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TITLE: Inventory & Summary of Embryo Transfer Work at the Cal Poly Dairy

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Inventory & Summary of Embryo Transfer Work at the Cal Poly Dairy

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INTRODUCTION

Over the past two decades the practice of Embryo Transfer (E.T.) has become a popular method to increase the number of progeny from exceptional female cattle. The Cal Poly Dairy has recently developed an extensive E.T. program and has continually worked with embryology experts to choose, flush and obtain embryos from the top cattle in the superior Holstein and Jersey herds. In the future the E.T. program will hopefully utilize embryos donated from outstanding cattle throughout the state. It has recently come to the attention of the faculty and staff of the Dairy Science Department that a more formal record keeping system for this procedure is necessary.

Due to the inordinate amount of turnover in dairy employees and the high number of student herdsmen working with the cattle and performing breeding tasks, it is vital that a well kept, easy to use system of record keeping be developed for the embryo work preformed at the dairy. This system will also be beneficial considering the current economic situation facing the dairy and the possible need in the near future to market both frozen embryos as well as the calves and heifers obtained from recent embryo transfer procedures.

The author has worked closely with faculty member Dr. Stan Henderson, as well as herd manager Rich Silacci to further develop and improve the current embryo transfer record-keeping program. This paper reviews relevant applied research, outlines the materials used, and discusses possible future benefits of such a program. In addition,

the author will determine current industry benchmarks as set by RuAnn dairy, with emphasis on the number of embryos produced per flush, and embryo transfer success rates. These benchmarks will be compared to the work done at Cal Poly to determine the success of the Cal Poly program. RuAnn and Maddox success rates will be used as a comparison because Cal Poly cattle are transferred by RuAnn personnel and dry donors are housed at RuAnn dairy. Additional background information will be obtained from the staff at Trans Ova Genetics located in Sioux Center, Iowa.

LITERATURE REVIEW

Historical Background

General Information. Embryo transfer is a common practice in the reproductive management of dairy herds to multiply high genetic merit cows. It is the process by which one or more embryos are collected from a female donor and transferred into female recipients to complete the gestation period. E.T. is commonly used in registered dairy cattle to "produce a large number of offspring from a genetically superior animal" (1). Embryo work has the potential of providing several economic benefits, however at a cost of nearly $250 per pregnancy (3) there is little margin for error when performing the procedure, or raising and marketing offspring.

Introduction to the Dairy Industry. As early as the 1880's research began in the field of embryology. The first successful embryo transfer occurred with angora rabbits in 1890, proving the hypothesis that a surrogate could successfully carry the embryo of a donor animal with no genetic effects from the surrogate on the offspring. Over the next 90 years extensive work was done in the field of embryology leading to the common practice of embryo transfer used in the dairy industry today. In 1930 the first bovine embryo was surgically collected from a donor cow, and the first live birth of a calf resulted from a surgically implanted embryo in 1951. It wasn't until the mid-1970's that embryo transfer became commercially used in dairy cattle. At that time it was a complicated and expensive procedure. In the late 1970's and early 1980's several procedures were perfected that allowed for the easy and relatively

inexpensive use of embryo transfer right on the farm. In 1978 a method was developed into non-surgically collect and implant embryos, followed by the ability in 1981 to freeze and thaw embryos reliably. Today, the majority of embryonic procedures are done non-surgically, and, often more embryos are frozen for later use than are implanted fresh.

Use at Cal Poly. Beginning in the 1980's as the industry began widely using the process of embryo transfer, the Cal Poly Dairy instituted a program of collecting and freezing embryos from superior Jersey cows for use with contracted bull mothers. Into the 1990's the program, although sporadic, continued using Cal Poly heifers as well as donated heifers for recipients as part of an enterprise project. Today, Cal Poly has a successful embryo transfer program, utilizing the top cows in the herd, faculty work closely with RuAnn and Maddox Dairies in Riverdale, California to flush, implant and produce superior offspring. Cal Poly currently has 5 live heifers that are the result of successful embryo transfers, in addition to 9 recipient heifers that are due to have embryo transfer calves within the next 9 months.

Procedure

Selection of the Donor Cow. The first step is the selection of the donor cow. Criteria often differ between producers, but common criteria to look at are genetic values, production records, physical confirmation, and perhaps most importantly, dollar value of offspring. The potential donor cow should be reproductively sound to produce

ideal results. She should have a normal reproductive schedule, as well as normal postpartum history. The Journal of American Breeders Association recommends using a donor who is at least sixty days fresh, with a healthy reproductive tract. Also it is prudent to consider females who have had regular heat cycles, a history of no more than two breedings per conception, no parturition difficulties or reproductive irregularities, and no conformational or detectable genetic defects. It is also important that the donor cow be in an appropriate body condition scores (BCS) at the time of collection to avoid difficulties brought on my metabolic inconsistencies (6).

Superovulation. Superovulation of the donor is the next step in the embryo transfer process. Superovulation is the release of multiple eggs during a single estrus cycle. Cows or heifers that are properly treated can release as many as 10 or more viable eggs during one estrus. An average of about 5 transferable embryos are obtained from normal, healthy donor animals. The basic principle of superovulation is to stimulate follicular development through the use of a hormone treatment with follicle stimulating hormone (FSH). Commercially available FSH is injected twice daily for four days, eight to 14 days following the end of estrus, while a functional corpus luteum (CL) is on the ovary. A prostaglandin injection is given on the third day of the treatment schedule, which will cause CL regression and a heat or estrus will occur approximately 48 to 60 hours later. Because of the release of many ova from the multiple follicles on the ovaries over a period of several hours, there may be a greater than normal need to be certain that viable sperm cells reach the oviducts. Often,

embryo transfer technicians will choose to inseminate the cow several times during and after estrus, using high quality semen with a high percentage of normal, motile cells. The correct site for semen placement is in the body of the uterus, which is consistent with conventional AI practices (8).

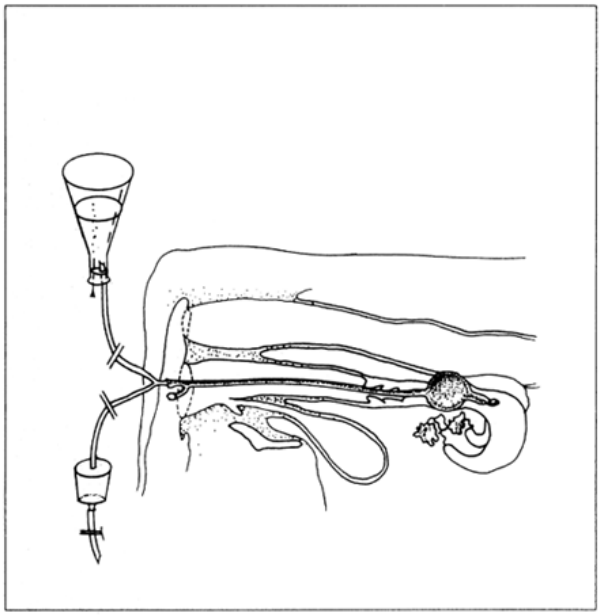

Figure 1. Non-surgical embryo recovery (5)

Flushing. To collect the embryos non-surgically, a small synthetic rubber catheter is inserted through the cervix of the donor cow seven to eight days after estrus, and a special medium, typically phosphate buffered saline with antibiotics, is flushed into and out of the uterus to harvest the embryos. This collection procedure is relatively simple and can be completed in 30 minutes or less without harm to the cow. Figure 1 is an illustration of this procedure. The donor is typically given an epidural and a sterilized stylet is placed in the lumen of the catheter to offer rigidity for passage

through the cervix into the body of the uterus. When the tip of the catheter is in the body of the uterus, the cuff of the catheter is slowly filled with approximately 2 ml of the saline solution. The catheter is then gently pulled so that the cuff is seated into the internal os of the cervix. Saline is then added to the cuff to completely seal the internal os of the cervix. A Y-connector with inflow and outflow tubes is attached to the catheter. Forceps are attached to each tube to regulate the flow of flushing fluid. The fluid is added and removed by gravity. The fluid in the uterus is agitated rectally. The uterus is finally filled with medium to about the size of a 40-day pregnancy. One liter of fluid is used per donor. Each uterine horn is filled and emptied five to 10 times with 30 to 200 ml of fluid each time. The embryos are flushed out with this fluid into a large graduated cylinder. After about 30 minutes, embryos settle and can be located under a microscope (6).

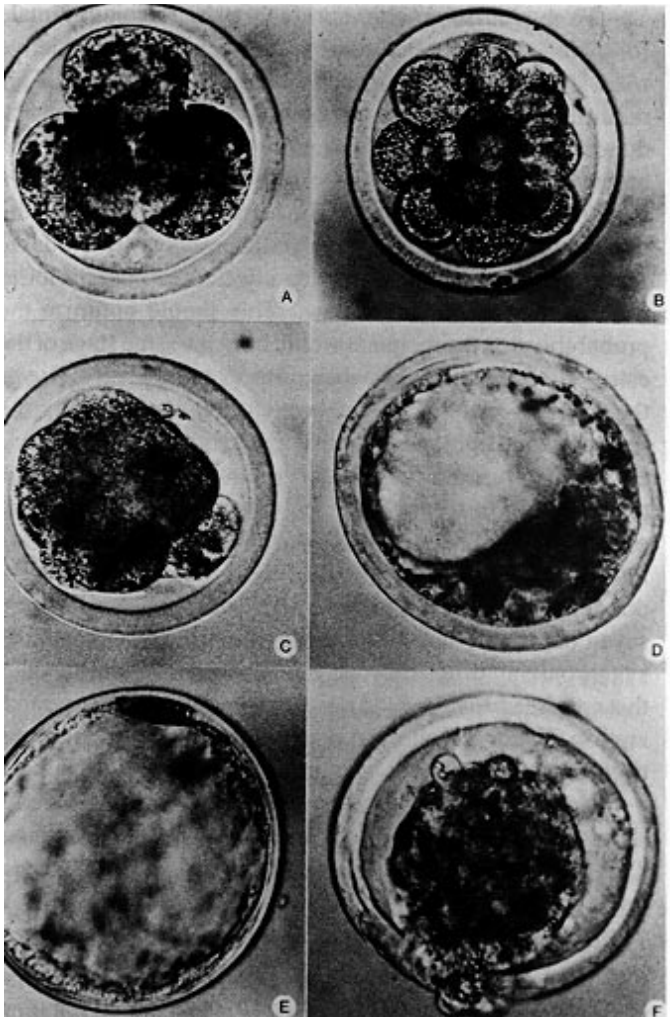

Figure 2. Cattle Embryos at various stages of development (3)

Selection. As the individual embryos are located using the microscope, they are evaluated for their quality and classified numerically as to their potential if transferred to a recipient female. The major criteria for evaluation include: Shape, size, color and texture of the cytoplasm, diameter, regularity of zona pellucida, presence of vesicles, and in some instances gender. Embryos can receive four grades as referred to in Table 1.

Table 1: Embryo grading (8)

Classification	**Avg. %**	**Description**
Excellent or Good	54%	Perfect or consisting of trivial imperfections. May be slightly asymmetrical or small.
Fair	30%	Definite but not sever abnormalities. Small size, or small amount of degeneration
Poor	8%	Considerable degeneration, vesculated cells, varying cell size, retarded by up to 2 days in development
Dead or Degenerate	8%	Severely degenerate; not worth transferring.

Embryos also are evaluated for their stage of development without regard to quality.

Table 2: Stages of normal embryonic development (8)

Stage	**Status**	**Days after Estrus**
1	Unfertilized	0-2
2	2-12 Cells (fig. 2A)	1-5
3	Early Morula (fig. 2B)	5-6
4	Morula (fig. 2C)	5-7
5	Early blastocyst (fig. 2D)	7-8
6	Blastocyst (fig. 2E)	7-9
7	Expanded blastocyst	8-10
8	Hatched blastocyst (fig. 2F)	9-11
9	Expanding hatched blastocyst	11-12

Freezing and Storing. Embryos can be transferred immediately upon recovery and evaluation, or may be stored frozen in liquid nitrogen and transferred at a later date. The freezing and thawing process is very intricate and usually results in an approximate 20 percent reduction in pregnancy rates from those observed with fresh

embryos. Freezing should be preformed within three to four hours of collection. Embryos should then be added to a saline-glycerol solution to be prepared for freezing. The pre-labelled 0.25- or 0.5-cc straws are then rinsed to remove any toxic residues. Next, straws are filled half-way with freezing medium, then an air bubble of 4–6 mm, then another column of freezing medium containing the embryo so that the straw is 90 percent full. The end is then sealed with heat or polyvinyl chloride powder. The straw is placed into the freezing machine horizontally where straws are cooled to –7°C. Then at a rate of .5°C per minute embryo straws are dropped to -30°C. Finally, embryos are plunged into liquid nitrogen for storage. Thawing should take place by holding the embryo in the air for 20 seconds, followed by a 20 second bath in 37°C water. Frozen embryos are a marketable commodity and have especially been useful in international sales of US genetics (8). Pricing is further discussed in the cost analysis section.

Implantation. The transfer of the embryo into the recipient cow first requires "loading" of the embryo into a 1/4 ml insemination straw. This is done under microscopic viewing with the aid of a 1 ml syringe. Just prior to embryo transfer, an epidural anesthetic may be given, and the ovaries of the recipient are palpated rectally to determine which ovary has ovulated. By holding open the vulva of the recipient cow (with or without the help of an assistant), the transfer gun is carefully passed through the cervix. The tip of the rod is then guided into the horn on the same side of

the ovary with the active CL. The embryo is gently expelled in the forward tip of that uterine horn. Great care must be taken to not cause damage to the lining of the uterus.

Efficiency and Economics

Rates. The first step in determining if an embryo transfer program is a viable option for any dairy is measuring efficiency and cost. The author has worked with Ms. Daniela Demetrio of RuAnn and Maddox dairies, the largest volume embryo transfer program in the western United States, to compile information for every month over the past three years to set a benchmark for the work done at Cal Poly. Following is a table illustrating the results of all of the flush work done over the past 36 months (some information may be skewed due to incomplete data for November and December 2009). The chart illustrates that an average of 50% of the total embryos flushed were viable. Lactating cows produced more viable embryos (56%) than non-lactating cows (42%), with the average cow producing roughly 4.2 viable embryos. Many of the non-lactating cows have been part of a continuous embryo transfer program. This may explain the lower number of viable embryos.

Table 3: RuAnn & Maddox Dairy embryo collections 2007-2009 (1)

Flush Program 2007-2009			
	Total	**Dry Cows**	**Milk Cows**
Number of Super Stimulated Cows	1944	986	1008
Number of Flushed cows	1811	953	858
%	93%	97%	85%
Total Structures	20041	12963	7078
Structures Per Cow	11.1	13.6	8.2
Viable	9382	5440	3942
Viable per Cow	5.2	5.7	4.6
%	47%	42%	56%
Fresh	3266	1937	1329
Frozen	6116	3503	2613
Inviable	10659	7523	3136
%	53%	58%	44%
Unfertile	9500	6608	2892
Degenerate	1159	915	244

After reviewing this information a list of all stored Cal Poly embryos was compiled. The following chart illustrates all implantations of both fresh and frozen embryos into heifers. The average pregnancy rate in heifers is 61.2%, with conception rate at Maddox dairy being 59.2% having a slightly lower conception rate than RuAnn which is 67.1%. It is also noted that the conception rates differ by nearly 7 % greater in fresh embryos versus frozen, which is slightly better than the national average, which tends to differ up to 20% between fresh and frozen embryos.

Table 4: Conception rates for embryo transfer in heifers-RuAnn (R) & Maddox (M) Dairies (1)

ET-Heifers 2007-2009 Conception Rate				
		Total	R	M
	Total	2911	802	2109
Fresh	Preg	1832	555	1277
	%	62.93%	69.20%	60.55%
	Total	910	166	744
Frozen	Preg	508	95	413
	%	55.8%	57.2%	55.5%
	Total	3821	968	2853
Total	Preg	2340	650	1690
	%	61.2%	67.1%	59.2%

Cost. The costs of embryo transfer are often variable. Many different options are offered by embryo transfer companies. As mentioned previously many professionals perform embryo transfer only on the farm or ranch where the donor cow is located. Others have facilities to house and board donor and recipient cows and perform embryo transfer under hospital-like conditions. Many technicians have the equipment and expertise to freeze and store embryos for later transplantation or shipment. The average cost of flushing one Holstein cow at RuAnn is approximately $460. If broken down to the national average of 5.2 viable embryos per flush the average cost per embryo is $88.57. With a pregnancy rate of 55% this equates to $161.10 per pregnancy. The following chart provided by RuAnn Dairy (4) illustrates this information, broken down based on the average cost of materials, hormones, fees and labor in California.

Table 5: Cost analysis of embryo transfer (1)

	Unit	Cost/unit	Total Cost
SUPEROVULATION AND AI			
Pluset	1.2	$110.00	$132.00
Prostaglandin	4	$2.20	$8.80
GnRH	1	$2.30	$2.30
Others (syringes, needles, …)	1	$5.00	$5.00
Semen	2.5	$25.00	$62.50
			$210.60
FLUSHING			
Ringer solution	1.8	$2.00	$3.60
Flush media (PBS) - 2liters	0.0625	$31.00	$1.94
Holding solution (50ml)	0.17	$18.00	$3.00
Ethilene Glycol (20ml)	0.20	$14.00	$2.80
Filter	1	$8.10	$8.10
Catheter/Silicone Tube	1	$4.00	$4.00
6-well dish	1	$2.95	$2.95
100x20 dish	1	$0.50	$0.50
35x15 dish	1	$0.22	$0.22
Straws 0.25cc	5.2	$0.85	$4.42
Straws 0.50cc	2.6	$0.10	$0.26
Tips	1	$0.35	$0.35
Syringes 12cc	1	$0.35	$0.35
Syringes 20cc	1	$0.44	$0.44
Racks, goblets, tabs, …	1	$1.00	$1.00
Others (pen, needle, pipette, ...)	1	$5.00	$5.00
			$38.93
OTHER COSTS			
Food (each donor 2 months)	60	$2.00	$120.00
Holtein Association	1	$5.00	$5.00
AI and Super labor	1	$15.00	$15.00
Flush Labor	1	$30.00	$30.00
Lab Labor	1	$15.00	$15.00
			$185.00

Embryos per cow	5.2
Flushing %	89%
Conception rate	55%

SUPEROVULATION AND AI	1.1236	$210.60	$236.63
FLUSHING	1	$38.93	$38.93
OTHER COSTS	1	$185.00	$185.00
TOTAL			**$460.56**
TOTAL per embryo	5.2		**$88.57**

Some embryo transfer centers may also provide recipients and charge $1200 to $1800 per pregnancy (6). Many purebred operations conducting embryo transfer on a regular basis consider that each "ET" calf must have a market value of $1500 to $2000 greater than other naturally conceived and reared calves in the herd before embryo transfer is considered (6). Producers considering using embryo transfer should first visit with their breed representative to determine the specific requirements needed for certification and registration of embryo transfer calves in that breed.

Cost of frozen embryos. Costs of frozen embryos can also vary greatly depending on a variety of factors, including breed, genetic merit of sire, classification of the dam, and location in the country. Embryo Central and Holstein USA both lists the average price of Holstein embryos to be $425. The most expensive embryos are listed as high as $750, and the least expensive being $350. (2)

Embryo Transfer Facilities

For all embryo work at the Cal Poly Dairy in the past 3 years Dr. Stan Henderson and herd manager Rich Silacci have worked with the staff at RuAnn and Maddox Dairies in association with Golden Genes in Riverdale, CA. Some of the most noted companies in the field of embryo transfer are Trans Ova Genetics located in Sioux Center, Iowa and EmTran located in Elizabethtown, Pennsylvania, and in the west, RuAnn Dairy of Riverdale, California. The first two companies offer several options

for reproductive technology, including; embryo transfer, in-vitro fertilization, semen sorting, genetic preservation, cloning, and very often donor and recipient care and management. All three companies also continue to do extensive research in embryo technology to create further opportunities for genetic advancement.

MATERIALS AND METHODS

The literature review looked at the history of Embryo Transfer both here at Cal Poly and in general, as well as the procedures of flushing and implantation, and the economic efficiency of the practice of embryo transfer. Data from the Cal Poly Dairy was collected and analyzed with the help of Dr. Stan Henderson, Mr. Rich Silacci, and Ms. Daniela Demetrio, to determine the current number of embryos as well as the number of live ET cows currently available at the Cal Poly Dairy. Also, Cal Poly success rates will be compared to the overall averages from RuAnn Dairy, which will be considered an industry benchmark. Total numbers of viable embryos will be used as the basis of comparison; however, other comparisons will be drawn from total number of embryos and number of frozen embryos. The materials presented here illustrate the use of Embryo Transfer at the Cal Poly Dairy and help to determine its current and future value to the herd.

RESULTS AND DISCUSSION

Flushes. Table 4 is a list of all embryo flushes preformed on females from the Cal Poly herd during the last 12 months. A total of 94 embryos were obtained from 5 cows. The average number of viable embryos per cow was 8.7, or 59% more than the RuAnn benchmark of 5.2. As reported by the data, several of the embryos have be transferred into recipient heifers with 5 frozen embryos being sold at the 2009 State Holstein sale, and the remainder frozen for future transfer or sale. Further breakdown of embryo locations follows. Embryos not accounted for in the following tables were considered to be degenerate and were discarded. The following table gives a detailed report on each flush and it's results.

Table 6: Flushes preformed on Cal Poly Cows.(1)

Date	Cow	Sire	Fresh	Frozen	VIABLE	TOTAL	Status
12/5/2008	1945	7H8081		7	7	15	Frozen embryos (2) transferred at Golden Genes mar-09. Embryos delivered to Alta (5), feb-09.
1/27/2009	1945	200H3205	1	14	15	25	Frozen embryos (14) transferred at Golden Genes mar-09. Fresh embryo transferred at Maddox.
2/26/2009	1940	7H7872	0	10	10	13	Frozen embryos (10) transferred at Golden Genes mar-09. Fresh embryo transferred at Maddox.
4/16/2009	1945	200H3205	0	4	4	21	Frozen embryos (4) transferred at Golden Genes jun-09.
4/27/2009	2127	7H8190	0	9	9	14	Frozen embryos (9) transferred at Golden Genes jun-09.
5/7/2009	1940	29H12209	1	10	11	0	Fresh embryo transferred at Maddox. Frozen embryos (10) transferred at Golden Genes jun-09.
7/15/2009	2126	11H8342	0	16	16	19	Frozen embryos (1) transferred at Calpoly sep-09.
7/22/2009	2127	7H8190	0	8	8	21	These embryos are not for sale. Frozen embryos (4) transferred at Calpoly sep-09.
8/10/2009	889	7J867	3	4	7	11	Fresh embryos transferred at Maddox/.Calpoly (4)sep-09.
8/10/2009	1940	29H12209	0	7	7	9	
8/12/2009	1945	200H3205	5	0	5	11	Fresh embryos transferred at Maddox.
10/5/2009	889	7H859	0	5	5	8	
		TOTAL	**10**	**94**			
		AVERAGE	**8.7**	viable embryo/cow			

Frozen Embryos Stored at RuAnn. A total of 31 of the 94 embryos obtained have been frozen and stored for later use. The Embryos are currently stored at RuAnn dairy, where the majority of transfers into recipient heifers will be preformed. Based on the bull used, several of these embryos are considered especially high value and could be successfully marketed in the future. Currently Cal Poly plans to market or implant these frozen embryos within the year. Table 5 lists the number of embryos from each donor cow that are currently frozen, as well as the sire of each embryo.

Table 7: Frozen embryos from Cal Poly donor cows (1)

TAG	NAME	SIRE	CANE	QUANT
1940	POLY LEE BEAUTY	PICSTON SHOTTLE	9060	7
889	POLY JACE HALLIE	CHASIN-RAINBOWS ACT RILEY ET	9063	5
2126	POLY MERCHANT GARDENIA	REGANCREST HHF MAC-ET	9057	7
2126	POLY MERCHANT GARDENIA	REGANCREST HHF MAC-ET	9058	8
2127	POLY HI METRO BARBIE	GEN-MARK STMATIC SANCHEZ	9059	4
			TOTAL	**31**

Pregnant Recipients. There are a total of 31 heifers currently diagnosed pregnant with embryos obtained from Cal Poly donor cows. Most of the recipient heifers are located at Golden Genes in Riverdale, with four at Maddox Dairy, and four currently housed at Cal Poly. Table 6 is a detailed report of the implantation date, donor cow, sire, recipient, location or recipient and due date. The embryo calves born at Cal Poly will be housed and raised at the Cal Poly Dairy, those born at another location will be raised at specified location. Currently there are no embryos that have been implanted without a confirmed pregnancy.

Table 8: Pregnant Recipients (1)

DATE	DONOR	SIRE	RECIPIENT	LOCATION	DIAGNOSTICS	DUE
1/28/2009	1945	200H3205	**74671**	Maddox	Pregnant	30-Oct-09
3/11/2009	1945	200H3205	**75881**	Golden Genes	Pregnant	11-Dec-09
3/11/2009	1945	7H8081	**75882**	Golden Genes	Pregnant	11-Dec-09
3/11/2009	1945	200H3205	**86614**	Golden Genes	Pregnant	11-Dec-09
3/11/2009	1945	7H8081	**86952**	Golden Genes	Pregnant	11-Dec-09
3/11/2009	1945	200H3205	**87871**	Golden Genes	Pregnant	11-Dec-09
3/11/2009	1983	200H3205	**2322**	Cal Poly	Pregnant	11-Dec-09
3/11/2009	2126	7H9817	**12853**	Cal Poly	Pregnant	11-Dec-09
3/11/2009	1945	200H3205	**87873**	Golden Genes	Pregnant	11-Dec-09
3/11/2009	2127	7H9893	**2129**	Cal Poly	Pregnant	11-Dec-09
3/11/2009	2127	7H9893	**2259**	Cal Poly	Pregnant	11-Dec-09
3/12/2009	2127	7H9893	**75745**	Golden Genes	Pregnant	12-Dec-09
3/12/2009	2127	7H9893	**87852**	Golden Genes	Pregnant	12-Dec-09
3/12/2009	1940	7H7872	**86541**	Golden Genes	Pregnant	12-Dec-09
3/12/2009	1940	7H7872	**86612**	Golden Genes	Pregnant	12-Dec-09
3/12/2009	1940	7H7872	**86637**	Golden Genes	Pregnant	12-Dec-09
3/12/2009	1940	7H7872	**87876**	Golden Genes	Pregnant	12-Dec-09
8-Jun	1945	200H3205	**87176**	Golden Genes	Pregnant	10-Mar-10
8-Jun	1945	200H3205	**84238**	Golden Genes	Pregnant	10-Mar-10
11-Jun	2127	7H8190	**84231**	Golden Genes	Pregnant	13-Mar-10
12-Jun	2127	7H8190	**84173**	Golden Genes	Pregnant	14-Mar-10
15-Jun	2127	7H8190	**87419**	Golden Genes	Pregnant	17-Mar-10
15-Jun	2127	7H8190	**84270**	Golden Genes	Pregnant	17-Mar-10
15-Jun	2127	7H8190	**84190**	Golden Genes	Pregnant	17-Mar-10
16-Jun	1940	29H12209	**87480**	Golden Genes	Pregnant	18-Mar-10
17-Jun	1940	29H12209	**87104**	Golden Genes	Pregnant	19-Mar-10
17-Jun	1940	29H12209	**84281**	Golden Genes	Pregnant	19-Mar-10
18-Jun	1940	29H12209	**84166**	Golden Genes	Pregnant	20-Mar-10
10-Aug	889	7J0867	**83357**	Maddox	Pregnant	12-May-10
12-Aug	1945	200H3205	**83027**	Maddox	Pregnant	14-May-10
12-Aug	1945	200H3205	**82294**	Maddox	Pregnant	14-May-10
					Total	**31**

CONCLUSION

The Over the past two decades the Cal Poly Dairy has done work with embryology experts to choose, flush and obtain embryos from the top cattle in their superior Holstein and Jersey herds. Due to the high amount of turnover in dairy employees and the various number of herdsmen working with the cattle and performing breeding tasks, as well as the current economic situation facing the dairy and the possible future need to market the embryos on hand as well as the calves obtained from their use the author has compiled information reagarding the embryos currently available at Cal Poly as well as a system of record keeping for future use of the Cal Poly faculty and dairy herd manager.

Through extensive research information was obtained to illustrate proper procedures for preparing and flushing donor cattle as well as implantation and storage of embryos. Through the assistance of Daniela Demetrio of RuAnn and Maddox dairies benchmarks for embryo work in the Western United States were set. Information on all of the current embryo work being done at Cal Poly was collected with the assistance of herd manager Rich Silacci. After comparing the embryo transfer work at Cal Poly to the industry standards set by Maddox and RuAnn dairies the author concludes that based on the discussion presented in the results section Cal Poly exceeds the industry standard in several ways.

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