natural mating.

The artificial insemination of dairy cattle has grown from an insignificant 7,359 cows inseminated in 1939, to 5,762,656 cows inseminated in 1956 (4). In 1956, the number of cows bred artificially represented approximately 25 per cent of the cows maintained for dairy purposes in the United States (3). In nine states, more than 40 per cent of the dairy cows were bred artificially (4). Artificial insemination associations were reported to be operating in every state in the Union (4). In 12 states, more than 100,000 cows were bred artificially during 1956 (2). These figures would indicate that the artificial breeding of dairy cattle has become widely accepted by dairymen.

In 1939, only seven studs were reported in operation (4). The number of studs increased steadily until 97 studs were in

operation in 1950. In more recent years, some studs have been discontinued, consolidated with others, or sold to larger organizations, thereby causing a decrease in the number of studs. On January 1, 1957, 75 studs were reported in operation (4). Even though 22 fewer studs were in operation in 1957 than in 1950, the number of cows inseminated more than doubled during the same period (4). The average number of first-services per artificial breeding stud in 1956 was more than 76,000 cows, ranging from 395 to 499,612 first-services (4). Grouping artificial studs operating in 1956 according to number of first-services showed that the number of first-services for 46 studs was less than 50,000 each, 50,000 to 99,000 for 13 studs, and 100,000 or more for 16 studs (4). These figures would indicate that studs with a volume of 50,000 cows or less represent an important segment of the artificial breeding in the United States. Many of the studs in which the number of first-services was 50,000 each or less, was from a sihgle unit in their respective states or areas. Also, the users of the service, in these areas, had representation in formulating stud policy. Thus, the importance of many artificial breeding studs cannot be measured in first-services alone. Consideration must be given to location of a stud and how well the service has been adapted to the particular needs of the area. The people in some areas have felt that the matter of representation in developing a service acceptable to them was important enough to justify financial support for their local stud in addition to

the usual first-service income. This financial assistance has been obtained by the organization of cooperatives, by assessing the members of the cooperative to obtain the funds required, and by legislative appropriations, and by soliciting supplementary funds from businesses and corporations.

Observations in the operation of the Kansas Artificial Breeding Service Unit indicated that the number of first-services, which are an indirect measurement of income, was the key to adequate financial support of a stud, and the insemination associations. In Table 1, it is shown that, within practical limits, increased first-service charges did not compensate for decreased volume of business either in technician income or association cash balance. Although these figures have reference to insemination associations, they have similar application to stud operations.

The average number of first-services for the Kansas Artificial Breeding Service Unit was 40,327 for the years 1950 to 1955 inclusive. Study of factors affecting operational costs of this stud would have application to 60 per cent of the studs operating in the United States in 1956. Also, this study may be useful in developing plans for future units that may be proposed in the 10 states that do not have studs (4).

COSTS AND MARGINS

It is generally known that the customary service fee, for

Table 1. Relation of volume of business to association fees, annual income and cash balance, and to technician fee and gross income. Survey of artificial insemination associations cooperating with the Kansas Artificial Breeding Service Unit, 1956.

Group No.	Av. First-services Jan. 1 to Dec. 31, 1956	Av. fee retained by association per first-service	Av. annual gross income per association	Av. cash balance Dec. 31, 1956	Av. first-service fee paid technician	Technician's av. annual gross income
I 15 Associations 1,000 ± first-services	1,392	$0.61	$849.00	$1,716.00	$4.36	$6,069.00
II 10 Associations 725-999 first-services	870	.66	574.00	985.00	4.71	4,098.00
III 10 Associations 500-72 4 first-services	628	.91	572.00	927.00	5.33	3,347.00
IV 18 Associations 250-499 first-services	376	.73	275.00	730.00	5.85	2,200.00
V 18 Associations Less than 250 first-services	176	1.19	209.00	500.00	6.77	1,192.00

the artificial breeding of dairy cattle, has been a fee for the first-service, with no additional fee to the stud needed after the first-service. A logical basis for establishing the first-service fee would be the summation of all costs of operation divided by the anticipated number of first-services, plus an allowance for unusual costs and some reserve fund.

During the planning stages of the artificial breeding program in Kansas, the problem of establishing an equitable service fee was a prime consideration. At that time, 1949, 90 studs were in operation (4). Most of those studs were contacted, by the planning committee, for information in regard to the cost of operation of their artificial breeding stud. However, no information was available. Therefore, it was necessary to establish the first-service fee in Kansas on an arbitrary basis, as apparently many other studs had done.

The net costs of operation for the Kansas Artificial Breeding Service Unit, using the number of first-services as the unit of evaluation are summarized in Table 2. The costs have been divided into 1) operational costs (which include all goods and services) and the depreciation of bulls, and 2) the use of capital. The use of capital has been sub-divided into depreciation of buildings and improvements, depreciation of equipment, and use of land. It should be noted that operational costs doubled in the first three years of operation from 1950 through 1952 (Table 2). After 1952 the cost of operation remained

Table 2. Summary of costs and margins in operating the Kansas Artificial Breeding Service Unit by years and average from March 1, 1950, through December 31, 1955.

Years and average	1950	1951	1952	1953	1954	1955	Average
Total and average[1] operational costs	$47,248	$76,815	$97,261	$100,091	$106,091	$97,432	$90,248
No. assns. receiving service	36	62	66	70	70	71	64
No. first-services	24,512	37,567	39,781	43,607	45,399	44,258	40,327
Operational cost per first-service	$ 1.93	$ 2.05	$ 2.44	$ 2.30	$ 2.34	$ 2.20	$ 2.23
Income per first-service	$ 3.00	$ 3.00	$ 3.00	$ 2.85	$ 2.75	$ 2.75	$ 2.87
Margin per first-service above operational costs	$ 1.07	$ 0.95	$ 0.56	$ 0.55	$ 0.41	$ 0.55	$ 0.64
Building and improvement depreciation @ 10% per year	$ 2,155	$ 4,502	$ 4,786	$ 4,842	6,619	$ 8,792	$ 5,437
Building and improvement depreciation cost per first-service	$ 0.09	$ 0.12	$ 0.12	$ 0.11	$ 0.15	$ 0.20	$ 0.14

Table 2 (concl.)

Years and average	1950	1951	1952	1953	1954	1955	Average [2]
Operational, and building and improvement cost per first-service	$ 2.02	$ 2.17	$ 2.56	$ 2.41	$ 2.49	$ 2.40	$ 2.37
Margin per first-service above operational, and building and improvement cost	$ 0.98	$ 0.83	$ 0.44	$ 0.44	$ 0.26	$ 0.35	$ 0.50
Depreciation: land $10,000 @ 4%, equipment @ 20% per year	$ 446	$ 2,981	$ 3,717	$ 4,412	$ 4,446	$ 3,669	$ 3,328
Land and equipment depreciation cost per first-service	$ 0.02	$ 0.08	$ 0.08	$ 0.10	$ 0.10	$ 0.08	$ 0.08
Net cost per first-service	$ 2.04	$ 2.25	$ 2.25	$ 2.51	$ 2.59	$ 2.48	$ 2.45
Net margin per first-service	$ 0.96	$ 0.75	$ 0.75	$ 0.34	$ 0.16	$ 0.27	$ 0.42
Total margin	$ 23,532	$28,175	$ 13,923	$ 14,826	$ 7,264	$11,950	$17,096

[1] All costs of operation exclusive of building, land and equipment depreciation.

[2] Average is for 5.83 years of operation.

reasonably constant. The rapidly rising cost of operations, during the first three years, can be explained best by the rapid growth in numbers of insemination associations receiving semen service. The number of insemination associations increased from 36 to 66, an increase of 83 per cent, from 1950 through 1952. Additional bulls were required to serve these added associations which meant additional feed and bedding, additional labor, and increased semen processing and shipping costs. The field staff also had to be increased to provide adequate supervision. The peak cost of operations, 106,091 dollars, was in 1954. In that year, 1954, five bulls were added to the battery, and expenditures for promotion were increased. These two factors accounted for the sharp increase in cost of operations despite the fact that the number of insemination associations remained the same.

Operational cost per first-service increased from 1.93 dollars in 1950 to a maximum of 2.44 dollars in 1952 (Table 2). This 27 per cent increase in cost per first-service can be compared to the more than 100 per cent increase in operational cost and quite obviously the increased number of first-services more than compensated for the increased cost.

Building and improvement depreciation in 1950 represents five months of depreciation of a newly constructed barn, office, and laboratory. From 1951 through 1953, building and improvement depreciation remained relatively constant (Table 2). The construction of badly needed bull stabling was initiated

in 1954 and completed in February 1955. The investment for additional stabling, explains the sharp increase in building and improvement depreciation reserve for 1954 and 1955.

Reserves for equipment depreciation increased steadily from 1950 to 1954. During this period, increased business required conversion from hand operated to machine operated equipment, additional vehicles for field supervision, additional freezing and refrigeration equipment, and other small items. As investment in more efficient machinery and additional equipment increased, the reserves for depreciation increased. The first decrease in depreciation was experienced in 1955. During this year some of the original equipment purchased was fully depreciated, yet usuable, accounting for the decrease. The 20 per cent per year depreciation schedule has been found to be generally adequate axcept for passenger vehicles. Passenger cars had been used two years then replaced and the trade in value did not equal the undepreciated value when the vehicle had been depreciated at the rate of 20 per cent per year.

The net margin per first-service declined steadily from 1950 to 1954. Several factors contributed to this decrease. Increasing operational costs and increasing depreciation reserves were the factors responsible for the decreasing net margin from 1950 through 1952. In 1953, adequate reserves allowed a reduction in service fee, but this was offset by an increase in first-services resulting in only a minor decrease

in net margin per first-service. A sharp increase in operational costs and depreciation costs in 1954 was not offset by an increase in first-services and the net margin decreased from 34 cents to 16 cents. Increased costs accounted for eight cents of the 18 cent decrease in net margin in 1954. The remaining 10 cent decrease in net margin was due to the 10 cent difference in income per first-service.

The average net margin per first-service was 42 cents or 15 per cent of the service fee dollar. Such a margin might seem excessive for a service program, but it was deemed necessary for the Kansas Artificial Breeding Service Unit in order to establish and maintain a reserve adequate to meet any emergency, and or, provide for needed expansion, because no funds other than service fees were available. Most businesses can either borrow money or, if organized as a cooperative, assess the membership to meet emergencies or provide for expansion.

In summary, it may be concluded that an average first-service fee of 2.45 dollars per first-service was adequate to maintain the Kansas Artificial Breeding Service Unit for the period studied (Table 2). A service fee of 2.87 dollars was adequate to maintain the stud and establish a reserve fund needed to meet emergencies and provide for expansion. Many factors influence the cost of operations, and the requirements for acceptable service in a particular area will either increase or decrease

the service fee necessary. Also, the years of service, cumulated reserves, and ease with which additional funds might be obtained would have a bearing on the safety factor of the service fee.

ANALYSIS OF COSTS OF OPERATION

In the analysis of costs of operation in Table 3, the costs of operation are segregated into 10 major segments. Some segments pertain to a single commodity or service, others include various goods and services. Decision, as to segregation, was concerned with application to an analysis of an artificial breeding business. Regardless of segregation, operational costs include:

1. All goods and services required to produce semen.
2. Cost of transporting semen to insemination associations.
3. Provide technical supervision in the field.
4. Cost involved in complying with the requirements of the Purebred Dairy Cattle Association (4) governing artificial breeding.

Further examination of Table 3, indicates that the difference in percentage points from year to year for some segments was quite small, for others the difference was considerable. The objective of this study was to determine the factors that contributed to the total cost of any segment and why these factors remained constant or varied.

Table 3. Analysis of costs of operating the Kansas Artificial Breeding Service Unit by years and segments, from March 1, 1950, through December 31, 1955.

	1950		1951		1952		1953		1954		1955		Average [1]	
	Total:	Per-cent:	Total:	Per-cent:	Total:	Per-cent:	Total:	Per-cent:	Total:	Per-cent:	Total:	Per-cent:	Total:	Per-cent:
	$		$		$		$		$		$		$	
Depreciation of bulls	4,363	9.2	8,759	11.4	13,412	13.8	16,363	16.3	17,157	16.2	12,345	12.7	12,418	13.8
Feed	4,394	9.3	7,138	9.3	9,107	9.4	8,989	8.9	10,610	10.2	9,625	9.9	8,553	9.5
Bedding	1,818	3.9	2,494	3.2	2,078	2.1	3,044	3.0	2,720	2.6	2,962	3.0	2,592	2.9
Utilities	682	1.4	1,697	2.2	1,760	1.8	2,003	2.0	1,768	1.7	1,610	1.7	1,786 [2]	2.0 [2]
Labor	13,435	28.4	15,802	20.6	16,773	17.3	18,620	18.5	18,122	17.1	18,589	18.5	17,383	19.3
Super-vision	9,310	19.7	17,340	22.6	18,544	19.1	19,370	19.3	19,940	18.8	22,400	22.9	18,337	20.3
Operating supplies and service	6,590	13.9	10,558	13.7	13,745	14.1	14,750	14.7	15,403	14.5	11,207	11.5	12,393	13.7
Semen shipping	3,833	8.1	7,969	10.4	9,867	10.1	9,306	9.3	9,716	9.1	11,718	12.0	8,990	9.9

Table 3 (concl.)

	1950		1951		1952		1953		1954		1955		Average [1]	
	Total	Percent	Total	Percent	Total	Percent	Total	Percent	Total	Percent	Total	Percent	Total	Percent
	$		$		$		$		$		$		$	
Advertising and promotion	2,391	5.1	3,821	5.0	8,464	8.7	5,778	5.8	5,370	5.1	5,346	5.5	5,346	5.9
Maintenance and repair	432	1.0	1,237	1.6	3,511	3.6	2,185	2.2	5,285	4.9	1,630	1.7	2,449	2.7
Grand total	47,248	100.0	76,815	100.0	97,261	100.0	100,408	100.0	106,091	100.0	97,432	100.0	90,248	100.0

[1] Average for 5.83 years of operation except as noted

[2] Average for 5.33 years of utility payments

Discussion of Factors Affecting Different Segments of Cost

Every factor affecting the cost of operations was determined by the number or amount required and the price per unit. It is generally recognized that consumers have only limited control of prices paid for goods and services, however, number or amount of goods and services purchased is within the realm of control by the consumer.

In the operation of an artificial breeding unit, control of some items of cost can be exercised, whereas, others are more or less fixed. For example, management can determine the number of bulls required for service but once the bulls are purchased, so much feed and bedding will be required to maintain them. This example also demonstrates that some factors affecting cost, influence not only one segment but several other segments. More bulls usually resulted in higher cost of bull depreciation, increased feed and bedding cost and possibly increased labor costs.

Some factors affecting cost of operation remain fairly constant in both number and price per unit and are not greatly influenced by or influence other factors. This was found to be true of utilities (Table 3). Expenditures for advertising and promotion were entirely within the control of management. The number of bulls, or associations, or any other factor, had no bearing on this expenditure.

Analysis of the variables affecting the cost of operations

can provide opportunities to reduce costs yet maintain equal standards. Each segment outlined in Table 3, and the factors affecting the cost involved will be considered separately.

Depreciation of Bulls

Operational costs of the Kansas Artificial Breeding Service Unit included current operating expenses, and investments for equipment, improvements, and bulls. To consider investments in their proper perspective, some system of allocating these costs proportionately for any given period must be provided. Otherwise, large investments in any one year could distort the financial picture for that year. Conversely, postponement of investments, or temporary lack of need for investment, could imply a false impression of financial progress. Therefore, some method of equating investment costs, at least for major items, was deemed advisable.

Expenditures for replacement of bulls, for the Kansas Artificial Breeding Service Unit, resulted in a large cash outlay and was a major investment item. The average cost for bulls on a systematic depreciation schedule averaged 13.8 per cent of the total operational costs. Thus, the rate of depreciation becomes an important factor. Initially, the rate of depreciation for bulls was set arbitrarily because of unavailable facts. It is self-evident that the funds necessary for depreciation of bulls would be affected by

1) the number of bulls required for service, 2) prices paid, and 3) the service time of the bulls in the stud.

Analysis of some of these factors, based on experience in operating the Kansas Artificial Breeding Service Unit, should provide facts upon which to appraise the validity of the depreciation schedule. The variability in numbers of bulls purchased by years, cost by years and average, and percentage of total operational costs, when a definite depreciation schedule was used, is shown in Table 4.

Table 4. Number of bulls purchased by years and average compared with depreciation costs and percentage of operational costs for bull depreciation at the Kansas Artificial Breeding Service Unit.

	1950	1951	1952	1953	1954	1955	Av.
No. of bulls purchased	24	11	14	19	13	4	15
Total investment	$14,073	$9,601	$14,477	$22,998	$13,204	$4,000	$13,417
Cost of bull depreciation	$ 4,363	$8,759	$13,412	$16,363	$17,157	$12,345	$12,418
Percentage of operational cost for bull depreciation	9.2	11.4	13.8	16.3	16.2	12.7	13.8

The data shown emphasizes the need for equating the large investment for bulls. The cost of depreciation, when a depreciation schedule is used, was not only affected by the number

and cost of bulls purchased within a given year but also by the number and cost of bulls purchased during the previous year. For example, the cost of depreciation in 1950 was only half the cost of depreciation for 1951, even though less than half the number of bulls were purchased in 1951 that were purchased in 1950 (Table 4).

The affect of the factors that influenced the cost of depreciation of bulls at the Kansas Artificial Breeding Service Unit will be considered in the following discussion.

Factors Affecting Time of Service of Bulls in Artificial Breeding. Service time of bulls at the Kansas Artificial Breeding Service Unit was influenced by the length of time each bull remained fertile and in good health, and by the relative production and type of his daughters. Some bulls were removed from service because of lack of production information on their daughters, or because of low production by their daughters even though the bull was healthy and fertile, whereas, other bulls were removed because of death, poor health, or low fertility in spite of the fact that the daughters were acceptable in type and production. The reasons for disposal of bulls at the Kansas Artificial Breeding Service Unit, and the number and percentage removed for each reason, are shown in Table 5.

Table 5. Summary of all bulls placed in service after March 1, 1950 and died or were removed before December 31, 1955 at the Kansas Artificial Breeding Service Unit.

Reason for disposal	Number of bulls	Per cent
Low fertility	18	28
Death from various incurable diseases	10	15
No production information	8	12
Back or leg problem	7	11
Leased - returned to owner	7	11
Replaced by bull having daughters more desirable type and production	5	8
Low production of daughters	4	6
Infectious disease	3	5
Refused to mount or serve an artificial vagina	2	3
Injury	1	1
Total	65	100

More than one-fourth, 26.2 per cent, of the bulls placed in service were removed because of either there was no production information of the daughters, or the production of the daughters was too low, or replaced by bulls having daughters with more desirable type and production (Table 5). In the

survey made by Becker and Arnold (1) it was shown that of 2,859 bulls placed in artificial service, 1,073, or 37.5 per cent, were removed because of low production, undesirable type, or lack of production summaries of the daughters. Thus, study of time in service of bulls in artificial breeding should include all bulls used even though some were fertile and active breeders when discarded. The major single reason for disposal of bulls at the Kansas Artificial Breeding Service Unit was low fertility, representing 27.2 per cent of all bulls removed (Table 5). Unavoidable losses due to death, injury, disease, and back or leg problems accounted for 32.2 per cent of the bulls removed from service. Bulls that were leased and returned to their owners represented 10.8 per cent of the bulls removed (Table 5). This was planned turn-over rather than loss.

Although this study involves the period from March 1, 1950, through December 31, 1955, service time of bulls used at the Kansas Artificial Breeding Service Unit was reviewed for all bulls placed in service from March 1, 1950 through December 31, 1956, and had completed their time in service by December 31, 1956. The additional year provided complete data on more bulls and included data on some bulls that had remained in service for six years and would have otherwise been excluded.

Service time for all bulls brought into the stud for service after March 1, 1950 through December 31, 1956 and removed by December 31, 1956, at the Kansas Artificial Breeding

Service Unit is tabulated by six month intervals in Table 6.

Table 6. Range in service time for all bulls placed in service after March 1, 1950, and removed by December 31, 1956 at the Kansas Artificial Breeding Service Unit.

Time in service years	Number sires	Percent	Cumulative percent
0.5 or less	5	6	6
0.6 - 1	15	18	24
1.1 - 1.5	4	5	29
1.6 - 2.0	9	11	40
2.1 - 2.5	15	18	58
2.6 - 3.0	14	17	75
3.1 - 3.5	6	7	82
3.6 - 4.0	3	4	86
4.1 - 4.5	7	8	94
4.6 - 5.0	2	2	96
5.1 - 5.5	1	1	97
5.6 - 6.0	1	1	98
6.1 - 6.5	1	1	99
6.6 - 6.8	1	1	100
Total	84	100	100

More than half the bulls, 58 per cent, were removed by the time they had been in service at the bull stud 30 months or less. Only 25 per cent of the bulls remained in service longer than three years, and four per cent remained in service more than five .

Time in service may be affected by breed differences and by ages when bulls are placed in service. These factors are considered as separate items.

Influence of Breed Differences on Service Tenure. Selection standards for bulls used at the Kansas Artificial Breeding Service Unit in general were the same among all six breeds with the exception of production levels. The minimum acceptable production level for each breed was within the top 25 per cent of all bulls proved within the breed, thus, equalizing selection among breeds. All bulls were subjected to the same general health and fertility tests before being placed in service. Feeding and mangement while in service was the same for all bulls except feed allowance for size. No prejudice prevailed among breeds with respect to removal from service. Differences by breeds in ages when bought, and inherent breed differences are the only two remaining factors that might affect service time.

The average ages by breeds when bulls were placed in service, and the average service time are shown in Table 7. Considerable variation existed in average service time, but it is difficult to determine by inspection whether differences in average ages and in average service time were statistically significant among breeds.

Analysis of variance was used to test for significant differences in mean age of the breed groups. The differences were found to be non-significant ($F = 0.41$ with 5 and 78 degrees

of freedom), and any differences were probably due to chance. Therefore, it was assumed that the breed groups were placed in service at essentially the same age.

Table 7. Summary of average age and service time for bulls, by breeds, placed in service after March 1, 1950 and removed by December 31, 1956 at the Kansas Artificial Breeding Service Unit.

Breed	No. of bulls	Av. age (years) when placed in service	Av. time in service in months
Ayrshire	12	6.1	26
Brown Swiss	14	5.9	32
Guernsey	17	6.4	28
Holstein	17	6.5	35
Jersey	11	7.0	34
Milking Shorthorn	13	5.8	41
Total or average	84	6.3	32

Having established that all bulls received the same treatment, analysis of breed differences in regard to service time seemed justified. Analysis of variance by breeds indicated that no significant differences among breeds in service time existed ($F = 1.53$ with 5 and 78 degrees of freedom).

Breed differences, based on the results of these analyses, are not a factor affecting service time under the selection, feeding and management, and culling practices that prevailed at the Kansas Artificial Breeding Service Unit.

Relationship of Age when Placed in Service to Service Time. There is a general belief that younger bulls have a greater service time expectancy than older bulls. If such a relationship does exist then depreciation of bulls would be most effective if adjusted for the age of bulls when placed in service. Becker and Arnold (1) summarized the service time of 691 bulls that completed their remaining useful life in artificial service, and a declining trend in service time was observed with increasing age. These 691 bulls were from a total of 2,859 bulls for which a complete service history was available. Their study of these 691 bulls indicates how long bulls remained in service if not removed for reasons related to errors in selection, such as low production or poor type of daughters. Of the 2,859 bulls, 1,073 or 37.5 per cent, were removed while still fertile, and because of undesirable type, pedigree, or low production of their daughters (1). The experience of the Kansas Artificial Breeding Service Unit, and the data reported by Becker and Arnold (1), would seem to justify including all bulls for which data is available, regardless of reason for removal, in estimating average service time of bulls in artificial breeding.

The service time of 84 bulls removed from service at the Kansas Artificial Breeding Service Unit was summarized by age when placed in service (Table 8). There was little difference in service time of bulls from four to nine years of age, and a deviation upward for bulls 12 years of age and older

from the slight downward trend for bulls nine to 11 years of age (Table 8). Differences were tested for significance and although, the results of analysis of variance approached significance, ($F = 1.88$ with 5 and 78 degrees of freedom) the difference was not significant at the 5 per cent level.

Table 8. Service time by age groups of all bulls placed in service after March 1, 1950 and removed before December 31, 1956 at the Kansas Artificial Breeding Service Unit.

Age group in years	Number of bulls	Average service time in months
3 or less	9	41
4 - 5	29	32
6 - 7	26	31
8 - 9	9	29
10 -11	7	16
12 and over	4	19
Total or average	84	32

This group of dairy bulls did not represent a random sample of dairy bulls, but were rigidly selected for special service. All bulls were subjected to the same tests for health and fertility before being placed in service, which would tend to minimize differences among ages. Bulls five years of age or younger would not have any daughters, or at least would have fewer daughters in production, therefore, a greater percentage in this age group would be subject to removal because of un-

desirable daughters than bulls in older age groups. This factor would also tend to minimize differences in service time among age groups.

Since none of the variables analyzed had a significant influence on service time, a depreciation based on average service time seemed to be most logical. The mean service time was 32 months for the bulls placed in service after March 1, 1950 and removed from service before December 31, 1956 at the Kansas Artificial Breeding Service Unit. Basing a depreciation schedule on 30 months service would have the advantage of cumulating depreciation reserves at a slightly greater rate than a schedule based on 32 months. Cost of depreciation for bulls is, therefore, based on 30 months service in the analysis of costs shown in Table 3.

The effect of varying numbers of first-services per year, when varying purchase prices for bulls are paid, on the cost of depreciation of individual bulls is shown in Table 9. The depreciation schedule used was 40 per cent of the purchase price per year. This rate of depreciation for bulls was based on the fact that 12 months was 40 per cent of the 30 month time in service. The effect of the integration of purchase price and average number of first-services on depreciation cost per first service can be demonstrated in the following example: An investment of 500 dollars per bull and an annual average of 1000 first-services per bull would result in a depreciation cost of 20 cents per first-service (Table 9). Increasing the

purchase price per bull by 250 dollars to a total of 750 dollars would require an annual average of 1500 first-services per bull to prevent an increase in the cost of depreciation per first-service. A 1000 dollar investment per bull would require 2000 first-services, and a 2000 dollar investment per bull would require 4000 first-services per year to prevent the cost of depreciation from increasing to more than 20 cents per first-service (Table 9). Similar comparisons could be made for any other cost per first-service with an integration of purchase price and varying number of first-services per year. The number of first-services increase at a standard rate as the purchase price increases. For example, at 40 per cent depreciation per year, each 250 dollar increase in purchase price will require an additional 500 first-services per year to maintain the cost of bull depreciation per first service at a given level.

The average cost of bull depreciation per bull per year and per first-service by breeds is shown in Table 10. The most impressive fact shown in Table 10, is the effect of number of first-services on the cost of depreciation per first service. The cost per first-service for depreciation of bulls averaged 28 cents, and ranged from 13 cents for Holsteins to 79 cents for the Ayrshires (Table 10). Although differences existed in the average price, the numbers of first-services outweighed the differences in average purchase prices. The highest average purchase price was for Holsteins, but the

Table 9. A projection of cost per first-service for bull depreciation at varying numbers of first services per year and varying purchase prices when depreciation is calculated at 40 per cent of the purchase price per year.

Average number of first-services per bull per year	Purchase price of a bull: $250	$500	$750	$1000	$1500	$2000	$2500	$3000	$3500	$4000
	Depreciation cost per first service @ 40 % per annum									
300	0.33	0.67	1.00	1.33	2.00	2.67	3.33	4.00	4.67	5.33
350	0.29	0.57	0.86	1.14	1.71	2.29	2.86	3.43	4.00	4.57
400	0.25	0.50	0.75	1.00	1.50	2.00	2.50	3.00	3.50	4.00
450	0.22	0.44	0.67	0.89	1.33	1.89	2.22	2.67	3.11	3.55
500	0.20	0.40	0.60	0.80	1.20	1.60	2.00	2.40	2.80	3.20
600	0.17	0.33	0.50	0.67	1.00	1.33	1.67	2.00	2.33	2.67
700	0.14	0.29	0.43	0.57	0.86	1.14	1.43	1.71	2.00	2.29
800	0.13	0.25	0.38	0.50	0.75	1.00	1.25	1.50	1.75	2.00
900	0.11	0.22	0.33	0.44	0.67	0.89	1.11	1.33	1.56	1.78
1000	0.10	0.20	0.30	0.40	0.60	0.80	1.00	1.20	1.40	1.60
1250	0.08	0.16	0.24	0.32	0.48	0.64	0.80	0.96	1.12	1.28
1500	0.07	0.13	0.20	0.27	0.40	0.53	0.67	0.80	0.93	1.07
1750	0.06	0.11	0.17	0.23	0.34	0.46	0.57	0.69	0.80	0.91
2000	0.05	0.10	0.15	0.20	0.30	0.40	0.50	0.60	0.70	0.80
2250	0.04	0.09	0.13	0.18	0.27	0.36	0.44	0.53	0.62	0.71
2500	0.04	0.08	0.12	0.16	0.24	0.27	0.40	0.48	0.56	0.64
3000	0.03	0.07	0.10	0.13	0.20	0.27	0.33	0.40	0.47	0.53
3500	0.03	0.06	0.09	0.11	0.17	0.23	0.29	0.35	0.40	0.46
4000	0.03	0.05	0.08	0.10	0.15	0.20	0.25	0.30	0.35	0.40

lowest cost per first-service was for that breed because of the highest number of first-services.

Factors Affecting the Number of Bulls Required. Several factors influence the number of bulls required to provide adequate semen service. These factors and their relative importance are considered as they affected requirements of the Kansas Artificial Breeding Service Unit.

Number of Breeds. Each breed, for which semen service was provided, required a minimum battery of three or four bulls. Semen collected, processed and stored at 35-40° F. was usually used by the insemination associations for two days after collection. Thus, to maintain a satisfactory supply of semen in the field, it was necessary to ship fresh semen to the associations three or four times each week. Each bull normally was collected (two ejaculates) once each week. This system of operation established the minimum basic requirement of one bull per breed for each shipment within a seven day period. Discounting other factors, to be discussed later, the total number of bulls required for service varied directly with the number of breeds for which service was provided. Thus, a minimum battery of bulls for six breeds would be 18 to 24 bulls.

Frequency of Semen Shipments. In the Kansas Artificial Breeding Service Unit, the 60-90 non-returns to first-services averaged 62 per cent from March 1, 1950, through December 31, 1955. This level was considered acceptable and was maintained

Table 10. Average annual depreciation cost per bull per year and effect of number of first-services on depreciation cost per first-service by breeds. Kansas Artificial Breeding Service Unit March 1, 1950, through December 31, 1955.

Breed	Av. 1st. serv. per bull per year	Av. purch. price per bull	Av. depr. per yr. (@ 32 mo. av. service time)	Av. total 1st servs. per bull	Av. depr. cost per 1st serv.
		$	$		$
Ayrshire	382	814	301	1,031	0.79
Brown Swiss	479	739	274	1,293	0.57
Guernsey	988	1,047	388	2,668	0.39
Holstein	3,107	1,080	400	8,389	0.13
Jersey	568	789	292	1,534	0.51
Milking Shorthorn	999	910	337	2,697	0.34
Average	1,218	919	340	3,289	0.28

by shipping fresh semen either every other day or on a fixed shipping schedule of four times per week. Under certain circumstances an artificial breeding unit may find it expedient to ship fresh semen more frequently. Increasing the frequency of shipments caused an increase in the number of bulls needed. For example, in 1953, semen shipments were made every other day and 35.2 bull-year equivalents were required to meet this schedule. In 1954, when semen shipments were made on a fixed four-day per week schedule, 40.8 bull-year equivalents were required. The increased frequency of semen shipments in 1954, would have required a theoretical 15 per cent increase in bull year equivalents (Table 11). The actual increase was 5.6 bull year equivalents and an actual 15 per cent increase in comparison with 1953. Although the increase in frequency of shipment may not have been the entire reason for increased bull requirement, it was the major contributing factor.

Number of Insemination Associations Receiving Semen Service. In Table 11, the number of insemination associations receiving service is compared with the number of bulls required for service, when semen from six breeds was provided. Frequency of semen shipments was maintained on an every other day basis from 1950 through 1953, and the ratio of bull-year equivalents to number of associations remained about the same (Table 11). As previously mentioned, the frequency of shipment was increased in 1954 from every other day to a fixed

four shipments per week, which accounted for the increased number of bulls required when there was no increase in the number of associations being served, and the ratio of bull-year equivalents to associations decreased (Table 11). The basic reason for the need of additional bulls as the number of associations increased was the physiological limitations of bulls. As previously stated, the usual practice was to collect each bull once each week. Of 820 ejaculates from 18 bulls the average volume was 4.6 cc. with 57 per cent of the spermatozoa motile and an average gross concentration of 1.4 billion spermatozoa. Extension of this semen at the rate of 12 million motile spermatozoa per cc. of extended semen would result in an average volume of 309 cc. of extended semen. The most practical minimum quantity of extended semen shipped to insemination associations was 5 cc. Thus, from the average ejaculate the requirements for 60 insemination associations should be provided if each received one 5 cc. vial from each breed. This quantity of semen was usually found adequate, for most associations, in three of six breeds. A higher demand for service in three breeds required that more than the minimum quantity of semen be shipped to some insemination associations.

Demand for Service. More than 5 cc. of extended semen were needed by most of the insemination associations for three

of the six breeds. The interrelationship of other factors influencing the number of sires required for service, made the effect of demand for semen required difficult to demonstrate.

Table 11. Comparison of number bulls required with the number of associations receiving service and the resulting ratio when six breeds were involved at the Kansas Artificial Breeding Service Unit.

	1950	1951	1952	1953	1954	1955
No. assns. being services	36	62	66	70	70	71
No. of bull-year equivalents required	18.7	28	31.3	35.2	40.8	40.1
Ratio of bull-year requirements to no. of assns.	1.9	2.2	2.2	2.0	1.7	1.8

However, the demand for semen in the Holstein breed exceeded other factors influencing the number of bulls required, and additional bulls were necessary to meet the demand for semen (Table 12). Holstein was the only breed in which demand for semen within a breed was noticeable.

Increased demand within associations required additional semen, and had a greater influence on increased bull requirement than demand within breeds. In 1955, 23 of the 71 insemination associations, 32 per cent of the associations, inseminated more than 725 cows, or 61 per cent of the total first-service cows. These 23 associations required more semen per association but less semen per first-service to maintain

dependable service than the 48 associations which bred fewer than 725 first-service cows, and 39 per cent of the total first-services. The 48 associations breeding operated satisfactorily with minimum shipments of all breeds except Holstein.

Table 12. Comparison and ratio of number of first-services to bull-year equivalents for six breeds in service at the Kansas Artificial Breeding Service Unit from March 1, 1950 through December 31, 1955.

	Ayrshire	Brown Swiss	Jersey	Guernsey	Milking Shorthorn	Holstein
Av. no. first-services per year	1,759	2,492	2,784	5,333	5,896	22,063
Av. no. bull-year equivalents per year	4.6	5.2	4.9	5.4	5.9	7.1
Ratio of bull-year equivalents per year to no. first-services per year	1:382	1:479	1:568	1:988	1:999	1:3,107

Differences in demand for semen was noticeable both between breeds and between associations. These factors both tended to have a direct effect on the number of bulls required for service.

Seasonal Variation. Differences in seasonal demand for service as shown in Fig. 1. The peak seasonal demand was

caused by the desire of dairymen to have their herds in high production during the winter months.

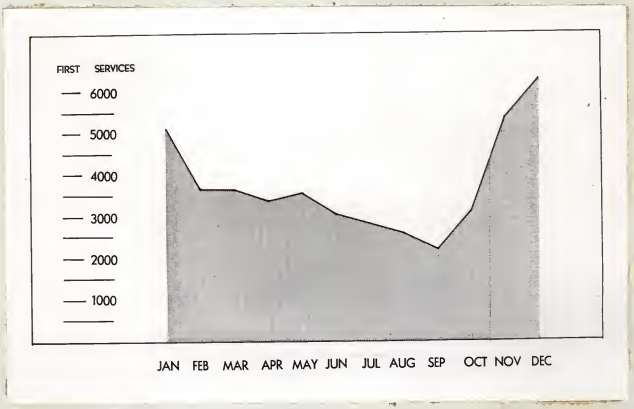

Fig. 1. Seasonal variation by months in first-services.

The average number of first-services per year from 1950 through 1955 was 40,327. An arithmetic average of first-services per month would be 3,360 first-services. Most associations could probably be supplied sufficient semen to meet such a monthly average from a minimum battery of bulls in all breeds except Holstein. However, enough bulls must be maintained to meet peak demands, and not just an average demand.

Monthly demand for semen varied from a little more than enough for 2,000 cows in September to more than 6,000 cows in December. The effect of such seasonal variation can be emphasized further by the fact that in 1956, 650 cc. of extended Holstein semen per shipment was required in July, August, and September, whereas in the following November, December, and January, 1,450 cc. per shipment was needed. Due to the fact that it is not practical to move bulls in and out of service as demand changes, battery strength must be maintained to meet peak requirements. In areas where seasonal variation is less pronounced, fewer bulls would be required to breed the same number of cows.

Miscellaneous Factors. Sire selection committees and management can affect the number of sires maintained for service. Efforts to offer a greater selection of bulls to patrons, continuing in service bulls of substandard fertility, and continuing in service bulls that have daughters of breeding age in herds of patrons could each affect the number of bulls maintained.

Sire selection committees may find it desirable to exceed required bull battery strength for any or all of the following reasons:

1. Purchase of an outstanding bull that happens to be offered for sale at a time when the number of bulls on hand are adequate for requirements.

2. Sample one or more young bulls that are to be returned to natural service for possible future heavy service in the bull stud.
3. Over stock as a promotional project.

On occasion it may be desirable to maintain bulls of substandard fertility because of the outstanding production and type of their daughters. Although this may be a valid reason for maintaining such bulls, semen should be shipped from another bull of the same breed as a fertility safety factor. Obviously, such a practice would increase the number of bulls maintained, particularly in the breeds with lowest numbers of first services.

Bulls for which an inbreeding problem exists present much the same problem as bulls of substandard fertility. If a bull, for which an inbreeding problem exists, is maintained in service semen from an additional bull must be shipped with the semen from the bull for which inbreeding may prevail. In breeds of low demand the bull requirements are increased beyond semen quantity requirements if any of the bulls involve an inbreeding problem.

Decisions of sire selection committees and management had a very real effect on the bull requirements for satisfactory semen service. Although these factors are difficult to measure, they could have more influence on numbers of bulls maintained than such tangible factors as number of associations, or

seasonal variation in demand.

Physiological limitations of bulls modified very factor, and is the primary reason for increased bull needs as the number of insemination associations increase. Also, it may be the reason for an increase in bull needs when the demand for service is increased. Only after all factors are considered can bull requirements be established. The desires of selection committees and management, however, must be tempered to keep bull numbers within practical limitations. The experience of the Kansas Artificial Breeding Service Unit in regard to bull needs from March 1, 1950 through December 31, 1955, are shown in Table 13.

Table 13. Bull-year requirement in comparison with associations and first-service volume by breeds for the Kansas Artificial Breeding Service Unit from March 1, 1950 through December 31, 1955.

	Ayr-shire	Brown Swiss	Guernsey	Hol-stein	Jersey	Milking Shorthorn	Av.
Av. no. bull-years per year	4.6	5.2	5.4	7.1	4.9	5.9	33.1
Av. no. first-services per year	1,759	2,492	5,333	22,063	2,784	5,896	40,327
Av. no. first-services per bull per year	382	479	988	3,107	568	999	1,218
Av. no. assns. years per year	64	64	64	64	64	64	64
Av. no. first-services per assn.	27	39	83	345	44	92	630

If only one bull had been maintained in the Ayrshire, Brown Swiss, and Jersey breeds, the average first-services per sire per year would have been less than for the Holstein breed which averaged 7.1 bulls maintained per year (Table 13). Frequency of shipment and the number of associations had the greatest effect on bull requirement for the Ayrshire, Brown Swiss and Jersey breeds. In the Holstein breed, demand for service and number of associations had the greatest influence on bull requirement. The number of associations had the greatest effect on bull requirement in the Guernsey and Milking Shorthorn breeds with some possible effect by seasonal demand. Bull requirements in all breeds were effected by the effects of inbreeding during the period from March 1, 1950 through December 31, 1955 at the Kansas Artificial Breeding Service Unit.

Prices Paid and Total Investment for Bulls. The prices paid for bulls used at the Kansas Artificial Breeding Service Unit were not fixed by formula or policy. Bulls for artificial breeding cannot be considered as a standardized commodity, but as units of production with values unique to particular bulls at particular times. Some of the factors that influenced price were proving, breed, pedigree, age, need for the bull, and health and fertility. These factors are so interrelated and some of them so intangible that measurements of importance and estimates of value could not

be made. The price paid for any individual bull was the result of the value placed on the bull by the owner and the decision, by the selection committee as to whether or not the bull was worth the investment for this stud.

The total and average investments in bulls by breeds and for all breeds is summarized in Table 14. The average price paid for bulls, by breeds, was determined by a straight average of all bulls purchased by the Kansas Artificial Breeding Service Unit from January 1, 1950 through December 31, 1955. The average price per bull range from 739 dollars for bulls of the Brown Swiss breed to 1,080 dollars for bulls of the Holstein breed and averaged 919 dollars per bull for all bulls of all breeds (Table 14). Although the average price per bull varied among breeds, the differences were not significant when tested by analysis of variance ($F = 1.32$ with 5 and 79 degrees of freedom).

The average number of bulls purchased per year was a straight average of all bulls purchased by the Kansas Artificial Breeding Service Unit from January 1, 1951 through December 31, 1955. Bulls purchased in 1950, the first year of operation, were excluded from calculations of the average number of bulls purchased per year. The number of bulls purchased in 1950 far exceeded the number of bulls purchased in subsequent years because bull batteries were being established in 1950 and thereafter only necessary replacements were purchased. The average number of bulls purchased per year ranged from 1.4

per year for the Ayrshire breed to 2.8 per year for the Holsteins and the average for all breeds was 12.2 bulls per year (Table 14).

Table 14. Summary of average purchase price of bulls by breeds and number of bulls purchased and total that were purchased by the Kansas Artificial Breeding Service Unit from January 1, 1950 through December 31, 1955.

Item	Ayr-shire	Brown Swiss	Guernsey	Hol-stein	Jersey	Milking Shorthorn	Total
Total no. bulls purchased	11	14	18	18	11	13	85
Total cost of bulls	$8,950	$10,346	$18,839	$19,441	$8,680	$11,827	$78,083
Av. cost per bull	$ 814	$ 739	$ 1,047	$ 1,080	$ 789	$ 910	$ 919
Av. no.[1] bulls purchased per year	1.4	2.0	2.6	2.8	1.6	1.8	12.2
Av. ann. investment for bulls	$1,140	$1,478	$ 2,270	$ 3,024	$1,262	$ 1,638	$11,212

[1] Bulls purchased in 1950, the first year of operation, were excluded from the average number of bulls purchased per year because the large number of bulls purchased to begin operations far exceeded the number of bulls required each year thereafter for replacement.

The average number of bulls purchased per year was a straight average of all bulls purchased by the Kansas Artificial Breeding Service Unit from January 1, 1951 through December 31, 1955. Bulls purchased in 1950, the first year of operation,

were excluded from calculations of the average number of bulls purchased per year. The number of bulls purchased in 1950 far exceeded the number of bulls purchased in subsequent years because bull batteries were being established in 1950 and thereafter only necessary replacements were purchased. The average number of bulls purchased per year ranged from 1.4 per year for the Ayrshire breed to 2.8 per year for the Holsteins and the average for all breeds was 12.2 bulls per year (Table 14).

The average annual investment by breeds and for all breeds ranged from 1,140 dollars for the Ayrshire breed to 3,024 dollars for the Holstein breed and the average annual investment for all breeds was 11,212 dollars (Table 14). The average annual investment was the product of the average number of bulls purchased per year, by breeds and total, and the average purchase price.

Any factor that tended to increase the number of bulls in service increased the cost of bull depreciation and related costs such as feed and bedding. Of the factors that tended to increase the number of bulls required, demand for service was the only factor that compensated for increased costs with increased income. As previously stated, a fee is charged for each first-service, and as first-services increase, income also increases.

The influence of number of first-services and annual investment for bulls by breeds is shown in Table 15. The

largest average annual investment for bulls was for the Holstein breed, yet the average annual cost per first-service was lowest because of the high number of first-services (Table 15). The average annual investment for bulls of the Ayrshire breed would need to be reduced from 1,140 dollars (Table 15) to 247 dollars to reduce the annual bull investment cost per first-service to the 14 cent cost of the Holstein breed.

Table 15. Relationship of annual investment for bulls to fee per first-service as influenced by differences in number of first-services among breeds at the Kansas Artificial Breeding Service Unit from March 1, 1950 through December 31, 1955.

Item	Ayrshire	Brown Swiss	Guernsey	Holstein	Jersey	Milking Shorthorn	Average
Av. ann. first-services	1,759	2,492	5,333	22,063	2,784	5,896	40,327
Av. ann. investment for bulls	$1,140	$1,478	$2,720	$3,024	$1,262	$1,638	$11,212
Av. cost per first-service for bull purchases	$0.65	$ 0.59	$ 0.51	$ 0.14	$0.45	$ 0.28	$ 0.28

Differences in demand for first-services among breeds would be a justifiable reason for a variation in purchase price among breeds. As previously stated, there are arithmetic differences in the average purchase price of bulls among the breeds, but

the differences are not significant (Table 14). Because of prevailing prices, the price differences among breeds could not be varied sufficiently to entirely compensate for the differences among breeds in number of first-services, and yet obtain bulls of comparable merit among breeds. If the purchase price of bulls among breeds cannot be varied, to at least partially compensate for differences in number of first-services, then perhaps service for the breeds with low numbers of first-service should be terminated. The immediate results of such an action would be to reduce the gross income of the stud 45 per cent by reducing the total number of first-services from the annual average of 40,327 first-services for all breeds to the 22,063 annual average first-services for the Holstein breed (Table 15). The average income per first-service was 2.87 dollars (Table 1). Thus, the effect of discontinuing the breeds with low numbers of first-services would be to reduce the average annual gross income of the stud from 115,738 dollars for 40,327 first-services to 63,321 dollars for 22,063 first-services. Many segments of the cost of operations, such as depreciation of bulls, feed, bedding, and labor would probably be reduced in proportion to the reduction in number of bulls. However, if the number of insemination associations and the frequency of semen shipments remained the same, some segments of cost of operations such as supervision, semen shipping, utilities, and other miscellaneous items would not be materially reduced.

Summation of the segments of cost of operation from Table 3, on the basis of service for one breed instead of six, would total about 66,000 dollars per year compared with an average annual income of 63,321 dollars. Thus, if the five breeds with low numbers of first-services were estimated an increase in the fee per first-service would be necessary to pay for the costs of operations. The cost of operations includes not only the segments mentioned, but also provision for reserves necessary for depreciation of equipment, buildings, and improvements.

Also, insemination associations would be affected, by the elimination of the breeds with low first-service numbers, in a manner similar to the effect on the bull stud. The average first-service number for the associations in group I was 1,392 (Table 1). Elimination of the low first-service breeds would, on the average, reduce the annual number of first-services for these insemination associations to 55 per cent of their former average or 766 first-services per year. Reducing the average number of first-services of the associations from 1,392 to 766 first-services would result in an increase in the fee retained by the association and fee paid the technician (Table 1). Thus, the end result of necessary increases to compensate for lower gross income would be a higher fee to the dairyman for breeding service.

In addition to the undesirable feature of increased fees caused by the elimination of breeds with low numbers of first-

services, the number of herds for which service would be available would also be reduced. Thus, the elimination of breeds with low first-service numbers would result in the Kansas Artificial Breeding Service Unit being only 55 per cent as effective in the mass improvement of dairy cattle through breeding as when service for all six breeds is provided.

Feed and Bedding Costs

The feed and bedding segments of the costs of operations, for the Kansas Artificial Breeding Service Unit, were affected by the number of bulls required for service and fluctuations in the prices paid for feedstuff and bedding. A comparison of the year equivalent of bulls maintained per year with the cost of feed and bedding is shown in Table 16. The total cost of feed and bedding per year varied with the number of equivalent bull years (Table 16). However, the average cost per bull year for feed and bedding increased each year from 332 dollars in 1950 to 357 dollars in 1952. In 1953, the average cost for feed and bedding per bull year decreased from the 1952 average of 357 dollars to 342 dollars, and decreased each year thereafter to a low of 314 dollars in 1955 (Table 16). The average cost of feed and bedding per bull per year from 1950 through 1955 was 337 dollars (Table 16).

Table 16. The cost of feed and bedding and per cent of cost of operations per year and average in comparison with the number of bull year equivalents maintained per year at the Kansas Artificial Breeding Service Unit.

	1950	1951	1952	1953	1954	1955	Average
No. bull year equivalents	18.7	28.0	31.3	35.2	40.8	40.1	33.1
Cost of feed and bedding	$6,212	$9,632	$11,185	$12,033	$13,330	$12,587	$11,146
Av. cost per bull per year	$ 332	$ 344	$ 357	$ 342	$ 342	$ 314	$ 337
% total cost of operations expended for feed and bedding	13.2	12.5	11.5	11.9	12.8	12.9	12.4

The average cost per bull per year was relatively uniform in both annual cost and in percentage of total operations. Some variation can be expected due to changes in prices for feed and bedding, and in proportion of bulls of different sizes. The possibility of a trend at the Kansas Artificial Breeding Service Unit to have had an increasing proportion of larger bulls from 1950 to 1952, and an increasing proportion of smaller bulls from 1953 to 1955 has been considered (Table 17). The comparison of bull year equivalents with bull year equivalents and the bulls year equivalents adjusted for weight (Table 17).

Table 17. A comparison of bull year equivalents by breeds and by years with bull year equivalents adjusted for differences among breeds in average body weight by breeds and years.

Breed	Av. body wt.[1] lbs.	Factor[2] weight	1950 Bull year equiv.	1950 Adj. bull year equiv.	1951 Bull year equiv.	1951 Adj. bull year equiv.
Ayrshire	1,800	1.0	3.3	3.3	5.0	5.0
Brown Swiss	2,000	1.1	2.8	3.1	4.8	5.3
Guernsey	1,550	0.8	3.7	3.0	4.6	3.7
Holstein	2,150	1.2	3.3	4.0	5.0	6.0
Jersey	1,350	0.7	2.7	1.9	3.9	2.7
Milking Shorthorn	1,950	1.1	2.9	3.2	4.7	5.2
Av.or total	1,826	1.0	18.7	18.5	28.0	27.9

Table 17 (concl.)

Breed	1952 Bull year equiv.	1952 Adj. bull year equiv.	1953 Bull year equiv.	1953 Adj. bull year equiv.	1954 Bull year equiv.	1954 Adj. bull year equiv.	1955 Bull year equiv.	1955 Adj. bull year equiv.
Ayrshire	5.4	5.4	4.3	4.3	4.5	4.5	4.5	4.5
Brown Swiss	3.8	4.2	5.8	6.4	6.1	6.7	7.0	7.7
Guernsey	5.0	4.0	5.8	4.6	7.0	5.6	5.6	4.5
Holstein	6.9	8.3	7.3	8.8	8.9	10.7	9.8	11.8
Jersey	4.4	3.1	5.3	3.7	6.3	4.4	6.0	4.2
Milking Shorthorn	5.8	6.4	6.7	7.4	8.0	8.8	7.2	7.9
Av.or total	31.3	31.4	35.2	35.2	40.8	40.7	40.1	40.6

[1] Average body weight of bulls from monthly body weights recorded for the period from November 1953 through June 1954.

[2] The breeds were weighted by a factor that would adjust for differences among breeds in average body weight due to the fact that bulls were fed according to body weight.

The concentrates fed to bulls in service at the Kansas Artificial Breeding Service Unit changed little from March 1, 1950 through December 31, 1955 (Table 18). The average ration used contained about 75 per cent total digestible nutrients and about 16 per cent crude protein. The usual ingredients, which were varied to take advantage of price differences, were corn, milo, oats, bran, soybean oil meal, steam bone meal, and salt. The ration was adjusted to individual bull requirements, but every mature bull was fed 0.5 pound concentrate per day per 100 pounds body weight upon arrival at the bull stud. The bulls were weighed once a month and rations were adjusted to maintain proper body weights. An average ration fed for 28 bulls, representing the six dairy breeds, was 0.46 pounds of concentrate per hundred pounds of body weight. The 28 bulls, for which rate of feeding was quoted, were on a feeding trial for six months. This period was selected because of the accuracy of feed and body weight data.

The roughage fed consisted of alfalfa hay and some native grass hay. Native grass hay was used when a bull tended to bloat or to scour. Mature bulls were fed hay at the rate of approximately one pound per 100 pounds of body weight. Only minor adjustments were made in rates of roughage feeding; adjustments in the ration were made by changing the rate of concentrate feeding. The average rate of hay feeding for 28 bulls in service, which were on the feeding trial for six

months, was 0.99 pounds per hundred pounds of body weight. No roughage other than alfalfa hay and small amounts of native grass hay was fed.

White pine shavings, purchased baled and by railroad carload lots, were used for bedding. Appearance and high absorbency were the main reasons for using this material for bedding. Although no comparative data are available, shavings were considered to be as economical as straw due to the fact that the cost per ton for straw was equal to the cost per ton for shavings, and the absorbency of shavings was at least equal to straw.

The average cost per bull was 124 dollars per year for concentrates, 134 dollars per year for roughage, and 78 dollars for bedding, making a total average cost for feed and bedding of 337 dollars per year (Table 18).

Weight adjustment for differences among breeds in average weight of bulls had a marked effect on bull year equivalents within breeds. The Guernsey breed ranked third in actual number of bull year equivalents but ranked fifth in number of bulls when adjusted for weight, the Ayrshire breed ranked sixth in actual bull year equivalents and fourth when adjusted for weight (Table 18).

The total cost of feed and bedding varied as the body weight adjusted bull year equivalents (Table 18). The cost per first-service for feed and bedding varied among breeds

Table 18. Cost of concentrate, roughage and bedding by breeds, per average bull, total and average, and cost of feed and bedding per first-service by breeds and average for six breeds at the Kansas Artificial Breeding Service Unit.

Breed	Av. body wt.	Factor for wt. adjustment	Bull year equivalents per year	Adjusted bull years per year	Av. concentrate cost per breed per year	Av. roughage cost per breed per year	Av. bedding cost per breed per year	Total av. feed and bedding cost	Av. no. first-services per year	Av. feed and bedding cost per first-service
Ayrshire	1800	1.0	4.6	4.6	$570	$ 616	$359	$1550	1759	$ .88
Brown Swiss	2000	1.1	5.2	5.7	$707	$ 764	$445	$1921	2492	$ .77
Guernsey	1550	0.8	5.4	4.3	$533	$ 576	$335	$1449	5333	$ .27
Holstein	2150	1.2	7.1	8.5	$1054	$1139	$663	$2865	22063	$ .13
Jersey	1350	0.7	4.9	3.4	$422	$ 456	$265	$1146	2784	$ .41
Milking Shorthorn	1950	1.1	5.9	6.5	$806	$ 871	$507	$2191	5896	$ .37
Av. per bull per year	1826	1.0	1.0	1.0	$124	$ 134	$ 78	$ 337	1218	$ .28

the number of first-services, except for the Guernsey and Milking Shorthorn breeds (Table 18). The Milking Shorthorn breed ranked second highest in number of first-services and second highest in cost of feed and bedding resulting in the cost per first-service for feed and bedding being third from the highest. The Guernsey breed ranked third in number of first-services, fifth in cost of feed and bedding and fourth from the highest in cost of feed and bedding per first service (Table 18).

Labor Costs

The total cost of labor was affected by 1) the number of bulls required for service, 2) number of associations receiving service, 3) adaptation of labor saving materials and equipment, and 4) management factors. The cost of labor per association, per bull, and per first-service are summarized by years and average in Table 19. Although the cost of labor per association remained fairly constant, the cost of labor decreased per bull with the exception of the increase in 1955, which was due to a slight increase in cost of labor and a slight decrease in the number of bulls (Table 19). The cost of labor per year varied with the number of first-services, and averaged 43 cent per first-service (Table 19).

The cost of labor was second only to the cost of supervision in percentage of total cost of operations of the Kansas Artificial Breeding Service Unit. Labor cost represented an

Table 19. The total cost of labor per association, per bull, and per first-service by years and average at the Kansas Artificial Breeding Service Unit.

	1950	1951	1952	1953	1954	1955	Average
Cost of labor	$13,435	$15,802	$16,773	$18,620	$18,122	$18,589	$17,383
No. assn. years per year	36	62	66	70	70	71	64
Cost of labor per association	$ 373	$ 255	$ 254	$ 266	$ 259	$ 262	$ 272
No. bull year equivalents per year	18.7	28.0	31.3	35.2	40.8	40.1	33.1
Cost of labor per bull year equivalent	$ 718	$ 564	$ 536	$ 529	$ 444	$ 464	$ 525
No. first-services per year	24,512	37,567	39,781	43,607	45,399	44,258	40,327
Cost of labor per first-service	$0. 55	$ 0.42	$ 0.42	$ 0.43	$ 0.40	$ 0.42	$ 0.43

average of 19.3 per cent of the total cost of operations, ranging from 20.4 per cent in 1950 to the low of 17.1 per cent in 1954 (Table 20). Factors affecting labor requirement were 1. number of bulls required for service, 2. number of insemination associations receiving semen service, and 3. management factors such as proper equipment, organization of work assignments, methods of operations, and salaries paid.

Labor was classified according to work assignment. Barn labor was designated as the labor required to feed and care for bulls, lead bulls for collection, minor barn and equipment repairs and care of grounds. Laboratory labor was designated as the labor required for all duties involved in semen collection, semen processing and shipping, and some custodial assignments. Office labor was designated as the clerical, stenographic and accounting requirements of the bull stud. The relative cost requirements of each subdivision of the labor segment is shown in Table 20. The cost of barn labor averaged 8.8 per cent of the total cost of operations and represented the greatest requirement per year (Table 20). The cost of laboratory labor ranked a close second to barn labor and averaged 7.4 per cent of the total cost of operations, but was consistently lower throughout the period from 1950 through 1955 (Table 20). The cost of office labor averaged 3.1 per cent of the total cost of operations, was the lowest cost subdivision of labor and varied the least among years (Table 20).

Table 20. Relative costs and percentage of total cost of operations by years and average for labor and the subdivisions of labor from 1950 through 1955 at the Kansas Artificial Breeding Service Unit.

	1950		1951		1952		1953	
	Cost	% of total cost oper-ation	Cost	% of total cost oper-ation	Cost	% of total cost oper-ation	Cost	% of total cost oper-ation
Barn labor	$5,973	12.6	$7,567	9.9	$8,333	8.6	$8,020	8.0
Laboratory labor	5,432	11.5	5,595	7.3	5,740	5.9	7,800	7.7
Office labor	2,030	4.3	2,640	3.4	2,700	2.8	2,800	2.8
Total cost and percentage	$13,435	28.4	$15,802	20.6	$16,773	17.3	$18,620	18.5

Table 20 (concl.)

	1954		1955		Average		
	Cost	% of total cost oper-ation	Cost	% of total cost oper-ation	Cost	% of total cost oper-ation	Av. % of labor costs
Barn labor	$8,192	7.7	$8,240	8.4	$7,946	8.8	46
Laboratory labor	7,130	6.8	7,049	7.2	6,646	7.4	38
Office labor	2,800	2.6	3,300	3.4	2,791	3.1	16
Total cost and percentage	$18,122	17.1	$18,589	19.0	$17,383	19.3	100

Barn Labor Requirement and Cost. The cost of barn labor was consistently higher than the other subdivisions of labor representing an average of 46 per cent of total labor costs (Table 20). The number of bulls in service and provision for stabling had the greatest effect on the cost of barn labor. Barn labor was supplied by two full time employees and supplementary part time labor by students at Kansas State College. Barn labor was highest in 1953 even though fewer bulls were in service than in subsequent years (Table 21). This was probably due to the fact that in 1953 the bulls in service exceeded the available stabling and it was necessary to picket bulls outside. This situation increased labor because of the inconvenience and increasing handling required for collection and watering. In 1950 and 1951, average barn labor costs per bull were high because the number of bulls did not fully utilize the time of two employees, yet two men were necessary as a safety factor in the handling of the bulls. Although barn labor costs remained fairly uniform, particularly from 1952 through 1953, the barn labor cost per bull dropped considerably from 1953 through 1955, due to provision for adequate stabling and the number of bulls more fully utilized the time of the employees.

Laboratory Labor Requirement and Cost. Laboratory labor costs ranked second among the subdivisions of labor and averaged 38 per cent of total labor costs (Table 20). Laboratory

labor costs were most affected by the number of associations receiving semen shipments and the application of labor saving equipment and materials to laboratory procedures. Laboratory labor consisted of one full time technician, one half-time assistant from 1953 through 1955, and supplementary labor by students at Kansas State College. In 1950, the cost of laboratory labor was 151 dollars per association and highest for the entire period (Table 22). In 1950, the laboratory technician assisted in the training of insemination technicians in addition to laboratory duties. The expenditures for laboratory labor dropped from the peak in 1950, of 151 dollars per association to 91 dollars per association in 1951, and 87 dollars per association in 1952 (Table 22). Prior to 1952, glass semen shipping vials were used. These vials were washed, sterilized, and labeled by hand. In 1952, the use of expendable plastic vials was initiated, and accounted for some of the decrease in laboratory labor costs (Table 22). Even though expendable plastic vials reduced labor requirements in 1952, the hand labeling of individual vials involved considerable labor. In 1954, equipment for machine labeling was obtained and the total cost of labor was reduced from 7,800 dollars in 1953, to 7,130 dollars in 1954 (Table 22). No major change in operation was initiated in 1955, yet the gross expenditure for labor decreased slightly (Table 22).

Table 21. Cost of barn labor by years and average in comparison with the number of bulls required for service by years and average at the Kansas Artificial Breeding Service Unit.

	1950	1951	1952	1953	1954	1955	Average
Cost of labor	$5,973	$7,567	$8,333	$8,020	$8,192	$8,240	$7,946
No. bull year equivalents	18.7	28.0	31.3	35.2	40.8	40.1	33.1
Cost of barn labor per bull year	$ 319	$ 370	$ 366	$ 228	$ 201	$ 205	$ 240

Table 22. Cost of laboratory labor by years and average in comparison with the number of associations receiving semen service by years and average at the Kansas Artificial Breeding Service Unit.

	1950	1951	1952	1953	1954	1955	Average
Laboratory labor	$5,432	$5,595	$5,740	$7,800	$7,130	$7,049	$6,646
No. of assns. years by year	36	62	66	70	70	71	64
Cost of labor per assn.	$ 151	$ 90	$ 87	$ 111	$ 101	$ 99	$ 104

Office Labor Requirement and Cost. Office labor were the smallest fraction of total labor costs and represented an average of 16 per cent of total labor costs (Table 20). Office labor consisted of one employee from 1950 through 1954, with an additional half time clerk-typist employed in 1955. Theoretically, as the number of associations and the number of first-services increase, the expenditures for office labor should have increased, however, the main reason for increased office labor costs from 1950 through 1954, was salary increases (Table 23). The adaptation of labor saving devices were more evident in office procedure than any other department of the Kansas Artificial Breeding Service Unit. The use of machine duplicators, postage meter machine and the development of an effective accounting system contributed much to office efficiency, however, the adaptation of the mark-sense principle of the International Business Machine Corporation to use for field breeding receipts, in 1951, was the major factor contributing to the efficient use of office labor. The Statistical Laboratory at Kansas State College processed the field breeding receipts as a routine practice at an average cost of 75 dollars per month. Processing of breeding receipts was not a part of office requirement at the Kansas Artificial Breeding Service Unit.

Every insemination made in the field by the insemination association technician was recorded on a standard triplicate receipt form. One copy of every triplicate receipt was forwarded to the office of the Kansas Artificial Breeding Service

Table 23. Cost of office labor by years and average compared with the number of associations receiving semen service by years and average at the Kansas Artificial Breeding Service Unit.

	1950	1951	1952	1953	1954	1955	Average
Office labor	$2,030	$2,640	$2,700	$2,800	$2,800	$3,300	$2,791
No. of assn. years per year	36	62	66	70	70	71	64
Cost of office labor per assn.	$ 56	$ 43	$ 41	$ 40	$ 40	$ 46	$ 43
Cost of breeding receipt processing.	$ 00	$ 923	$ 897	$ 909	$ 883	$1,011	$ 924[1]
Cost of office labor and breeding receipt processing	$2,030	$3,563	$3,597	$3,709	$3,683	$4,311	$3,715[1]

[1]Average for five years because IBM processing was not initiated until 1951.

Unit. These breeding receipts were processed each month as a routine practice to:

1. Enumeration of first-services for invoice purposes.
2. Calculation of breeding efficiency by insemination associations and average.
3. Calculation of breeding efficiency by bulls and average by breeds.
4. Record breeding records of registered cows for registry purposes.

Processing the breeding receipts to obtain necessary information involved the handling of individual breeding receipts two to four times. Spot counts indicated that the total number of receipts, for any particular month, equaled twice the number of first-service breeding receipts. This would mean that in an average year, 80,654 breeding receipts would be handled two to four times or the equivalent of at least 161,308 items per year. It can be conservatively estimated that if these receipts were processed by hand, an average of two minutes per item would have been required to process the breeding receipts or an average of 5,376 hours per year or 26.8 standard 200 hours months per year. At an average cost of 150 dollars per month for clerical help, the annual cost of office labor would have been increased by 4,020 dollars or double the combined actual cost of office labor and breeding receipt processing (Table 23).

Since the number of bulls maintained influenced the cost of

labor, the proportionate share of labor costs as affected by differences among breeds in the number of bulls required, and the average number of first-services, is summarized in Table 24. The average cost of labor per first-service among breeds varied indirectly with the number of first-services, except for the Guernsey and Milking Shorthorn breeds (Table 24). Due to the fact that more Holstein bulls were required for service, the Holstein breed required the greatest share of labor, however, the high number of first-services for that breed resulted in the lowest labor cost per first-service (Table 24).

Supervision

The supervision segment, of the cost of operations at the Kansas Artificial Breeding Service Unit, include 1) management, 2) technical assistance for insemination technicians, 3) organizational and operational assistance for insemination associations, 4) insemination technician training, and 5) the editing of a monthly publication. The cost of supervision, including salaries and travel cost, averaged 20.3 per cent of the total cost of operations (Table 25).

Management was the subdivision of supervision concerned with supervision of bull stud employees, planning, purchasing and other duties incidental to the dependable operation of the Kansas Artificial Breeding Service Unit. The cost of

Table 24. Cost of labor per first-service by breeds and average as affected by the average number of bulls required and average number of first-services at the Kansas Artificial Breeding Service Unit.

Breed	Av. bull year equivalents per year	% of total bull year equivalents	Pro rata average cost of labor per year	Av. no. 1st services per year	Average cost of labor per 1st serv. by breeds
			$		$
Ayrshire	4.6	14	2,434	1,759	1.38
Brown Swiss	5.2	16	2,781	2,492	1.12
Guernsey	5.4	16	2,781	5,333	0.52
Holstein	7.1	21	3,650	22,063	0.17
Jersey	4.9	15	2,608	2,784	0.94
Milking Shorthorn	5.9	18	3,129	5,896	0.53
Total or average	33.1	100	17,383	40,327	0.43

management averaged 6.4 per cent of the total cost of operations and ranged from a high of 10.2 per cent in 1950, to a low of 5.4 per cent in 1952 (Table 25). Management represented an average of 32 per cent of the cost of supervision (Table 25). Unlike some segments of costs of operation, the cost of management cannot be apportioned to the number of insemination associations, or the number of bulls required for service, because most functions of management would prevail regardless of the number of breeds, bulls, or insemination associations. The cost of management increased gradually from 1950 through 1955 (Table 25). However, the increased cost of management was not in proportion to the increase in number of associations. In 1950, 36 insemination associations were receiving semen service and the cost of management was 4,800 dollars, or a cost of 133 dollars per association for management of the bull stud. In 1955, 71 associations were receiving semen service and the cost of management of the bull stud was 6,540 dollars, or a cost of 92 dollars per association.

Field supervision was concerned with the technical and organizational problems of insemination associations. Therefore, the number of insemination associations affected the cost of field service. Management modified the cost of field service by decisions concerned with the hiring of field supervisors. Early in 1950, the first year of operation, it was thought that management could provide the necessary field supervision, because of the low number of insemination

Table 25. The relative cost of the subdivisions of supervision by years, total, and average at the Kansas Artificial Breeding Service Unit.

Year and average	1950 Cost	1950 % of total cost operation	1951 Cost	1951 % of total cost operation	1952 Cost	1952 % of total cost operation	1953 Cost	1953 % of total cost operation
	$		$		$		$	
Management	4,800	10.2	4,920	6.3	5,280	5.4	6,000	5.9
Field supervision	4,210	8.9	10,560	13.7	11,320	11.7	11,340	11.4
Miscell. duties	300	0.6	1,860	2.4	1,944	2.0	2,030	2.0
Total cost of superv.	9,310	19.7	17,340	22.6	18,544	19.1	19,370	19.3

Table 25 (concl.)

Year and average	1954 Cost	1954 % of total cost operation	1955 Cost	1955 % of total cost operation	Average cost	Average % of total cost operation	Average percentage of superv. costs
	$		$		$		$
Management	6,240	5.9	6,540	6.7	5,794	6.4	32
Field supervision	11,600	10.9	13,560	13.9	10,736	11.9	58
Miscell. duties	2,100	2.0	2,300	2.3	1,807	2.0	10
Total cost of superv.	19,940	18.8	22,400	22.9	18,337	20.3	100

associations receiving service. The number of insemination associations, however, continued to increase until a field supervisor was hired in August of 1950. Organizational assistance, in conjunction with the Extension Dairy Specialists, for insemination associations required the majority of the field supervisor's time in 1950 and 1951. Further increases in the number of insemination associations and the organizational problems associated with the growth in number of associations required the full time of two field supervisors by January, 1951. The increasing number of insemination associations, with the accompanying increasing need for field supervision, account for the marked increase in cost of field service in 1951, compared with the low cost in 1950 (Table 25).

The miscellaneous duties of supervision included investigation of bulls for use at the bull stud, editing of the monthly publication "Bull Tales", preparation of pedigrees for publication, and the publication of educational information and publicity leaflets. In 1950, the miscellaneous duties were quite limited, consisting mainly of the publication of five issues of "Bull Tales" (Table 25). The responsibilities for bull investigation were assumed by the field supervisors in 1951, in addition to the preparation of the monthly publication and other promotional material. This accounted for the sharp increase in cost (Table 25). The cost of miscellaneous duties remained relatively constant from

1951 through 1955 (Table 25).

The cost of supervision increased sharply in 1951, with slight increases each year thereafter (Table 26). The sharp increase in the cost of supervision in 1951 was due to the increase in the number of insemination associations and the accompanying organizational assistance required (Table 26). The cost of supervision averaged 287 dollars per association, ranging from a low of 259 dollars in 1950, to a high of 315 dollars in 1955 (Table 26). The cost of supervision per first-service averaged 45 cents per first-service, and ranged from a low of 38 cents in 1950, to a high of 51 cents in 1955 (Table 26).

Cost of Operational Supplies and Services

Operational supplies and services represented an average of 13.7 per cent of the total operational costs of the Kansas Artificial Breeding Service Unit. This segment of the costs of operations was sub-divided into three parts 1) semen processing supplies and services, 2) office supplies, and 3) miscellaneous supplies and services (Table 27).

Semen Processing Supplies and Services. Semen processing supplies and services included the cost of laboratory supplies, semen shipping materials, and breeding efficiency summaries. Total cost of semen processing, supplies, and services was affected by:

Table 26. The cost of supervision by years and average and per insemination association and per first-service by years and average for the Kansas Artificial Breeding Service Unit.

	1950	1951	1952	1953	1954	1955	Average
Cost of supervision	$9,310	$17,340	$18,544	$19,370	$19,940	$22,400	$18,337
No. assns.	36	62	66	70	70	71	64
Cost of supervision per association	$ 259	$ 280	$ 281	$ 277	$ 285	$ 315	$ 287
No. first-services	24,512	37,567	39,781	43,607	45,399	45,399	40,327
Cost per first-service	$ 0.38	$ 0.46	$ 0.47	$ 0.44	$ 0.44	$ 0.51	$ 0.45

1. The number of insemination associations receiving semen service
2. The development of equipment and supplies specifically designed or modified for artificial breeding
3. The method of operations
4. The frequency of semen shipments
5. The number of bulls needed for service

Semen processing supplies and services represented 64 per cent of the cost of operational supplies and service. The cost of semen processing supplies and services increased each year from 1950 through 1954, then decreased in 1955, to a lower cost than that of 1952 (Table 27). The increased cost of operational supplies and services, in 1951, was accompanied by an increase in the number of associations but the average cost per association decreased from 183 dollars per association in 1950, to 170 dollars per association in 1951 (Table 27). The entire increase in total cost of operational supplies and service in 1952, was due to the increased quantities of semen processing supplies and services purchased. The number of insemination associations increased to such an extent that more than 11,000 semen shipments were necessary in 1952. The enormity of semen shipping resulted in acute problems in the handling of shipping materials and sterilization and labeling of semen vials. Attempts to develop expendable packaging for semen shipping resulted in

Table 27. The cost of components of operational supplies and services by years, total and average, and cost per insemination association, and per first-service by years and average for the Kansas Artificial Breeding Service Unit.

Year and average:	1950	1951	1952	1953	1954	1955	Average
Semen processing supplies and services	$ 2,973	$ 5,966	$ 9,373	$10,025	$11,251	$ 6,967	$ 7,985
Office supplies	$ 632	$ 1,107	$ 1,243	$ 1,090	$ 797	$ 821	$ 976
Miscellaneous supplies and services	$ 2,985	$ 3,485	$ 3,129	$ 3,635	$ 3,355	$ 3,419	$ 3,432
Total cost of operation supplies and services	$ 6,590	$10,558	$13,745	$14,750	$15,403	$11,207	$12,393
No. assn. years by year	36	62	66	70	70	71	64
Cost of operational supplies and services per year	$ 183	$ 170	$ 208	$ 211	$ 220	$ 158	$ 194
No. first-services per yr.	24,512	37,567	39,781	43,607	45,399	44,258	40,327
Cost of operational supplies and services per first-service	$ 0.27	$ 0.28	$ 0.35	$ 0.34	$ 0.34	$ 0.25	$ 0.31

higher costs for semen shipping supplies and services through 1954 (Table 27). The factors that finally resulted in lower costs for semen processing supplies and services in 1955 were:

1. The use of expendable plastic semen vials packaged in sealed sterile containers. (Plastic vials eliminated sterilization, and made possible the practical use of machine labeling.)
2. The use of machine labeling which was initiated in 1954, enabling one man to label one month's supply of semen vials in eight hours at a negligible cost for ink. (Labels suitable for hand labeling cost 1.5 cents each or an expenditure of more than 1,000 dollars per year for semen vial labels.)
3. The reconditioning and reuse of shipping materials which resulted in a net saving of 15 cents per semen shipping package.

The cumulative effect of efforts to reduce the cost of semen processing supplies and services resulted in a low cost of 158 dollars per association in 1955 (Table 27).

Increasing numbers of first-services from 1950 through 1955, and the resultant increased number of breeding receipts did not increase the cost of machine tabulation of breeding efficiency summaries. Cost of machine tabulation did not increase, because the maximum number of breeding receipts processed did not approach the per hour capacity of the tabulating machines.

Regardless of the number of breeding receipts processed, more man hours were required than machine time and man hours remained relatively constant because procedure remained the same.

Office Supplies. Expenditures for office supplies represented an average of 8 per cent of the cost of operational supplies and services and increased each year from 1950 through 1952 (Table 27). Increased expenditures accompanied the increasing number of insemination associations and the resulting greater correspondence and accounting requirement. The expenditures for office supplies were relatively minor and varied little from 1953 through 1955 (Table 27).

Miscellaneous Supplies and Services. Miscellaneous supplies and services include the fees for:

1. Veterinary treatment and semi-annual health tests of bulls at the bull stud
2. Membership in the National Association of Artificial Breeders
3. Blood typing and analyses and reports
4. Pedigree research and copies of professional photographs
5. Insemination technician training materials
6. Emergency technician service and speakers at meetings
7. Surveys and special services

Expenditures for miscellaneous supplies and services were necessary to comply with the regulations of the Purebred Dairy

Cattle Association (5) governing artificial breeding, protect the health of the bulls in service, and provide information and service needed for dependable semen service. Thus, expenditures for miscellaneous supplies and services could not be controlled to any great extent and the cost varied in accordance with requirements from year to year (Table 27).

The expenditures for operational supplies and services were most affected by the cost of semen processing supplies and services. The cost of operational supplies and services increased per first-service from 1950 through 1952, remained relatively constant through 1954, and declined sharply in 1955, because of improved procedures and equipment (Table 27).

Semen Shipping Costs

Semen shipping costs represented an average of 9.9 per cent of the total annual cost of operations for the Kansas Artificial Breeding Service Unit. The percentage of total costs for semen shipping ranged from a low of 8.1 per cent in 1950 to a high of 12 per cent in 1955. Shipments of semen were sent to each of the insemination associations on an every other day basis from 1950 through 1953. In 1954 and 1955, four semen shipments per week were made to each of the insemination associations. There was little variation in weight or dimension of the semen shipping package from 1950 through 1955. The following factors affected semen shipping costs:

1. The number of insemination associations receiving semen shipments.

2. The frequency of semen shipments.
3. The price per shipment charged by the various transportation organizations.

The increased number of associations receiving semen service in 1951, compared with 1950, was largely responsible for the marked increase in total semen shipping cost in 1951 (Table 28). Also, the increase in total cost of semen shipping in 1951, was caused by the need for emergency semen deliveries by private airplane during a period when flood conditions disrupted the less expensive and usual means of delivery (Table 28). In addition, in 1952, increases were in part caused by an increase in the shipping rates by the carrier delivering a majority of the semen shipments at that time, and to a lesser extent by the addition of four more associations (Table 28). In 1953, there was a shift of some of the semen shipments from the carrier which had increased rates in 1952, to a carrier charging less per shipment. The savings realized, by use of the less expensive carrier, resulted in a reduction in semen shipping costs and an accompanying lower cost of shipping per association. As previously mentioned, an increase in the frequency of semen shipments was initiated in 1954. This increase in frequency should have caused a 15 per cent increase in the cost of semen shipping. However, a continued shift, in 1954, of some semen shipments to a less expensive carrier offset the effect of increased frequency of semen shipping, and the total shipping costs increased 410 dollars in 1954,

or only four per cent instead of the anticipated 15 per cent (Table 28). Increased shipping rates caused the increase in shipping costs in 1955 and the increase in cost per association (Table 28).

The cost of semen shipping averaged 22 cents per first-service, ranging from a low of 16 cents in 1950, to a high of 26 cents in 1955 (Table 28). Seemingly minor changes in transportation rates could have a significant effect on expenditures for semen shipping. For example: An average increase in transportation rates of ten cents per shipment would increase shipping cost 1,100 dollars because an average of 11,000 semen shipments were involved. Although the increasing number of first-services each year from 1950 through 1954, would tend to decrease semen shipping cost per first-service, the increased number of associations receiving semen service and the increased transportation rates tended to increase costs, thus resulting in little change in cost of semen shipments per first-service (Table 28).

Advertising and Other Promotion Costs

Expenditures for advertising and promotion are, for the most part, at the descretion of management. In Kansas, the growth of the artificial breeding program from 1950 through 1952, taxed the capacities of the stud for adequate bull stabling and for field supervision. Thus, little solicitation for additional business was either necessary or adviseable.

Table 28. The cost of semen shipping by years and average and per insemination association and per first-service by years and average for the Kansas Artificial Breeding Service Unit.

Year and average	1950	1951	1952	1953	1954	1955	Average
Yearly cost of semen shipping	$ 3,833	$ 7,969	$ 9,867	$9,306	$ 9,716	$11,718	$ 8,990
No. of insemination association year equivalents	36	62	66	70	70	71	64
Yearly cost of semen shipping per association	$ 106	$ 129	$ 150	$ 133	$ 139	$ 165	$ 140
No. first-services per year	24,512	37,567	39,781	43,607	45,399	44,258	40,327
Cost of semen shipping per first-service	$ 0.16	$ 0.21	$ 0.25	$ 0.21	$ 0.21	$ 0.26	$ 0.22

After additional stabling was provided and other operational procedures were made more efficient it was found that the capacities of the stud exceeded the use of the service, particularly in the breeds with low numbers of first-services. Solicitation of additional business would have been advisable and any additional business might have reduced costs of operation per first-service.

Expenditures for solicitation from 1950 through 1955, were a minor fraction of the expenditures for advertising and promotion. The primary purpose of practically all expenditures for advertising and promotion was to keep the users of the artificial breeding service informed of the bulls in service, the breeding efficiency, and various other features of the program. The expenditures for advertising and promotion averaged 13 cents per first-service and ranged from 10 cents per first-service in 1950 and 1951 to 21 cents in 1953 (Table 29).

Annual expenditures for advertising and promotion were, on the average, about equal for the monthly publication "Bull Tales" and the aggregate cost of pedigrees, leaflets, annual reports, and exhibits (Table 29). Average annual expenditures for advertising and other promotion were 5.9 per cent of the total cost of operations (Table 3) for the Kansas Artificial Breeding Service Unit and exceeded this percentage only one year, when the percentage was 8.7 per cent in 1952. Thus, expenditures for advertising and other promotion were about in proportion to the total cost of operations. The unusually

Table 29. The cost of advertising and promotion by components, years, total and average, and cost per first-service per year and average for the Kansas Artificial Breeding Service Unit.

Year and average :	1950	1951	1952	1953	1954	1955	Average
Monthly Publication "Bull Tales"	$ 845	$ 2,031	$ 3,091	$ 2,946	$ 3,636	$ 3,310	$ 2,926
Pedigrees, leaflets, fair exhibits	$ 1,546	$ 1,790	$ 5,373	$ 2,832	$ 1,734	$ 2,036	$ 2,626
Total cost of advertising and promotion	$ 2,391	$ 3,821	$ 8,464	$ 5,778	$ 5,370	$ 5,346	$ 5,552
Number of first-services	24,512	37,567	39,781	43,607	45,399	44,258	40,327
Cost of advertising and promotion per first-service	$ 0.10	$ 0.10	$ 0.21	$ 0.13	$ 0.12	$ 0.12	$ 0.14

high expenditure for advertising and other promotion in 1952, was due to the printing, in large quantities, of pedigrees of all bulls in service at one time. Printing instead of mimeographing pedigrees was initiated in 1952. Mimeograph duplication was not practical due to the quantity of pedigrees required for all users of the artificial breeding service. A multilith process that reduced cost and was as acceptable as printing, was used for duplication of pedigrees in 1954 and 1955.

From 1952 through 1955, an average of 10,000 copies of "Bull Tales" were printed and mailed monthly to the users of the artificial breeding service. Variations in the annual cost, for printing and mailing "Bull Tales" from 1952 through 1955, were due to whether or not a special edition was published and the cost of the special edition. Special editions of "Bull Tales" were published in 1952, 1954, and 1955. The low cost in 1950 and 1951, was due to the fact that only five issues of "Bull Tales" were printed in 1950, and to lower numbers of copies per issue published in 1951 as compared with 1952 and subsequent years (Table 29).

Utilities, Maintenance, and Repair

Utilities, maintenance, and repair comprised an annual average cost of 4.7 per cent of the total cost of operations for the Kansas Artificial Breeding Service Unit. Utilities were paid for only three months, in 1950, and the buildings

and equipment were new and required little more than preventive maintenance (Table 30).

Maintenance and repair were unusually high in 1952 and 1954 (Table 30). In 1952, major repairs were necessary for a deep well pump, and in 1954, all water lines had to be replaced in the barn built in 1950. Usual maintenance consisted of painting, replacement of worn parts, and routine preventive maintenance for machinery, electrical, and plumbing service.

Utilities, maintenance and repairs cost an average of 12 cents per first-service. The highest cost per first-service was 16 cents in 1954, and the lowest average cost was five cents per first-service in 1950 (Table 30).

Observations of operation of the Kansas Artificial Breeding Service Unit indicated the following practices would keep the cost of utilities, maintenance and repair to a minimum:

1. Routine preventive maintenance as specified by the manufacturer or as indicated by experience
2. Use of equipment and improvements for the purpose designed, and in a manner consistant with good practice
3. Timely repair or replacement of worn or faulty parts or equipment
4. Conservation of utilities when not in use
5. Proper conditioning of equipment before and after use

Table 30. The cost of utilities, maintenance and repairs by years, average, and total, and cost of utilities, maintenance and repairs per first-service by years and average at the Kansas Artificial Breeding Service Unit.

Year and average :	1950 :	1951 :	1952 :	1953 :	1954 :	1955 :	Average
Utilities	$ 582	$ 1,697	$ 1,760	$ 2,003	$1,768	$ 1,610	$ 1,786
Maintenance and repair	$ 432	$ 1,237	$ 3,511	$ 2,185	$5,285	$ 1,630	$ 2,449
Total for Utilities, maintenance and repair	$ 1,114	$ 2,934	$ 5,271	$ 4,188	$7,053	$ 3,240	$ 4,235
Number of first-services	24,512	37,567	39,781	43,607	45,399	44,258	40,327
Cost of utilities, maintenance and repair per first-service	$ 0.05	$ 0.08	$ 0.13	$ 0.10	$ 0.16	$ 0.07	$ 0.12

SUMMARY AND CONCLUSIONS

No published information pertaining to the costs of operating a bull stud for the artificial breeding of dairy cattle, has been available. This study of factors affecting costs of operations at the Kansas Artificial Breeding Service Unit would seem applicable to 60 per cent of the bull studs operating in the United States in 1956, because of similarity in size, and may be useful in developing plans for future units.

Bull studs for the artificial breeding of dairy cattle derive their income primarily from fees for first-service inseminations. Establishing an equitable fee was a problem in meeting probable operational costs for acceptable service, depreciate of investments, and establish a reserve fund to meet emergencies and provide for expansion. Study of the Kansas Artificial Breeding Service Unit indicated that a first-service fee of 2.45 dollars was adequate to meet operation costs. This fee was adequate for an annual average of 40,327 first-services, when 64 insemination associations regularly received semen shipments, and service from six breeds of dairy cattle was provided. An average first-service fee of 2.87 dollars was more than ample to meet operational requirements and establish a reserve fund for emergencies and provide for expansion. How much the first-service fee could have been

reduced and meet the aforementioned objectives was not determined.

The costs of operations were segregated into ten major segments, and the factors affecting each of these costs were considered. Some segments of cost were found to be affected by a single factor, others by several factors, and some factors affected several segments of the cost of operation.

The rate of depreciation of bulls was shown to be affected by the service time of bulls in the stud, prices paid and total investment in bulls, and the number of bulls needed for service. Service time of bulls was not affected significantly by breed differences or age when placed in service. The average time in service averaged 32 months for all bulls placed in service and for which completed service records were available. Differences in prices paid for bulls among breeds was not significant, but the total investment was affected by the number of bulls in service. Factors affecting the number of bulls needed for service were:

1. Number of breeds for which service is provided
2. Frequency of semen shipments to insemination associations
3. Number of insemination associations receiving semen service
4. Demand for service within associations and within breeds

5. Variations in seasonal demand for service
6. Decisions by management in regard to bulls involving inbreeding and low fertility problems

Elimination of breeds with low annual first-service demand would not reduce cost of operations per first-service. Such action would ultimately increase the cost per first-service of the artificial breeding service to the dairyman, and reduce the effectiveness and extensiveness of the artificial breeding program. The average annual cost for depreciation of bulls was 28 cents per first-service.

Feed and bedding costs varied directly with the number of bulls maintained. Feed and bedding needs averaged 0.46 pounds of concentrates, and 0.99 pounds of hay per 100 pounds of body weight. The average annual cost of feed and bedding was 337 dollars per bull, or 28 cents per first-service.

The number of bulls needed for service had the greatest influence on the requirement for barn labor. However, provision of adequate stabling with resultant greater convenience in handling, reduced the cost of barn labor from 228 dollars per bull per year to 201 dollars per bull per year with an average of 240 dollars per bull per year. Laboratory labor costs were affected by the number of insemination associations receiving semen shipments and average cost was 104 dollars per association per year. The use of equipment and materials specifically designed or modified for use in artificial

breeding also affected the costs of laboratory labor. The requirements for office labor was minimized by the use of machine tabulation and processing of field breeding receipts. The cost of office labor did not increase in proportion to the increase of insemination associations or number of first-service inseminations. The average annual cost of labor was 43 cents per first-service.

The cost of the supervision segment of the total cost of operations was directly influenced by the number of insemination associations receiving semen service. The cost of management was not particularly affected by increases in associations or number of first-services, but field supervision costs increased as the number of insemination associations increased. The average annual cost of supervision was 287 dollars per association or 45 cents per first-service.

Operational supplies and services were affected by:

1. The number of insemination associations receiving semen service
2. The development of equipment and supplies specifically designed or modified for artificial breeding
3. The method of operations
4. The frequency of semen shipments
5. The number of bulls required for service

The cost of operational supplies and services was most affected by the cost of semen processing supplies and services.

The development of equipment and supplies for artificial breeding and improvement in the methods of operation were responsible for a reduction from an annual cost of 220 dollars per association in 1954, to 158 dollars per association in 1955. The cost of operational supplies and services was 31 cents per first-service.

The number of insemination associations receiving semen service, the frequency of semen shipments, and variations in cost per shipment among transportation organizations influenced the cost of semen shipping. When the number of insemination associations remained constant, the differences in cost per shipment among carriers had the greatest influence on total cost. The average annual cost of semen shipping was 140 dollars per association or 22 cents per first-service.

Expenditures for advertising and promotion of the Kansas Artificial Breeding Service Unit were mostly concerned with advising users of the service with the status of the program. Expenditures for solicitation were a minor fraction of the total costs for advertising and promotion. Advertising and promotion cost an annual average of 13 cents per first-service.

Utilities, maintenance and repair cost an annual average of 12 cents per first-service. Observation of operations of the Kansas Artificial Breeding Service Unit indicated that expenditures for utilities, maintenance and repairs can be minimized by:

1. Routine preventive maintenance as specified by the manufacturer or as indicated by experience
2. Use of equipment and improvements for the purpose designed, and in a manner consistent with good practice
3. Timely repair or replacement of worn or faulty parts or equipment
4. Conservation of utilities when not in use
5. Proper conditioning of equipment before and after use

The difference in costs of operations and income was used to depreciate investments in buildings, improvements, equipment, and establish reserves to meet emergencies, and provide for expansion. The average total costs of operations for the Kansas Artificial Breeding Service Unit was 2.22 dollars per first-service. The average income per first-service was 2.87 dollars.

The variables influencing investment, rate of depreciation, and reserves necessary to meet emergencies and provide for expansion are a matter of judgment and of requirements for acceptable service in a particular area.

The factors influencing the cost of various segments of the cost of operations of an artificial breeding unit will be affected by the requirements for acceptable service in a particular area. The delineation of factors influencing costs

of operations may be of assistance in estimating the needs of artificial breeding units when basic factors such as number of breeds, number of insemination associations, and approximate annual number of first-services are known.

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A STUDY OF SOME FACTORS AFFECTING OPERATIONAL COSTS OF AN ARTIFICIAL BREEDING UNIT

by

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The factors influencing the cost of various segments of the cost of operations of an artificial breeding unit will be affected by the requirements for acceptable service in a particular area. The delineation of factors influencing costs of operations may be of assistance in estimating the needs of artificial breeding units when basic factors such as number of breeds, number of insemination associations, and approximate annual number of first-services are known.