USE OF A STANDARDIZED PROTOCOL TO IDENTIFY FACTORS AFFECTING THE EFFICIENCY OF ARTIFICIAL INSEMINATION SERVICES FOR CATTLE THROUGH PROGESTERONE MEASUREMENT IN FOURTEEN COUNTRIES

M. GARCÍA
IVITA Research Centre,
Universidad Nacional Mayor de San Marcos, Lima, Peru

XA0101335

W.J. GOODGER, T. BENNETT
University of Wisconsin-Madison,
Wisconsin, United States of America

B.M.A.O. PERERA
Animal Production and Health Section,
International Atomic Energy Agency,
Vienna

Abstract

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The aim of this co-ordinated research project (CRP) was to quantify the main factors limiting the efficiency of artificial insemination (AI) services in cattle under the prevailing conditions of developing countries, in order to recommend suitable strategies for improving conception rates (CR) and the level of usage of AI by cattle farmers. A standardized approach was used in 14 countries over a five-year period (1995–1999). The countries were: Bangladesh, China, Indonesia, Myanmar, Pakistan, Sri Lanka and Vietnam in Asia; and Argentina, Chile, Costa Rica, Cuba, Peru, Uruguay and Venezuela in Latin America. A minimum of 500 cows undergoing first insemination after calving were expected to be monitored in each country. Data regarding farms, AI technicians, semen used, cow inseminated, characteristics of the heat expression and factors related to the insemination were recorded. Three milk samples (or blood samples for dairy heifers and beef cows) were collected for each service to measure progesterone by radioimmunoassay. These were collected on the day of service (day 0) and on days 10–12 and 22–24 after service. Field and laboratory data were recorded in the computer package AIDA (Artificial Insemination Database Application) which was developed for this CRP. The study established the current status of AI services at selected locations in participating countries and showed important differences between Asian and Latin American farming systems. The mean (± s.d.) of the interval from calving to first service for 7 992 observations was 120.0 ± 82.1 days (median = 95 days) with large differences between countries ($P < 0.05$). The overall CR to first service was 40.9% (n = 8 196), the most efficient AI services being the ones in Vietnam (62.1%), Chile (61.9%) and Myanmar (58.9%). The interval between the first and second service was 44.6 ± 44.4 days (n = 1 959). Progesterone data in combination with clinical findings showed that 17.3% of the services were performed in non-cyclic cows; within this group 10.4% of cows were anoestrous or anovulatory, 2.2% were non-pregnant but bearing an active corpus luteum, and 4.7% were already pregnant. The highest incidence of problems was observed in farms of Cuba, Costa Rica, Indonesia and Venezuela. Progesterone data also showed that 27.4% of inseminated cows did not conceive but subsequent heats were unobserved, resulting in their non-pregnancy status being identified only at manual pregnancy diagnosis, usually 80–120 days after service. A further 10.1% of inseminated cows most probably conceived but lost their embryos between 16 and 50–60 days after service. These results show that nearly half of the inseminations were associated with factors of management deficiency or human error in the farms or in the AI service, thus adversely affecting the reproductive performance of the herds and leading to low efficiency of AI services.

1. INTRODUCTION

Specialized dairy farms and some dual-purpose (milk and beef) farms routinely use artificial insemination (AI) for breeding and genetic improvement; however, a number of biological, managerial and socio-economic factors affect the quality and efficiency of the technique and therefore limit the number of farmers embracing its use. On the other hand, actions aiming to improve the efficiency of the AI system have to be based on proper knowledge of the prevailing conditions and constraints.

Systematic and detailed collection of information regarding the farming system, farm characteristics, animal performance, application of the AI technique and heat expression may enable the identification of the limiting factors affecting the reproductive performance of dairy herds. Moreover, the measurement of progesterone using radioimmunoassay (RIA) in a series of milk samples (or blood in the case of dairy heifers and beef cattle) can add valuable information to evaluate the reproductive status at and after AI, and to determine factors that affect its efficiency. It is also a proven tool to monitor the responses to technical interventions aimed at ameliorating constraints to AI [1, 2, 3]. The results of these interventions can be reflected in improved efficiency in heat detection, better timing of AI and higher CR. These are key factors to increase the number of animals and farms being bred by AI. An additional benefit would be the identification of animals with pathological conditions such as anoestrus beyond 60 days after calving).

This paper presents a synthesis of the methodology adopted, and the results obtained, under the Joint FAO/IAEA Co-ordinated Research Project (CRP) entitled "Use of RIA and Related Techniques to Identify Ways of Improving Artificial Insemination Programmes for Cattle Reared under Tropical and Sub-tropical Conditions", which was implemented in 14 developing countries over a period of 4 years. The objective of this paper is to compile salient information from individual country projects, in order to highlight the potential value of the methodology used (i.e. progesterone RIA, clinical data, field data-entry forms and a computer database) for improving the efficiency of AI systems in developing countries. It is emphasized that the aim is not to compare the efficiency of AI services or to highlight differences between countries, and that the results do not apply at national level, but reflect the status of AI services at specific locations selected for the study in the different countries. The authors fully acknowledge the scientific rights of the project counterparts to the data obtained under this project, and wish to refer the reader to the individual papers published by them in this IAEA-TECDOC for the detailed results.

2. MATERIAL AND METHODS

2.1. Selection and technical backstopping of the participating institutions

The full description of the project including the rationale, scientific scope, operating procedure and requirements for participation were published in an IAEA Newsletter in 1994 [4] and distributed worldwide through various means including FAO and UNDP offices in developing countries. Around 30 proposals for research contracts were received, mainly from institutes in Asian and Latin American countries. Selection of suitable proposals was done on the basis of technical capabilities, adequate links with large AI services and availability of facilities and expertise on progesterone RIA. The institutions selected were from Bangladesh (BGD), China (CPR), Indonesia (INS), Myanmar (MYA), Pakistan (PAK), Sri Lanka (SRL), and Vietnam (VIE) in Asia (n = 7), and from Argentina (ARG), Chile (CHI), Costa Rica (COS), Cuba (CUB), Peru (PER), Uruguay (URU), and Venezuela (VEN) in Latin America (n = 7).

The chief scientific investigator (CSI) of each research contract participated in a research coordination meeting (RCM) in November 1995 in Vienna, to standardize work plans and key activities between participating countries, and to be trained on the use of AIDA (Artificial Insemination Database Application) a computer software package developed for this project [5]. A second RCM took place in February 1997 in Melbourne, Australia to review preliminary results and define technical interventions. The third and final RCM took place in May 1999 in Uppsala, Sweden to present the final results and prepare papers for publication. A group of advisers in the field of animal reproduction, artificial insemination, semen evaluation, and RIA technically supported the contract holders during the meetings and through correspondence at other times.

In addition, some of the authors visited many of the project sites during the implementation of the survey. Copies of the data tables recorded on AIDA were also interchanged at various times by e-mail for review and advise.

2.2. Data collection

Field activities were conducted mainly during 1996 and 1997 in the 14 participating countries, but in a few places this period was extended until 1998. The laboratory work was completed by May 1999.

Information regarding the farms involved in the survey, AI technicians, semen and sires, inseminated animals, heat expression observed by farmers and AI technicians, and characteristics of the local AI services was collected. Five data-entry forms were prepared to collect field information (i.e. farm, AI technician, semen batch, cow, insemination). The forms, which were translated into the local languages, were designed in a way that most of the information could be entered by ticking off the options in a list, and little information had to be written down. All paper forms resembled the on-screen forms of the computer database to facilitate data entry. The list of recorded parameters, data recording forms, and further explanation can be found in García, 1996 [5].

It was expected that the survey would cover a minimum of 500 cows undergoing the first insemination after parturition. However ARG, CUB, MYA and PAK could not reach this target. The farms were selected on the basis of their being representative of the farming system in the study area. Elite farms or those with higher than average productivity or reproductive performance were avoided. AI technicians were not informed of the real objectives of the study to avoid any bias in the results due to changes in their attitude and performance.

2.3. Milk (and blood) sampling and laboratory analysis

Three samples were collected. The first was taken on the day of service (day 0), the second between days 10–12 after service, and the third between days 22–24 after service. The third sample was only collected if the animal was not observed in heat at the expected time. The sampling scheme was repeated for subsequent services in some countries.

A typical milk sample consisted of 5–20 mL of milk collected from any healthy quarter of the mammary gland into vials with sodium azide as a preservative, kept in refrigeration (+4°C) for 3–7 days and then defatted by centrifugation (2 000 g ×15 min). Blood samples (5–10 mL) were usually collected from the jugular vein into heparinized vacutainers, centrifuged within 4 hours, and the plasma harvested. Skimmed milk and plasma samples were kept at –20°C until analysis.

Progesterone concentration in milk or plasma samples was measured using the FAO/IAEA RIA kits [6] which are based on a solid-phase RIA technique employing ^{125}I-progesterone as tracer.

2.4. Data storage and statistical analysis

An *ad hoc* database using Microsoft Access 2.0 and runtime files was developed to enter the field data and laboratory results [5]. This software entitled "AIDA" (Artificial Insemination Database Application) had on-screen data-entry forms for farms, AI technicians, semen batches, inseminated cows, services, and progesterone values. The application contained facilities for data verification and a large number of built-in reports with simple statistical analysis for calculating reproductive performance and the interpretation of progesterone values. AIDA also had data export routines for a number of datasets to export raw and calculated data in Excel 3.0 format.

The statistical analyses used in the study are described in "GAIDA" (Guide for AIDA Data Analysis) [7].

3. RESULTS AND DISCUSSION

3.1. Characteristics of farms and AI services

3.1.1. Farms

The surveys in Asian countries, except in CPR, focused mostly on smallholder farms (1-2-cows) but some 10–20 cow-farms were also included. Data from INS and SRL included two distinct types of farms (smallholdings and large farms) and the data was therefore analysed separately for each type of farm. As shown in Table I the predominant type of animals were dairy cattle, with some dual-purpose

TABLE I. PREDOMINANT CHARACTERISTICS OF FARMS AND FACTORS RELATED TO INSEMINATIONS IN THE 14 COUNTRIES PARTICIPATING IN THE PROJECT

Country	N° of Farms	Purpose	Housing	N° of cows/farm	Milkings per day	Suckling	Km from AI unit to farm	Heat detection	Time of AI (% am)	AI - PD[4] interval (d)
Argentina	8	Dairy	None	180	2	None	0	Visual	40.5	?
Chile	7	Dairy[1]	Night corral	150	2	None	13.1	Visual	85.4	109.8
Costa Rica	4	Dual	Corral	74	1-2	Several	0	Visual	23.4	67.1
Cuba	4	Dairy	Corral	286	2	Several	0	Visual	100.0	?
Peru	9	Dairy	Corral	350	2-3	None	0	Visual	49.3	?
Uruguay	5	Dairy	None	180	2	None	3.4	Visual	97.6	?
Venezuela	6	Dairy[1]	None	476	2	2 x day	19.7	Visual[3]	59.2	62.6
Bangladesh	406	Dairy[2]	Tie stall	2	1-2	Several	2.6	Visual	41.7	81.6
China	10	Dairy	Corral	266	2	None	0	Visual	?	60.4
Indonesia (a)	229	Beef[2]	Various	2	--	--	8.2	Visual	62.1	112.8
Indonesia (b)	1	Beef	Corral	7 500	--	--	40.0	Visual	78.4	83.8
Myanmar	222	Dairy	Tie stall	2	1-2	Several	3.5	Visual	41.4	83.4
Pakistan	107	Dairy	Tie stall	2	2	2 x day	10.0	Visual	100.0	?
Sri Lanka (a)	246	Dairy	Tie stall	1	2	2 x day	5.2	Visual	52.9	81.0
Sri Lanka (c)	4	Dairy	Tie stall	230	2	None	0	Teaser	4.3	67.0
Vietnam	467	Dairy	Tie stall	3	2	2 x day	4.6	Visual	59.3	100.2

(a) Small farms; (b) Co-operative farm; (c) Government farm

[1] Some cows for dual purpose; [2] Some cows for draught; [3] Some farms use teaser bulls; [4] Interval from AI to pregnancy diagnosis (mean in days)

animals and, in the case of INS, mainly beef cattle. Hand milking was done 1–2 times per day using the calf for the "let-down" of milk. Farm records were non-existent or limited to cow cards.

The Latin American studies all had large farms with cattle populations ranging from 20 to 1 500 dairy cows, mainly of the Holstein type. Cattle were kept in corrals (CHI, COS, CUB, PER) or grazed in large paddocks (ARG, URU, VEN). Milking was done twice a day by machine and without the presence of the calf (Table I). Farm records were mainly kept in computers and in printed cow cards.

3.1.2. Artificial insemination units

Farmers contacted the AI units for insemination services using various mechanisms. Inseminators had to travel long distances to reach Latin American farms that did not have their own inseminators (CHI, VEN), while under Asian conditions, most of the farms were located within 1–7 km from the AI unit (Table I) and inseminators used bicycles, motorcycles or cars for transportation.

The time for providing AI services in relation to the time when heat was first observed did not have a common pattern. All services in PAK and CUB and most of the services in CHI and URU were performed in the mornings (Table I), whereas other places had an even distribution between morning and afternoon services. The interval between heat observation and AI was only recorded in 7 countries and some intervals were unusually long (BGD 17.6 h, SRL 20.9 h and VIE 22.4 h). Pregnancy diagnosis by rectal palpation was usually done between 80–120 after the service (Table I).

3.1.3. AI technicians

The number of inseminators included in the survey varied between 2 and 19 (mean: 8.3 and median: 7) per country. The inseminators in Asia were mainly employed by government AI centres whereas in Latin America they were regular staff of private farms and co-operatives. Large variability was found among the average number of services done by a technician per month and in their educational background (Table II).

3.1.4. Semen and sires

The semen used was produced locally in most countries, except in PER and COS which mostly used imported semen. Frozen straws were the most common type of semen; however pellets were also used, either partly (CPR and VIE) or exclusively (CUB). Some chilled semen was used in BGD and SRL. An interesting difference was that Asian AI services used 0.25 mL straws whereas the Latin Americans used 0.5 mL straws (Table II). Thawing of frozen semen was done mainly in warm water.

The number of sires involved in the study varied from 7 to 68 per country (mean 29.9, median 25, Table II). The quality of the semen, when it was evaluated, was usually within acceptable standards, with the exception of PAK where motility and viability of sperms were low at the AI units due to inappropriate storage and handling.

3.1.5. Inseminated cows

As shown in Table III the age at first service after parturition in the surveyed population was 5.6 ± 2.3 years (mean ± s.d, n = 5 476) and parity was 2.8 ± 1.7 (n = 5 953), without significant differences between countries. This homogeneous nature of the population as age and parity was concerned, facilitated the possibility of comparing other variables in the study.

The need for some sort of professional assistance during parturition was high in ARG (16.7%), CHI (30.2%) and URU (11.5%). It is a common practice in these large farms to keep cows close to parturition time in delivery corrals and around-the-clock specialized staff observing the animals and intervening if calving is taking longer than 1–2 h. A high incidence of retention of placenta was observed in VIE (9.9%).

Body condition and milk yields at AI were abnormally low in Holstein cows in CUB (1.9 and 4.8 kg, respectively) due to lack of concentrates and scarcity of forage in the country. Body weight at AI greatly differed between countries, mainly due to the variety of breeds and nutritional regimes. The higher body weights were observed in PER (591 kg), CHI (546 kg) and URU (536 kg), and the lowest in BGD (211 kg), the latter reflecting the small size of the indigenous animals (Table III).

TABLE II. PREDOMINANT CHARACTERISTICS OF SEMEN USED AND AI TECHNICIANS IN AN AI SURVEY CONDUCTED IN 14 COUNTRIES.

Country	N° of sires	Semen			AI Technician				
		N° of batches	Source	Semen type (volume, ml)	N°	Age (years)	Level of education	AI per Month[1]	Employer
Argentina	30	32	Local[2]	Straw (0.25)	10	40.0	High /Primary school	23	Private /government farm
Chile	52	65	Local[2]	Straw (0.5 /0.25)	6	48.5	Diploma/Primary	195	Self employed / various
Costa Rica	11	15	Imported	Straw - ?	4	28.2	Primary school	?	Private farm
Cuba	19	20	Local	Pellets (0.5)	7	33.3	Diploma	150	Government farm
Peru	68	68	Imported	Straw (0.5)	19	?[5]	Various	20	Private farm
Uruguay	24	24	Local[2]	Straw (0.5)	3	39.6	Primary / High school	135	Private /government farm
Venezuela	51	60	Local	Straw (0.5)	10	36.3	High /Primary school	90	Private farm /co-operative
Bangladesh	26	145	Local[2]	Straw /Chilled[3]	7	39.9	Diploma	165	Government AI centre
China	67	67	Local	Straw /Pellets (0.25)	8	34.2	High / Professional	?	?
Indonesia (a)	6	14	Local	Straw (0.25)	14	29.1	High /Primary school	?	Government AI centre
Indonesia (b)	2	5	Local	Straw (0.25)	2	?	High school	?	Government AI centre
Myanmar	11	45	Local	Straw (0.25)	5	48.4	Diploma	65	Government AI centre
Pakistan	7	7	Local	Straw (0.5)	2	28.8	Diploma	35	Government AI centre
Sri Lanka (a)	24	68	Local[2]	Straw /Chilled[4]	8	42.9	High school	54	Government AI centre / farm
Sri Lanka (c)	7	7	Imported	Straw (0.25)	7	34.2	High school	43	Government farm
Vietnam	13	13	Local[2]	Pellets /Straw (0.5)	4	35.5	Professional / Diploma	200	Government AI centre

[a] Small farms; [b] Co-operative farm; [c] Government farms

[1] Average N° of inseminations per month; [2] Some were imported; [3] Various volumes; [4] 0.25/1.0; [5] Unknown

TABLE III. PREDOMINANT CHARACTERISTICS OF INSEMINATED ANIMALS AND HEAT EXPRESSION IN AN AI SURVEY CONDUCTED IN 14 COUNTRIES

Country	N° of cows	Main breed	Parity	BCS at AI	BW at AI (kg)	Milk yield at AI (kg)	Heat signs	Swelling of vulva	Pipette passage (%)[1]
Argentina	163	Holstein	2.6	2.7	?	24.4	Standing	Marked[2]	8
Chile	713	Friesian	2.6	2.8	546	21.8	Standing	Marked[2]	18
Costa Rica	484	Crossbred	3.7	?	?	?	Standing /Mounting	?	8
Cuba	251	Holstein	3.4	1.9	394	4.8	Standing	Marked	5
Peru	732	Holstein	2.7	2.7	591	24.7	Standing	Various	1
Uruguay	728	Holstein	2.5	2.2	536	19.4	Standing	?	0
Venezuela	499	Crossbred	3.2	3.0	445	7.9	Standing	Various	0
Bangladesh	444	Indigenous	2.5	2.9	211	2.7	Mounting / Bellowing	Marked[2]	12
China	2 018	Holstein	?	?	?	?	?	?	?
Indonesia (a)	359	Bali	3.0	3.6	287	- -	Mucous /Standing	Marked	0
Indonesia (b)	248	Brahman	2.5	2.9	320	- -	Various	Marked	16
Myanmar	270	Crossbred	3.4	3.3	378	10.4	Mucous /Mounting	Marked	3
Pakistan	110	Various	3.0	3.5	358	5.5	Mucous /Mounting	Slight	0
Sri Lanka (a)	265	Various	2.7	2.6	296	6.3	Mucous /Bellowing	Marked[2]	2
Sri Lanka (c)	126	Various	3.1	2.8	408	11.0	Various	Marked[2]	2
Vietnam	583	Holstein	2.2	?	413	16.0	Mucous/Standing	Marked	12
Total / Mean:	7 993		2.8	2.8	422	13.3			

[(a)] Small farms; [(b)] Co-operative farm; [(c)] Government farms
[1] Frequency of difficulty in passing the pipette through the cervix; [2] Slight in some cases

3.1.6. Heat expression and AI

The presence of mucous discharge in the vulva area was the most frequently used sign of heat expression under tie-stall Asian farm conditions. Other signs such as the cow mounting others or the cow allowing to be mounted were important in farms with several animals (Table III). On the other hand, in Latin American farms the standing cow was the basic sign for AI and other heat signs were rarely accepted. Heat synchronization was applied to inseminate some cows in INS and for most of the animals in CUB.

Inseminators generally reported a marked swelling of the vulva at the time of AI, otherwise a slight swelling. The level of difficulty in passing the AI pipette through the cervix (easy, difficult, impossible) was reported as difficult in ≥10% of the services by inseminators in BGD, CHI, IND (large farm only) and VIE (Table III).

3.2. Reproductive performance

Table IV shows the reproductive performance of inseminated cows in the 14 areas of the surveys. The difference in the number of observations between the interval to first service (n = 7 991) and conception rate to first service (n = 8 196) was due to missing calving dates and unavailability of inseminated cows for the pregnancy diagnosis test in several countries. CPR had the largest dataset (2 018 cows) and PAK had the smallest (110 cows).

The overall calving to first service interval was 121.5 ± 82.1 days (median = 95 days) with large differences between countries. The shortest intervals were in PER, CHI and ARG, probably due to the higher genetic quality of the animals, better nutrition and management, and more suitable climatic condition for rearing Holstein-type cattle. The long interval observed in CUB can be attributed to poor nutrition due to the severe national economic constraints during the survey period. This interval was longer in most Asian countries, especially in indigenous cattle of BGD and PAK (around 200 days) and in small beef farms in INS (around 270 days).

The overall mean for the calving to conception interval was only 16 days longer than the interval to first service. This figure has to be interpreted with caution as it represents less than 50% of the inseminated population. Many cows did not get pregnant and were culled, while many others may have got pregnant at a later stage but to services that were not monitored.

The overall conception rate to first service (CRFS) was 40.9%. Conception rate to all services was not calculated for the purpose of this summary, since a considerable proportion of cows that returned in heat were not monitored further. The highest CRFS were obtained by AI services in VIE (62.1%), CHI (61.9%) and MYA (58.9%) whereas those from CUB, INS, PAK, and PER had the lowest rates. The reasons identified for poor performance in CUB were those already described plus the fact that many cows with low body condition were subjected to heat synchronization. In PAK it was due to poor handling of frozen semen at the AI units, while in PER cattle suffered the effects of unusual heat stress due to "El Niño" which may have caused early embryonic death and subsequent anoestrus [8]. A high proportion of beef cattle in INS (in both types of farms) were inseminated during the luteal phase, as will be shown later.

Differences in CRFS due to farm size, body condition at AI, ease of pipette passage, years of experience of the AI technician, swelling of vulva at AI and semen source were evaluated in countries having a balanced number of animals between groups. Farms in VIE and MYA with 1–2 cows or with 5–20 cows had similar CRFS, whereas in COS and VEN large farms (>300 cows) had lower rates (14.8 and 22.2% respectively) compared with medium size farms (20–300 cows, 44.4 and 53.3%, respectively) ($P < 0.05$). This difference was not significant in medium (47%) versus large farms (56.0%) in CHI. Body condition at AI proved to be important when datasets from AI systems in BGD, CHI, SRL and VEN were pooled (Figure 1, n = 1 494). Cows with a score of 1.0–2.4 (on a 1–5 scale) had lower CRFS (33.1%, $P < 0.05$) than cows with BCS of 2.5-3.5 (40.0%) and >3.5 (40.4%).

Pooled data from BGD, SRL, VIE, ARG, CHI, COS and CUB (n = 2 330) showed differences in CRFS ($P < 0.05$) between inseminations carried out by inseminators with < 7 years of experience (24.9%) and those with 7.1–12.0 years (44.2%) and > 12 years (43.5%). The degree of swelling of the vulva at AI (none, slight and marked) did not show any significant relation with CRFS (n = 1 519, $P > 0.05$), and local semen had similar performance to imported semen in SRL and URU, but showed lower CRFS in BGD (38.9 vs. 57.5%, $P < 0.05$).

TABLE IV. INTERVALS (DAYS) FROM CALVING TO FIRST SERVICE AND TO CONCEPTION, AND CONCEPTION RATE TO FIRST SERVICE IN AN AI SURVEY CONDUCTED IN 14 COUNTRIES

	Calving to 1st Service Interval (d)				Calving to Conception Interval (d)				Conception Rate[1]	
	n.	Mean	s.d.	Median	N	Mean	s.d.	Median	n	%
Latin America	3 583	99.8	69.6	80.0	1 981	122.3	76.0	96.0	3 773	38.9
Argentina	365	91.1	56.5	80.0	149	92.3	47.7	81.0	366	41.6
Chile	663	88.7	56.9	74.5	490	107.9	73.3	83.5	713	61.9
Costa Rica	497	118.1	85.0	91.0	270	141.6	99.7	104.5	484	39.7
Cuba	250	158.4	109.6	112.0	38	174.9	108.4	144.0	251	15.1
Peru	617	80.5	35.2	71.0	249	113.5	61.3	93.0	732	25.7
Uruguay	692	101.5	48.8	88.0	601	133.9	61.0	124.0	728	40.4
Venezuela	499	95.0	77.4	68.0	184	120.1	89.5	93.5	499	32.5
Asia	4 408	137.3	87.3	111.0	2 746	146.7	84.7	124.0	4 423	42.6
Bangladesh	449	195.9	86.9	184.0	232	195.9	88.4	184	444	46.2
China	1 951	113.7	74.8	91.0	969	138.4	92.2	112.0	2 018	37.8
Indonesia (a)	332	150.4	89.9	119.0	191	147.4	72.6	124.0	359	27.6
Indonesia (b)	243	269.5	97.0	227.0	65	255.1	91.3	223.0	248	24.6
Myanmar	361	104.6	41.4	94.0	264	110.4	42.9	97.0	270	58.9
Pakistan	87	205.6	131.7	166.0	30	209.1	119.2	166.0	110	27.3
Sri Lanka (a)	272	174.4	87.9	155.0	256	190.8	91.5	177.5	265	53.6
Sri Lanka (c)	133	111.2	74.2	87.0	171	156.5	92.7	136.0	126	49.2
Vietnam	580	107.5	34.6	104.0	568	118.9	38.7	115.0	583	62.1
Total:	7 991	121.5	82.1	95.0	4 727	137.6	81.3	115.0	8 196	40.9

(a) Small farms; (b) Co-operative farm; (c) Government farms

[1] Conception rate at first service

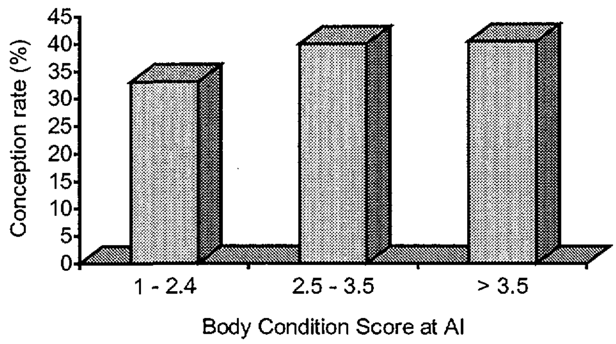

FIG.1. Effect of body condition score (1–5 scale) at artificial insemination (AI) on conception rate to first service in dairy and dual-purpose cows from Bangladesh, Chile, Sri Lanka and Venezuela.

The inter-service interval between the first and the second service in 1 959 observations was 44.6 ± 44.4 days. This is equivalent an average of one missing heat between services. Serious problems in heat detection were observed in the COS and CPR AI services as the intervals were >57 days.

3.3. Problems identified in the AI services

Basically, the sample on the day of service was used to verify whether the animal was inseminated during the luteal phase (i.e. incorrect timing, high progesterone values); the two-sample set (day of service and at mid-cycle) was used to verify whether the animal was cycling and had ovulated; and the three-sample plus pregnancy diagnosis strategy (the third sample collected at day 22–24 after AI) was used to verify whether the animal had conceived, had lost the embryo, had been inseminated while already pregnant or had been inseminated when acyclic. The most common occurrences of progesterone values and the respective interpretation are shown in Table V.

Two major deficiencies were identified in the AI services through progesterone concentration from samples collected in more than 8 500 inseminations (Table VI). AI at inappropriate times occurred in 17.3% of all services denoting serious heat detection errors at farm level. These services were performed in non-cycling cows (10.4%) and in cows with active Corpora Lutea (CLs) at AI (6.9%); most of the latter were already pregnant. Inseminations in non-cycling cows was most common in CUB, INS (both farm types), COS and VEN (Table VII). Services in cows bearing an active CL occurred mainly in INS-large farm (17.8%), SRL-small farms (13.2%) and URU (11.8%).

The second major deficiency was related to post-AI estrous detection and herd management, which affected 37.5% of the inseminations (Table VI). In this case, 10.1% of the inseminated animals suffered late embryonic deaths (between 16–60 days after service) but were not reported in heat until pregnancy diagnosis took place, usually 80–120 days after service. Another group representing 27.4% of the inseminated animals failed to conceive to that service but subsequent heats remained undetected until pregnancy diagnosis was performed. Farms in CPR and URU had the highest late embryonic deaths (17%), whereas farms in CUB, PER and INS had the largest frequencies of cows with unobserved heats after failed inseminations (68.9, 45.3, and approx. 40%, respectively).

3.4. Practicability and constraints of the 3-sample strategy

The 3-sample set (milk or blood) collected at days 0, 10–12, and 22–24 in relation to the insemination, together with pregnancy diagnosis by rectal palpation, proved to be a sound strategy for evaluating the efficiency of reproductive management at farm level and the outcome of AI services. However, it is also important to point out that the system requires a large number of cows in the evaluation scheme in order to get a meaningful set of data. The number of animals will depend, among others factors, on the farming system, the genetic variability of the population, the number of variables to be considered in the analysis, and the efficiency of the sample collection.

TABLE V. INTERPRETATION OF RIA PROGESTERONE DATA ALONE OR IN COMBINATION WITH CLINICAL INFORMATION FOR THE EVALUATION OF AI SERVICES (HIGH: ≥3 NMOL/L; LOW ≤1 NMOL/L) USING MILK (OR PLASMA) SAMPLES COLLECTED AT DIFFERENT INTERVALS AFTER AI

N° of samples	Day of collection			Pregnancy diagnosis	Interpretation
	0	10-12	22-24		
Three	Low	High	High	Positive	Pregnancy
	Low	High	Low	Negative	Non-fertilization, early embryonic mortality, (post AI-anoestrus)
	Low	High	High	Negative	Late embryonic mortality (>day 16), luteal cyst, persistent CL
	High	High	High	Positive	AI on pregnant animal
Two	Low	High	--	--	Ovulatory cycle
	Low	Low	--	--	Anoestrus, anovulation, short luteal phase
	High	High	--	--	AI on pregnant animal, luteal cyst
	High	Low	--	--	AI during the luteal phase
One	Low	--	--	--	AI at a time other than the luteal phase
	High	--	--	--	AI during the luteal phase

TABLE VI. FACTORS DETRIMENTAL TO THE AI SERVICE THAT WERE IDENTIFIED THROUGH THE 3-SAMPLE STRATEGY AND SUBSEQUENT PREGNANCY DIAGNOSIS

Main problem	Specific deficiency in the AI system	Population affected (%)
• Inappropriate AI probably due to wrong estrous detection		17.3
	o AI in cows with active *corpora lutea*	6.9
	o AI in non-cyclic cows	10.4
• Deficient estrous detection and herd management		37.5
	o Cows fail to conceive, subsequent heats are unobserved and found not-pregnant at pregnancy diagnosis test	27.4
	o Cows conceive but had late embryonic losses and are found not-pregnant at pregnancy diagnosis test	10.1

Collection of the first milk sample is not a major problem as it can be taken by the inseminator. The other two samples require someone to visit the farms or have to be done by the farmers (small farms) or farm employees (large farms) on the exact days and from the correct animals. In the case of the latter approach, some mechanism has to be in place for delivering the samples to the laboratory. A second constraint is that in 18.4% of the 3-sample sets of this study (n = 6 483) at least one sample showed intermediate progesterone values (>1 - < 3 nmol/L), and therefore the dataset become invalid for proper interpretation. Good quality RIA laboratories can reduce this figure through accurate assay results, but other factors such as mishandling of samples can contribute to this problem.

4. CONCLUSIONS

The standardized methodology used across countries and the strategy of combining data from the field and laboratory, together with uniform data-entry forms and a computer database, allowed the generation of unique information regarding reproductive management and AI systems in developing countries. It resulted in linkages between research institutes and AI centres and permitted identification of the main limiting factors at each specific location within the 14 Asian and Latin American countries participating in the project.

The survey showed that nearly half of the services were linked to a detectable and measurable deficiency, mainly related to a human error, which severely affected reproductive performance of cattle herds and also the quality and efficiency of AI services. Future efforts must be focused on alleviating the problems identified and will involve the following, depending on location: education of farmers on heat detection, herd management practices and better nutrition; improving the knowledge and skills of inseminators in AI practices; further research on embryo mortality, suckling practices and methods for heat induction/synchronization; improved semen handling, storage and quality control; and improved recording, evaluation of results and follow-up services to farmers by the providers of AI services.

Similar surveys would be valuable in other developing countries to improve the quality and efficiency of AI services.

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