PN ABU-428
93855

TECHNICAL ASSESSMENT OF ARP

1. SUBPROJECT DESCRIPTION : STUDIES ON EMBRYOS TRANSFER TECHNOLOGY AND BIO-ENGINEERING IN LIVESTOCK SPECIES AND THEIR PATHOBIOLOGICAL IMPLICATIONS

A. PURPOSE

1. Statement of Purpose

The purpose of the subproject is to strengthen the National Agricultural Research system comprising of Indian Council of Agricultural Research (ICAR) and Agricultural Universities research capacity to embryo transfer (E.T.) research in Indian livestock with specific emphasis on buffaloes, cattle and goats. The major advantage of the technology pertains to the generation of greater number of offsprings from genetically superior female buffaloes, cattle and goats in a shorter period of time than is possible with the normal reproductive process.

The utilization of technology will help in genetic selection of bulls currently not possible through conventional progeny testing schemes as well as making large number of genetically superior males available to the artificial insemination (AI) system and thus help bringing rapid genetic improvement in designated livestock species.

The ICAR has designated the following 7 major Indian Institutions for this subproject :

1. Indian Veterinary Research Institute (IVRI), Izatnagar, U.P.
2. National Dairy Research Institute (NDRI), Karnal, Haryana.
3. Central Institute for Research on Buffaloes (CIRB), Hissar, Haryana.
4. Haryana Agricultural University (HAU), Hissar, Haryana.
5. G.B. Pant University of Agriculture and Technology (GBPUAT), Pantnagar, U.P.
6. Andhra Pradesh Agricultural University (APAU), Tirupati, A.P.
7. Central Institute for Research on Goats (CIRG), Makhdoom, U.P.

The research activities in embryo transfer are envisaged to the generation of greater number of offsprings especially males from genetically superior females in a much shorter period, which could subsequently be used in breeding program through artificial insemination (AI).

2. Linkage to Higher Goal

Due to inadequate nutrition and indiscriminate breeding, the productivity of the native livestock is extremely poor. The genetic improvement in majority of livestock species especially dairy cattle, sheep, goat and pig is contemplated to be brought through introduction of high productivity genes of superior exotic breeds. Animal breeding is slow to show results especially with species such as cattle and buffaloes which have long gestation interval. By selective breeding with conventional selection of sires on progeny performance will take several generations to improve breeds whereas through embryo transfer the genetic selection and breed improvement can be quickened considerably. The E.T. will allow the exploitation of superior female germplasm as is possible through AI in case of male germplasm. The determination of genetic merit of sires on the basis of full and half sisters made possible by E.T. though not as accurate as progeny testing will nevertheless bring similar genetic progress as through progeny testing through reducing generation interval to half. The E.T. will also help in genetic resources conservation and salvation of superior germplasm being lost through slaughter of high quality buffaloes and cows.

B. SPECIFIC OBJECTIVES

1. Statement of the Problem/constraints

The five year subproject under ARP focuses on the development of technology for embryo transfer in cattle, buffaloes and goats in India. The development of such technology in future years could lead to understand the mechanisms involved in genetic manipulations.

The specific problems identified in the subproject include (a) superovulation and synchronization of donor and recipient animals; (b) collection of ova and embryos for implementation of research and (1) in vitro fertilization, (2) embryo culture, (3) cryopreservation, (4) sexing, (5) cloning, (6) bio-engineering, (7) embryo-environmental interactions and (8) transfer of viable technology for field application.

Before the initiation of this subproject ICAR did not have (1) the full capacity for E.T. technology for buffaloes, cows and goats, also (2) there was no coordinated effort, although some of the centers were involved in development of some of the proposed techniques.

2. Descriptive Statement of the Objective

The subproject was approved by the Department of Economic Affairs on December 18, 1986 and the USAID issued PIL on January 19, 1987. The subproject was to provide major inputs in the form of training of Indian scientist, provision of equipment, supplies and consultancy services of U.S. scientists.

There are 8 centers to this subproject and each unit has its own objectives. These are :

a) ICAR Coordinating Unit : The ICAR shall have the overall responsibility for the coordination of Indo-USAID subproject on embryo transfer technology in livestock.

The objectives are :

1. Overall coordination and monitoring of the subproject "Embryo Transfer Technology and Bio-engineering in Livestock Species and their Pathobiological Implications".
2. Beginning second year, at least once in a year a technical workshop relating to the research topics handled under the subproject will be held, which will be attended by scientists from ICAR, collaborating research institutions and other concerned ICAR institutions. One or two U.S. scientists may also be invited to participate each year beginning second year.

3. ICAR Coordinating Committee will review and evaluate every six months activities under each subproject component. Annual reports will be submitted to ICAR by collaborating research institutions indicating details of research work completed and progress attained. Research results will be published in appropriate scientific journals.

b. IVRI : The proposed research focuses primarily on buffaloes and cattle but small ruminants and laboratory species shall be utilized for basic studies.

The objectives are :

1. Development of methodologies for *in vitro* fertilization and embryo culture.
2. Cryopreservation of embryos and development of different media culture.
3. Sexing, cloning and different aspects of genetic engineering.
4. Embryo - environmental interactions.
5. Pathobiological implications of embryo transfer including disease transmittance and immuno suppressive protein activity *in vitro*.
6. Application of embryo transfer technology to rural areas.
7. Superovualtion and synchronization of donor and recipient animals with emphasis in cattle, small ruminants, swine and rabbits.
8. Collection of ova (surgical and non-surgical) for implementation of various research methodologies.

c) NDRI : The proposed research focuses primarily on cattle.

The objectives are :

1. Non-surgical collection, short-term bovine and bubaline embryo culture, and transfer of embryos.
2. Evaluation of embryos and their cryopreservation.

3. Extension of embryo transfer technology to field units under field/farm conditions (Operational Project) and manpower development through embryo transfer technology training.

4. Superovulation and synchronization methodologies among cattle.

5. Studies for optimizing dose response through evaluation of endocrine responses under different superovualtion regimes with specific reference to buffaloes.

6. Micromanipulation of embryos including sexing, cloning and microinjection of hormone principles.

7. Factors affecting ova production and embryonic survival of the developing zygote.

8. Immunophysiological responses of semen in the female reproductive tract, fertilization processes and immuno-suppressive and feto-maternal relationship.

d) CIRB : The proposed research focuses upon application of embryo transfer technology to increase milk production output in buffaloes and to generate more male buffalo calves for their evaluation as potential genetically superior sires.

The objectives are :

1. Large scale collection of ova (surgical and non-surgical) and transfer; *in vitro* fertilization, sexing and cryopreservation of ova collected non-surgically from the buffaloes.

2. Field application of embryo transfer - collection and transfer of *in vitro* fertilized, sexed, cryopreserved and/or fresh babaline ova from elite females to low production recipient females.

3. Utilization of standardized superovulation protocol developed by NDRI and HAU.

e) **HAU** : The proposed research focuses on buffaloes and cattle.

The objectives are :

1. To study superovulation regimes and embryo production and synchronization methodologies; transport and mobility mechanisms - Department of Gynaecology and Obstetrics.
2. Serum endocrine profile components - Department of Animal Production Physiology.
3. To study factors affecting ovum production.
4. Non-surgical collection and transfer of embryos.
5. Cryopreservation of embryos.

f) **APAU** : The proposed research focuses upon the transfer of cattle and buffalo ova following superovulation and non-surgical collection.

The objectives are :

1. Superovulation and synchronization of donor and recipient animals - standardization of the superovulating hormone regime in Ongole cattle.
2. Collection of ova - nonsurgical collection and short-term bovine (Ongole) embryo culture (M).
3. Field application - transfer of fresh or short-term cultured embryos from Ongole cows to recipients (M).

g) **GBPUAT** :The proposed research is very broad and focuses upon practical embryo transfer in cattle and buffalo; embryo manipulation methodologies and the effects of viral agents upon embryonic development and transmission of disease.

The objectives are :

1. Superovulation in cows and buffaloes.
2. Non-surgical collection and development of methodologies for cervical relaxations and dilation with associated measurement of cervical contraction and electrical activity properties.

3. Collection of numerous ova from buffalo, cattle, small ruminants and rabbits for various types of investigations, cryopreservation of embryos and embryo culture.

4. Field application - transfer of fresh or short-term cultured embryos to cattle, small ruminants and rabbits as a validation method for the cervical relaxation and dilation experiments.

h) CIRG : The proposed research focuses primarily on goats. The objectives are :

1. Large scale collection of ova (surgical and non-surgical) and transfer; in vitro fertilization; sexing and cryopreservation of ova collected non-surgical from the goats.

2. Field application of embryo transfer; collection and transfer of in vitro fertilized, sexed, cryopreserved and/or fresh goat ova from elite females.

C. INPUT/OUTPUT MATRICES BY OBJECTIVES

Specific Objectives

1. Specification of Inputs

(A) U.S.A.

(a) The USAID will arrange training of Indian scientists in embryo transfer technology in U.S.A.

(b) will provide needed basic equipment and supplies and

(c) arrange U.S. Consultants to visit India.

(b) Government of India (GOI)

The GOI through research institutions will provide scientific and technical staff, laboratory and animal facilities for the subproject. ICAR will manage the subproject and monitor the progress in the 7 research centers.

2. Specification of Inputs to Linked Outputs

The expected output will be evaluated through (a) superovulation and standardization of donor and recipient animals; (b) collection of ova for implementation of various basic research methodologies and (c) field application of the Embryo Transfer Technology (E.T.T.).

Each of these targets will have applicability to different centers through a primary focus and a minor focus depending upon basic infrastructural facilities and technical knowhow competence of the center. The linked output will be phased according to competence, developed over the period of the duration of this project.

II. TECHNICAL ASSESSMENT

A. PROGRESS BY OBJECTIVES

1. Assessment of Input provided

(a) U.S.A.

The progress of its subproject was monitored by holding annual workshops and review meetings at the ICAR headquarters where scientists from each center presented their reports. These workshops were also attended by U.S. Consultants consisting of Drs. R.P. Elsden, A.K. Karihaloo in 1987, 1988 and 1989 and Dr. D.S. Dhindsa in 1989. These workshops and review meetings critically evaluated the development of infrastructure facilities and implementation of technical program. After attending the workshops the U.S. Consultants visited most of the research centers to get firsthand information on the infrastructure developed and for assessing the need for equipment, supplies and other facilities to be provided under the project. The U.S. Consultants have over these years made their suggestions to the Indian scientists for improving their success rate for superovulation, estrous synchronization and collection of embryos as well as design of experiments to obtain meaningful and interpretable data.

The U.S. Consultants at the end of each visit submitted their findings, assessment of progress for each center and recommendations for required equipment supplied and further training of Indian scientists to Winrock International in New Delhi.

The input provided by the USAID for training of Indian scientists was appropriate and timely. However, the number of U.S. Consultants has been reduced considerably. Originally 15 persons were supposed to visit U.S.A., so far only three have visited U.S.A. Over the life of the subproject provisions were made to train 49 Indian scientists including attendance of international scientific meetings and study tours with a total budget for travel was $841,000 (see Appendix a).

Thirteen scientists have already been to U.S.A. for this purpose. It was decided that in future basic E.T. training will be given in India by the Indian scientists with the help of U.S. experts. However, for sophisticated techniques consisting of embryo freezing, splitting, sexing, cloning and gene transfer, Indian scientists will be trained in U.S.A. laboratories. As a result of these modifications, the training budget was reduced to $316,000 in July 1989. Similarly, the availability of U.S. experts was appropriate. However, there was an extraordinary delay in the procurement and shipment of supplies and equipment which delayed progress in the research centers. The current status of equipment and supplies is as follows :

All of the six centers who requested basic embryo transfer kits have received them. Five kits were delivered in April 1990 and one kit in June 1990. This will allow each center to undertake research on estrous synchronization, superovulation, embryo collection and embryo transfer.

In the equipment category, 24 units of equipment were requested under USAID program by the centers. Out of these, 5 units have been delivered. Six units are in the warehouse (U.S.A.) and are ready for shipment. Nine units have been contracted for and are expected in the warehouse between November 15 to December 15, 1990. Four units constituting two items in microscope (3 units) and micromanipulator (1 unit) are yet to be contracted (see Appendix b).

b) Government of India (GOI)

The Indian Government counterpart of the project was expected to service the project by providing the necessary support to its project through the identified institutes. Though the Institute identification and their research centers had been earmarked very objectively keeping the broad and the regional consideration but the participating institutes seemed to lack the requisite basic support

system for effective participation in the project except some of the large Institutes, e.g. IVRI and NDRI which had earlier received assistance for such work from a number of other internal and external agencies.

NDRI : The NDRI has two other projects related to this subproject :

1. A UNDP supported Center for Advanced Studies in Animal Biotechnology which also covers embryo transfer technology.
2. Department of Biotechnology, Ministry of Science & Technology, Government of India has a Science and Technology project on cattle improvement through embryo transfer. A center of this project is located at NDRI.

IVRI : The IVRI has three other projects related to this subproject :

1. A UNDP supported Center for Advanced Studies in Immuno biotechnology which includes embryo transfer.
2. Department of Biotechnology, Ministry of Science & Technology, Government of India has a Science and Technology project on cattle improvement through embryo transfer. A center of this project is also located at IVRI.
3. Center for Post-Graduate Education in Biotechnology including embryo technology is being also supported at IVRI by the Department of Biotechnology.

The Science and Technology project of DBT is being coordinated by NDDB (National Dairy Development Board).

2. Assessment of Output Achieved

Out of the seven centers selected for this subproject, five centers have achieved good success for estrous synchronization, superovulation, embryo recovery and transfer. These centers include NDRI, IVRI, CIRB, CIRG and APAU whereas remaining two centers, i.e. at HAU and G.B. PANT have not made much progress in these areas.

The detailed progress report is mainly based on my last review of the project conducted in January 1990 and in addition some information was obtained from NDRI in November 1990 and the progress made by each of the participating unit is as follows :

1. Indian Veterinary Research Institute in Izatnagar, U.P.

The physical facilities for carrying out embryo transfer and related aspects are excellent. The scientific staff has the background and great enthusiasm for carrying out research. The number of animals available and their maintenance quarters are excellent. Embryo transfer is being carried out both in cattle and in buffaloes.

Embryo transfer has resulted in about 25-30 percent pregnancies in cattle. However, the number of embryos transferred in buffaloes is small and no pregnancy has occurred so far. More difficulties are being encountered in estrous synchronization and superovulation in buffaloes as compared to cattle. However, efforts are being made to resolve these problems. Progress is being made at a very slow rate. Scientists at this Institute are very enthusiastic to start very sophisticated projects on splitting of embryos, freezing of embryos and gene transfer in cattle and buffaloes. Since their pregnancy rate in routine normal embryo transfer is quite low, the data obtained after freezing, splitting and gene transfer will further reduce the pregnancy rate. The scientists at this Institute should make every effort first to improve conception rate after fresh embryo transfer before going into more sophisticated and demanding techniques.

2. National Cattle Research Institute in Karnal, Haryana

a. Cattle

This center has done considerable work on embryo transfer in cattle in the past two years. They transferred 193 embryos which resulted in 46 pregnancies. Forty-three calves have been born. By embryo transfer they obtained

five calves from one donor and 10 calves from another animal by superovulation. This success in embryo transfer in cattle is good compared to other Indian research centers. However, it is still far below the success rate reported in western countries. Thirty-five embryos have been frozen. Two pregnancies have resulted from frozen embryos.

b. Buffaloes

Currently this center is putting more emphasis on buffaloes for embryo transfer and related aspects. Last year they have purchased 49 high milk yiled buffaloes from Bombay which will be used as donors. So far they have transferred 70 embryos and 12 animals were diagnosed as pregnant. Seven calves have been born. Seven embryos have been frozen; one pregnancy has resulted from frozen embryos.

They have been doing work pertaining to oocyte collection, maturation and *in vitro* fertilization utilizing material obtained from a Delhi slaughter house which is located about 130 kilometers away. They have successfully *in vitro* fertilized the oocytes and cultured these to the blastocyst stage. In January 1990, with the help of Dr. Suzuki from Japan, they have transferred nine *in vitro* fertilized embryos in buffaloes. So far one animal has been diagnosed as pregnant.

They have excellent laboratory facilities for hormone measurements and have done considerable work for the measurement of protein and steroid hormones in various species during estrous cycle, pregnancy and the anestrous period. An enzyme assay has been developed for measurement of minute quantities of progesterone in milk. This assay will be used for detecting estrous and pregnancy diagnosis in animals. The endocrine studies although not directly related to the project are required for understanding the superovulating responses. Methods for measuring hormones in the milk and blood will also help in estrous detection and pregnancy diagnosis.

3. Central Institute for Research on Buffaloes in Hissar, Haryana

The number of animals for embryo transfer is excellent. The management and maintenance facilities for animals are good. The scientists at this Institute have great enthusiasm for embryo transfer technology. However, the conception rate after embryo transfer in buffaloes is about 25 percent, which is very low as compared to cattle. Difficulties are being encountered in the superovulation, the ovulation rate is about 2.5 to 3 per animal. This is quite low as compared to cattle. Now the investigators have started collecting embryos from the naturally cycling animals after insemination. These embryos are being transferred into recipients, however, if recipients are not available the embryos are recovered and frozen for later use. Data are not available for success of by-transferring frozen embryos in buffalo.

4. Central Institute for Research on Goats in Makhdoom, U.P.

The research facilities, technical manpower and animal facilities are excellent. The center requires a phase contrast microscope and embryo freezing equipment. Surgical recovering and transfer of embryos has been done successfully on a sizeable number of goats. (Data pertaining to the success rate of this project was not available for this report).

5. G.B. Pant University of Agriculture and Technology in Pantnagar, U.P.

The center has made very little progress in the year of review. Twenty-four embryos were transferred in 12 recipient cows. One became pregnant and that animal aborted at 3-1/2 months of pregnancy. Despite the fact that two scientists have been trained in embryo transfer under the project, and a basic embryo transfer kit has now been supplied, there is serious lack of interest at the

center in implementing the program. This was reflected by non-submission of reports and non-participation in the annual workshops. During the last review a recommendation was made to close this center. It is understood this center has been closed for E.T.

6. Haryana Agricultural University in Hissar, Haryana

Two independent units, one in the Department of Gynaecology, College of Veterinary Sciences and the other in the Department of Animal Production Physiology, College of Animal Sciences are operating under the project. In spite of repeated advice from the project coordinating unit the two units have not been unified. Two trials for superovulation and collection of embryos in buffaloes with different combinations of hormones were carried out. However, the success rate is very low. A total of 30 embryos were collected during 1989. None of the fertilized embryos, however, were transferred due to non-availability of recipients. Considerable work on endocrine profiles in different species of animals during the estrous cycle and gestation, as well as the effect of environment on the hormone profiles, has been carried out.

7. Andhra Pradesh Agricultural University in Tirupati

The center has done some work on surgical recovery and transfer of embryos in cattle with success. The work as envisaged under the project has not progressed significantly. The center could profitably be linked with the large Ongole cattle breeding project at Lam and also with the University. This will allow it to utilize the large animal facilities of the breeding project, and help in utilizing the technologies for further genetic improvement.

B. Progress toward Objectives

1. Appropriateness of the Objectives

a. ICAR/SAU system

The objectives set up by the ICAR to develop the capacity for estrous synchronization, superovulation, collection and transfer of embryos in domestic animals were appropriate. The ICAR identified 7 major institutions for this purpose.

b. Indian system

The Indian universities that were enthusiastic to initiate this subproject have not been able in majority cases to provide adequate manpower, laboratory facilities and number of animals for this project.

2. Importance of U.S. Interest

a. Current

1. To maintain manpower.
2. Support to develop capacity for basic research.
3. Initiate transfer of technology.
4. Open new avenues for research in areas uninvestigated previously.

b. Future

1. Possibility of exchange of superior germplasm.
2. Export of high quality embryos from U.S.A. to India.

3. U.S. Role and Advantage in Cooperation

a. To train Indian scientists in basic Embryo Transfer Technology and other techniques.
b. Upgrade research facilities especially equipment and supplies not readily available in India.
c. Initiate transfer of technology.

d. Open new avenues for research in areas uninvestigated previously.

e. Possibility of germ exchange of superior germplasm within the country and to other countries.

f. Possibility of import of high quality embryos of superior dairy breeds from U.S.A. to India.

C. Progress toward Output

1. Relevance

a. Embryo transfer is highly relevant to the ICAR since the Council began the apex body for promoting, supporting and coordinating agricultural research in its own research institutes and state agricultural universities. A coordinated down stream flow of knowledge and expertise can only be expected through the ICAR system. The initiation of this subproject for E.T.T. under USAID has resulted in the initiation of E.T. program at the national level. Due to this project some collaborative activities are developing among various research institutes and agricultural universities. Such activities will eventually enhance the quality and productivity of food production and improve the quality of the rural population in India. It will also enhance the capability of Indian scientists for basic research in reproductive biology.

2. Mutuality of Interest

a. Current

Exchange of knowledge and competence enhancement in the developing countries.

b. Future

Extension of western technology of such species and genetic material which are non-existent in the western hemisphere but are relevant to their involvement in international development.

3. <u>Follow-on Cooperation</u>

a. This program will help scientists of India and the U.S.A. to develop cooperative programs for mutual interest.

b. This subproject will also help to develop cooperation and joint research programs among Indian Institutions.

III. CONCLUDING REMARKS AND RECOMMENDATION

This subproject on embryo transfer technology was started in 1987 and has subsequently been reviewed through the organization of annual workshops and review meetings where U.S. scientists are part of the subproject. The Unites States has provided training to ten Indian scientists for embryo transfer technology. The quality of the training is good, however, the duration of the training did not appear to be long enough, mainly due to inadequate advance preparation of the trainees. Thus, in future, such training for basic embryo transfer will be provided in India with the help of the U.S. experts. The duration of training may be adjusted to suit the requirements of the training groups at little extra cost.

Embryo transfer technology, although highly sophisticated and costly as compared to Artificial Insemination (AI) in general has tremendous relevance to the animal improvement program in India. (1) The small size of animal holdings and (2) lack of sufficient pedigree and performance recorded populations specifically of cattle and buffaloes limit genetic selection. The embryo transfer associated with open nucleus breeding herd could help in determining (a) the genetic merit of a large number of bulls on existing institutional farms and in making genetic progress through selection, especially in case of buffaloes and indigenous cattle breeds which coupled with AI with frozen semen will help in bringing faster genetic progress. The technique can also help in (b) salvage of superior dairy buffalo germplasm currently being lost through slaughter of high producing buffaloes in metropolitan cities after they go dry and also (c) in animal genetic resources conservation through cryopreserved embryos and oocytes.

Since the species and the type of breeds available in India are different from the countries where the embryo transfer technology has been evolved, it will require considerable research effort, both basic (including basic reproduction biology and hormone profiles) and applied, in adapting/evolving these technologies relevant to the Indian situation.

It will, therefore be necessary that the major training program in routine embryo collection and transfer be conducted in India using Indian cattle and buffaloes. U.S. scientists and Indian scientists may be involved in conducting such a training program. An earlier attempt to organize such training on embryo transfer in buffaloes in December 1988 was not very successful. Training of the Indian participants in the project is now scheduled in the early part of year 1991 at NDRI in Karnal where two U.S. scientists will be participating.

A concentrated effort should be made to ensure a successful training program. Both the Indian Veterinary Research Institute and National Dairy Research Institute have the responsibility of organizing such training regularly. Several training programs have already been conducted as a part of other embryo transfer program. However, the training in the areas of (1) embryo sexing, (2) cloning, (3) micromanipulation, (4) in vitro maturation, fertilization and culture of oocytes should be organised in the U.S.A. laboratories of Indian scientists who have well mastered the techniques of estrous synchronization, embryo collection and transfer.

For the success of the project it is necessary that the subproject make available the required equipment and supplies immediately. The participating institutes should also fulfil the commitments for providing manpower, the laboratory and animal facilities. The life of the project should also be extended at least by one more year without provision of additional resources from the ARP.

The coordination and management of the project is currently being handled by the Division of Animal Science at the ICAR headquarters. The headquarters so far has been able to organise annual workshops and review meetings but no consolidated reports have been prepared. Although logistic support and overall monitoring should be done by the headquarters, scientific coordination and monitoring should be made the responsibility of a senior scientist involved in the project at one of the participating institutes.

It is anticipated that the implementation of the recommendations made in the subproject will allow creation of basic infrastructure and trained manpower. These will have to be utilized in continuing basic and applied research on various aspects of female reproduction especially endocrinology, which will help in perfecting the protocols for superovulation, recovery and transfer of embryos. The project will also help in developing expertise and protocols in the area of (1) sexing, (2) cloning and (3) in vitro handling of oocytes and embryos. These techniques could help in genetic improvement through salvage of superior germplasm and animal genetic resources conservation. Both the research and development of embryo transfer technology and its application will have to be continued after the life of the subproject is over and would require continued support from the ICAR. In emerging areas, however, support from the ARP in terms of further training or supply of critical input may have to be continued.

In summary, the objective of this project is very worthwhile and will help in enhancing the capacity and capability of Indian scientists to expand for both basic and applied research in reproductive biology and genetics. However, in the original document of this subproject the objectives were not clearly stated and were too broad and ambitious. Some of the objectives may not be fully achieved during the life of the project due to the following reasons :

1. The project had a very slow start.
2. The procurement of equipment and supplies was delayed considerably due to many factors.
3. Some of the state universities have not fulfilled their commitments by providing facilities for this project.
4. Several of the sophisticated and demanding techniques dealing with in vitro fertilization, sexing, cloning, bio-engineering and gene transfer are difficult and may not be fully operational in India during the life of the project.

Appendix

TRAINING REQUIREMENTS

~~(In 000's of Dollars)~~

Institution Component	Year 1 No. Person	Year 1 Total Weeks	Year 2 No. Person	Year 2 Total Weeks	Year 3 No. Person	Year 3 Total Weeks	Year 4 No. Person	Year 4 Total Weeks	Year 5 No. Person	Year 5 Total Weeks	Total No. Person	Total Total Weeks
ICAR Coordinating Unit	7	42	3	10	3	10	3	10	3	10	19	82
IVRI	1	39	6	173	4	121	-	-	-	-	11	333
NDRI	2	52	2	52	2	52	-	-	-	-	6	156
CIRB	1	26	1	26	1	26	-	-	-	-	3	78
HAU	1	26	1	26	-	-	-	-	-	-	2	52
APAU	1	26	1	26	-	-	-	-	-	-	2	52
GBPUAT	1	26	1	26	1	26	-	-	-	-	3	78
CIRG	1	26	1	26	1	26	-	-	-	-	3	78
Total	15	263	16	365	12	261	3	10	3	10	~~46~~ 47	909

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Summary

Appendix - a

TRAINING COSTS
(In 000's of Dollars)

Component	Year 1		Year 2		Year 3		Year 4		Year 5		Total	
	No.	Cost	No.	Cost	No.	Cost	No.	Cost	No.	Cost	No.	Cost
ICAR Coordinating Unit	7	52	3	16	3	16	3	16	3	16	19	116
IVRI	1	33	6	150	4	105	-	-	-	-	11	288
NDRI	2	46	2	46	2	46	-	-	-	-	6	138
CIRB	1	23	1	23	1	23	-	-	-	-	3	69
HAU	1	23	1	23	-	-	-	-	-	-	2	46
APAU	1	23	1	23	-	-	-	-	-	-	2	46
GBPUAT	1	23	1	23	1	23	-	-	-	-	3	69
CIRG	1	23	1	23	1	23	-	-	-	-	3	69
Total	15	246	16	327	12	236	3	16	3	16	49	841

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Appendix

SUBPROJECT EMBRYO TRANSFER TECHNOLOGY

EQUIPMENT STATUS (AS OF NOVEMBER 1, 90)

SL.NO	ITEM DESCRIPTION	QUANTITY	COST	ESTIMATED DELIVERY TO WAREHOUSE USA	STATUS
	COORDINATING UNIT				
1	COMPUTER	1	1.122	WAREHOUSE	
2	VIDEO EQUIPMENT	1	0.501	WAREHOUSE	
3	SLIDE PROJECTOR	1	1.475	WAREHOUSE	
4	COPIER	1	11.113	WAREHOUSE	
	AFAU				
5	BASIC KIT	1	11.996		DELIVERED TO INSTITUTION
6	LAPARASCOPE	1	10.203		DELIVERED TO INSTITUTION
7	LAMINAR FLOW HOOD	1	1.114	15/12/90	
88	CENTRIFUGE, REFRIGERATED	1	0.425	15/12/90	
9	AUTOCLAVE	1	1.499	WAREHOUSE	
10	CO2 INCUBATOR	1	10.649	30/10/90	
11	MICROSCOPE	1	15.252	15/11/90	
	CIRG				
12	BASIC KIT	1	11.996		DELIVERED TO INSTITUTION
13	LAPARASCOPE	1	10.203		DELIVERED TO INSTITUTION
	CIRB				
14	BASIC KIT	1	11 996		DELIVERED TO INSTITUTION
15	LAPARASCOPE	1	10.203		DELIVERED TO INSTITUTION

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