IMPLEMENTATION OF ARTIFICIAL INSEMINATION PROGRAMS IN BEEF HERDS: Practical Considerations and Impact on Production

Lucas Cutaia
Technical Manager - Syntex SA
Luis Guillon, Buenos Aires, Argentina
lcutaia@syntexar.com

Introduction

The optimization of reproductive efficiency is one of the main factors that contributes to the improvement of the economic return of a livestock farm. Undoubtedly the pregnancy rate and especially its distribution, have a very important impact on the economics of a breeding property. Achieving a calf per cow per year in a bovine production system means that, during the 365 days of the year and a 283 day gestation period, the females should be pregnant again after 82 days of calving (8). Taking into account the 40 to 60 days of the recovery of the reproductive capacity after parturition under pasture based conditions, the cows only have one or two estrus cycles to conceive and maintain an inter-calving period of 12 months.

A goal of 95% of cows calving during a 60-day period is high but achievable. To achieve these results in the case of a natural service, 65 to 75% of the animals should get pregnant in the first 21 days of the breeding season. Therefore, it is necessary that 95 to 100% of the cows show signs of estrus in the first 21 days of service and that they have a conception rate of 70 to 80%. Undoubtedly achieving this ideal objective of production can be more or less feasible depending on the conditions of the different farms and the region in which they are located. Obtaining cows that have been bred and conceived earlier also has immediate economic benefits. The most important is that the calf of these cows will be older at weaning and therefore will be heavier.

The main objective of the implementation of Artificial Insemination (AI) in breeding facilities is to facilitate genetic progress in the herd. However, according to information and published data from Argentina in 2013, 4.5% of cattle were inseminated annually and within this percentage 80% of them were heifers (39, 12). Among the most important causes that hinder the massive use of AI, we can include those related to the management and inefficiency in the detection of heat. Probably the most useful alternative to significantly increase the number of AI's is the use of protocols that allow AI to be performed without the need for heat detection, commonly called Fixed Time Artificial Insemination (FTAI). On the other hand, the development of management alternatives to include FTAI programs in cows with offspring allows the insemination of a greater population of animals which is not only limited to heifers. Today (2017) 12% of the bovine females in Argentina are involved in a FTAI programs. The same trend can be observed in countries such as Brazil, Paraguay and Uruguay.

The purpose of this summary is to present FTAI trials in beef production systems and to show, through examples, the feasibility of implementing these programs under different management conditions, which have contributed to the exponential growth of the FTAI technique in South America.

Ovulation Synchronization Treatments and FTAI

In general, we can divide the FTAI protocols into those that use combinations of GnRH and prostaglandin F2α (PGF), called Ovsynch protocols (50) and those that use devices with progesterone (P4) and estradiol (14,17,18). The Ovsynch protocol has resulted in acceptable fertility for dairy cows (20, 50) and beef cows (45). However, the results of its application in breeding herds managed in extensive pasture based conditions have not been satisfactory, due to the low percentages of conception obtained in cows in anestrus (10,36). Therefore, the choice of this protocol in breeding herds will depend on the category of animals to be used and the state of cyclicity of the herd.

Protocols with progesterone intravaginal devices and estradiol.

There are currently efficient devices on the market that release P4 and that are kept intra-vaginally for a period of 7 or 8 days (16). The treatment protocol most commonly used is the administration of 2 mg of estradiol benzoate (EB) intramuscularly (im) together with the insertion of the P4 device in what we call Day 0 of the treatment. On Day 7 or 8, the P4 device is removed and PGF is administered im. 24 hours later, 1 mg of EB is administered im. FTAI is performed between 52 and 56 h after removal of the device (29). The fundamental function of the application of estrogens at the beginning of treatment is to induce the atresia of existing follicles and thus prevent the formation of persistent follicles that negatively interfere with fertility (14,17,44). Atresia of existing follicles is followed by the onset of a new follicular wave at 4 days (47), the presence of a new follicle and a viable oocyte is ensured at the moment of removal of the P4 device (15,14). Originally, the P4 device was placed intra-vaginal along with a capsule containing 10 mg of EB, to induce luteal regression and synchronize follicular development (38,54). However, since 1996, 2 mg of EB have been used via the im route because it was shown that the EB capsule is not effective in synchronizing follicular development (12) and is less effective than PGF in inducing luteolysis. Finally, the second EB administration is fundamental to synchronize ovulation and obtain good pregnancy rates with FTAI (26,29). Data of 431.008 inseminations performed between 2003 and 2015 resulted in an average of 50.39% with a range of 10% to 82%. The factors that most affected the pregnancy were the body condition (BCS) of the inseminated herd and whether the cows were cyclic or in anestrus.

We recently conducted an analysis of our database (no published data) in a large number of FTAI’s and observed that no large differences were found in the pregnancy percentages (Figure 1) obtained in different categories of animals. This shows that the protocols have been developed that ensures constant results in each of the different categories of animal in the herd

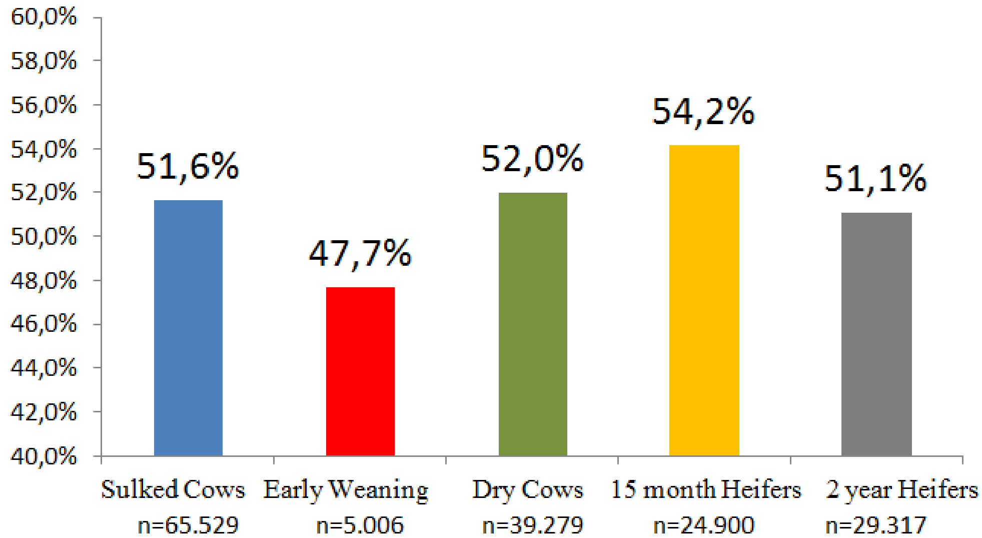

Figure 1. Pregnancy rates of FTAI in different categories

Use of Equine Chorionic Gonadotropin (eCG) in order to improve fertility in anestrus cows.

Suckled beef cattle under extensive grazing conditions often have a high incidence of postpartum anestrus, which increases the calving to conception interval and, consequently, negatively affects their reproductive performance. The insertion of intravaginal progesterone devices, combined with the application of equine chorionic gonadotropin (eCG) at the time of device removal, has been extensively used in *Bos indicus* herds with high incidence of postpartum anestrus (reviewed in Baruselli et al. 5).

The use of 400 IU of eCG at the time of progestin device removal resulted in increased pregnancy rates in cows without a CL at the time of insertion of the progestin device (5; 23). In another study (5), eCG treatment increased plasma progesterone concentrations and pregnancy rates in suckled cows treated during postpartum anestrus. Therefore, eCG treatment may be an important tool for increasing pregnancy rates at FTAI, to reduce the postpartum period, and to improve reproductive efficiency in postpartum *Bos indicus and Bos indicus x Bos taurus* beef cows. Analysis of data collected from 9,668 FTAI done from December 2000 through December 2003 has shown that *Bos taurus and Bos indicus x Bos taurus* crossbred animals treated with progestin-devices must have a body condition score (BCS) higher than 2.5 (scale 1 to 5) and ideally ≥3 to achieve pregnancy rates of 50% or higher (11). Conversely, the addition of eCG allowed for pregnancy rates close to 50% in cows with a BCS of 2 (11). It is very important to note that these results have been achieved only when cows were gaining body condition during the breeding season. If drought conditions or lack of feed prevent cattle from improving BCS during the breeding season, pregnancy rates will most probably be 35% or less, even after the administration of eCG (11;19; 23). Another analysis performed when 1,987 FTAI's where performed on Nelore cows confirmed that BCS is critical to achieve pregnancy rates and that the beneficial effect of eCG treatments was significant in cows with a BCS ≤3 (Fig. 2; 5). Since BCS is usually associated with cyclicity, it is conceivable that most cows in the lower BCS were anestrus at the time that treatments were initiated. When 485 *Bos indicus x Bos taurus* suckled cows were examined by real time ultrasonography at the time of device insertion, pregnancy rates in cows that had a corpus luteum (CL) when treatments were initiated did not differ between cows treated (56.3%) or not treated with eCG (56.5%) (11). However, eCG treatments increased pregnancy rates (eCG: 49.5% vs no eCG: 40%; P<0.05) in cows that only had follicles at the time of progestin device insertion. In yet another retrospective analysis of 2,489 FTAI's performed on suckled Nelore cows from two commercial farms in Brazil, pregnancy rates were not different between cows that were 40 to >80 d postpartum at the time of FTAI (40-49 d: 57/142, 52.8%; 50-59 d: 419/759, 55.2%; 60-69 d: 137/263, 52.1%, 70-79 d: 361/684, 56.3% and >80 d: 334/641, 52.1%, 5).

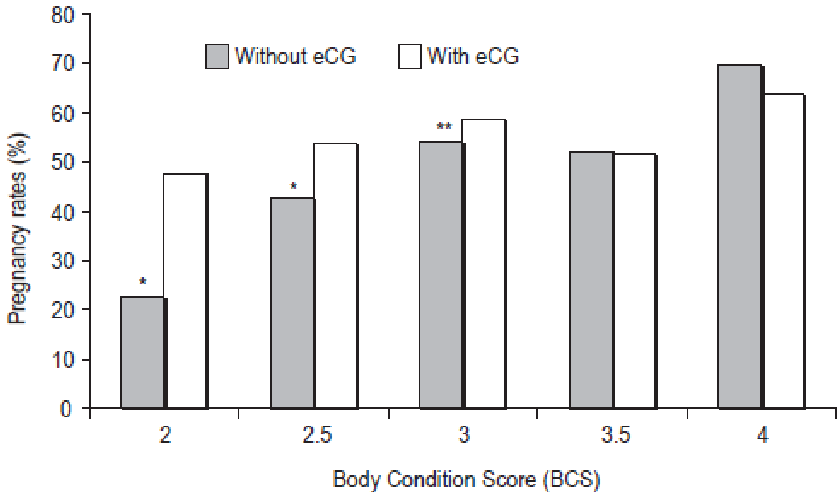

Figure 2. Effect of body condition scores (1 to 5 scale) on pregnancy rates in Nelore cows (n=1,984) treated with progestin-releasing devices with or without 400 IU eCG at device removal (* P < 0.05; ** P<0.1). Adapted from Baruselli *et al. 2005.*

Restricted suckled or calf removal associated with progestin devices has also been used for the induction of cyclicity in *Bos indicus* cows (3). We have recently conducted two experiments to compare the effects of eCG treatment and temporary weaning (TW) on ovulation and pregnancy rates in postpartum cows. In the first experiment, 39 lactating multiparous *Bos indicus x Bos taurus* crossbred cows, 60 to 80 days postpartum with a BCS between 2 to 2.5 (scale 1 to 5) were randomly allocated to 1 of 4 treatment groups, in a 2 by 2 factorial design (Maraña *et al*. 2006). On Day 0, all cows received a DIB device (intravaginal progesterone-releasing device with 1 g of progesterone, Syntex SA, Buenos Aires, Argentina) and 2 mg EB im (Benzoato de Estradiol, Syntex SA). On Day 8, DIB devices were removed and all cows received PGF and were randomly divided to receive 400 IU eCG im (Novormon, Syntex SA) at the same time or no further treatment. In addition, half of the cows in each treatment group had their calves weaned for 56 h from the time of DIB removal; the other half remained with their calves. All cows received 1 mg EB im on Day 9 and were examined every 8 h by ultrasonography, from the time of DIB removal until ovulation. The interval to ovulation (eCG, 72.0±1.4 h vs no eCG, 75.6±2.0 h and TW, 73.8±1.6 h vs no TW, 73.0±1.8 h) did not differ among groups (P>0.05). However, TW increased (7/10, 70.0%; P<0.05) and eCG treatment tended to increase (12/20, 60.0%; P<0.09) the proportion of cows ovulating compared to control cows (no TW or eCG treatment: 2/9, 22.2%).

Although there was no effect of eCG treatment on the size of the preovulatory follicle (eCG, 11.1±0.4 mm vs no eCG, 10.1±0.6 mm), the growth rate of the ovulatory follicle was greater (P<0.02) in cows treated with eCG (1.1±0.1 mm/d) than in those not treated with eCG (0.6±0.1 mm/d). Conversely, the ovulatory follicle was smaller in TW cows (9.9±0.4 mm), compared to those not TW (11.8±0.3 mm; P<0.05).

The second experiment was conducted over 2 years; 769 *Bos indicus x Bos taurus* crossbred suckled cows (year 2004, n=393 and year 2005, n=376) with a BCS of 2 to 2.5 were used (Maraña *et al*. 2006). All animals were examined by palpation per rectum at the time of initiating the treatment to determine ovarian status. Cows were randomly assigned to 4 treatment groups in a 2 by 2 factorial design (Control, eCG, TW and TW+eCG), so that cows with a CL (22.5%), follicles > 8 mm (30.0%) or ovaries with small follicles (<8 mm; 47.5%) were equally represented in each group. Temporarily weaned calves were separated from their dams by approximately 1000 m, to prevent any kind of contact between cows and calves. All cows were FTAI between 52 and 56 h after DIB removal. Data were analyzed by logistic regression. There was no interactions between years and treatments or between treatments (P>0.7). The overall pregnancy rate was lower in 2005 (109/376, 29.0%; P<0.01) than in 2004 (173/393, 44.0%), due to a drought during that breeding season; but in both years eCG treatment increased pregnancy rates (eCG, 154/377, 40.8% vs no eCG, 128/392, 32.6%; P<0.01). Conversely, no differences were found between cows that were TW (141/379, 37.2%) and those that were not (141/390, 36.1%; P>0.7). It was concluded that the use of eCG but not TW improved pregnancy rates following FTAI in postpartum *Bos indicus x Bos taurus* crossbred cows in moderate to low body condition. Results also suggest that the eCG-related increase in pregnancy rates may be due to the final growth rate of the ovulatory follicle. On the other hand, the absence or little effect of TW on pregnancy rates contrasts with data from another study done with Nelore cows, and those from other studies (reviewed in Baruselli *et al*. 2004). In the experiment with Nelore cows, 459 suckled cows were treated with Crestar (Intervet, Sao Paulo, Brazil) for 9 d and were divided into 1 of 4 treatment groups to receive or not receive 400 IU eCG im (Folligon, Intervet), and have calves TW for 56 h or not. In this case, both eCG and TW significantly increased (P<0.05) pregnancy rates (eCG, 126/227, 55.5% vs no eCG, 98/232 42.2%; TW, 121/229, 52.8% vs no TW, 103/230, 44.8%). Therefore, the beneficial effects of temporary weaning may differ, pending on the management and body condition of the cows. Moreover, to set up a temporary weaning program creates logistical problems in several farms and is probably the most resisted management technique by beef producers, at least in Argentina and Brazil. Nevertheless, the results from both studies confirmed those reported previously that eCG increased pregnancy rates in suckled cows enrolled in a FTAI program utilizing progestin devices and oestradiol (5; 23).

Attempts to reduce the number of handling required for the implementation of FTAI programs using P4 devices and estradiol in beef herds

For a treatment protocol to be appealing, it must be easy and simple to perform. Although the protocols currently used are relatively simple, it is necessary to handle the cows in the crush at least four times during a FTAI protocol. This has led many groups of researchers to seek alternative treatments that reduce the number of handlings required. An alternative protocol evaluated a while ago is the use of gonadotropin releasing hormone (GnRH) at the time of the FTAI instead of the administration of EB 24 hours after the removal of the P4 device. This protocol resulted in equivalent pregnancy rates (16). The problem with this protocol is that the cost of GnRH is higher than that of the EB and for that reason it is not extensively used in South America.

Another alternative evaluated and that has led to discussion is the administration of EB at the moment of removal of the device. The results of these works are summarized in Table 1. In work done by our group using cyclic cows and DIB devices (Syntex, Argentina) we found a greater synchronization of ovulations when we administered the EB 24 hours after the removal of the DIB (29) and lower pregnancy rates (31) using 96 zebu cross heifers from 18 to 24 months of age and 221 cows with calves (Table 1). Similar data were obtained by Cavalieri in Australia in zebu heifers (21). However, works by Ross (55) and Cesaroni (22) have found similar pregnancy rates in cows in anestrus and heifers. Fernandez-Francia *et al*. (35) found equal pregnancy rates in milk heifers, but in this case the FTAI was advanced in the EB 0 group, which was performed 36 hours after the removal of the DIB device instead of the 48 hours as in the other experiments. However, when a similar protocol was repeated in beef cows, but with the FTAI performed at 32 hours after the removal in the EB0 Group, the pregnancy rate was lower in the group where EB was administered 24 hours after device removal (58).

Another alternative to reduce the number of times that animals are handled is to use estradiol cypionate (ECP) as an ovulation inducer. The results of these works are summarized in Table 1. The ECP is a salt of estradiol with a longer half-life than the EB and could potentially be adapted to an estradiol application scheme as an ovulation inducer at the moment of removing the device with P4. Colazo *et al*. conducted two experiments in Canada to evaluate the effect of ECP on follicular dynamics, ovulation and pregnancy rates (20, 21). They found that the ECP administered at the time of CIDR-B removal was effective in synchronizing ovulation and obtaining pregnancy rates comparable to the administration of EB or ECP at 24 hours after device removal (24). When other agents that induce a more variable wave onset, such as GnRH or 1 mg of ECP and 50 mg of P4 were used, the pregnancy rate was higher ($P < 0.01$) in heifers that received ECP 24 hours after the removal of the CIDR (65%) than at the moment of removing the CIDR (52%) or GnRH at the time of the AI (51%; 25).

Taking these results into account, an experiment was conducted to evaluate the alternative of using ECP in a DIB and EB protocol (32). 389 Bonsmara cross heifers (1/2 Zebu x Bonsmara), from 18 to 24 months of age and with a BCS of 3 (scale 1-5) were included. On Day 0, all heifers received a DIB device along with 2 mg of EB (Syntex, Argentina). On Day 8, the DIB devices were removed and 0.15 mg of D (+) cloprostenol (Cyclase, Syntex) was administered. The heifers were randomly assigned to one of four treatment groups to receive 1 mg EB or 0.5 mg ECP at the time the DIB was removed (0h) or 24h later. In the heifers that received EB at 0h, FTAI was performed between 47 and 49 h after the DIB was withdrawn, while those treated with EB 24 h or with ECP (0 or 24h) were FTAI between 52 and 54 h after the DIB was withdrawn. As seen in Table 1, the type of estradiol used affected the results. A higher pregnancy rate in heifers treated with ECP at 24 h were achieved ($P < 0.05$) compared to the other treatment groups. Recently Giacusa et al. conducted two other experiments using Zebu cows with calves. These cows were treated with DIB and EB on Day 0 and the DIBs were removed and a dose of 150 ug of cloprostenol was applied on Day 8. The cows in experiment 2 also received 400 IU of eCG on Day 8. At this time the animals were randomly divided to receive a dose of 0.5 mg ECP (ECP 0h Group) or 24 h later (ECP24h Group). FTAI was performed on all cows between 52 and 56 h after the DIB removal. As can be seen in Table 1, no differences ($P > 0.1$) were found between the pregnancy percentages obtained with the application of 0.5 mg of ECP at the time the DIB was withdrawn or 24 h later in any of the two experiments.

Table 1. **Effect of the application of EB or ECP at the moment of withdrawal of a device with P4 or 24 h later on the percentages of pregnancy in FTAI cows and heifers.**

Reference	*Treatment & Time of FTAI	EB 0 h	EB 24 h	ECP 0 h	ECP 24 h	*P Value*
Cesaroni et al., 2000. (heifers. bos taurus)	CIDR+EB y PGF Día 6 FTAI 48h	35/65 (53.9%)	32/65 (49.2%)			*>0.1*
Ross et al.	MAP+MAP+EB FTAI 48h	45.0%	47.5%			*>0.1*
Cavalieri et al., 2002. (heifers. cebú)	CIDR + EB FTAI 48h	53/159 [a] (33.3%)	70/161 [b] (43.5%)			*<0.05*
Cutaia et al., 2005. (crossbreed cows and heifers)	DIB+EB FTAI EB0h: 48h y EB24h: 54h	64/158 [a] (40.5%)	79/149 [b] (53.0%)			*<0.05*
Fernandez Francia et al., 2005. (dairy heifers)	DIB+EB FTAI EB0h: 36h EB24 h: 48h	21/29 (72.4%)	21/29 (72.4%)			*>0.96*
Sorroarain et al., 2005. (sulked Taurus cows)	Triu-B+EB FTAI EB0h: 32h EB24 h: 48h	20/47 [a] (42.5%)	36/47 [b] (76.6%)			*<0.01*
Colazo et al., 2002. (heifers bos taurus)	CIDR+E-17β+P4 FTAI 54h		65/103 (63.1%)	62/98 (63.3%)	64/99 (64.6%)	*>0.7*
Colazo et al., 2003. (heifers bos taurus)	CIDR+ECP o CIDR+GnRH FTAI 54h			168/320 [a] (52.5%)	216/331[b] (65.3%)	*<0.01*
Cutaia et al., 2005. (crossbreed heifers)	DIB+EB FTAI EB0h: 48h EB24 h y ECP: 54h	42/98 [a] (42.8%)	45/98 [a] (45.9%)	46/95 [a] (48.2%)	62/98 [b] (63.2%)	*<0.05*
Giacusa et al., 2005. (cows)	DIB+EB IATF 54h			26/51 (50.9%)	25/52 (49.1%)	*>0.1*
Giacusa et al., 2005. (sulked cows)	DIB+EB+eCG IATF 54h			27/54 (50.0%)	27/50 (54.0%)	*>0.1*

In three out of five experiments conducted the pregnancy rate, when ECP were administered on the day of DIB removal (ECP 0h), is similar to that obtained with ECP injected 24 h later. It can be concluded that the use of ECP in a synchronization program is an alternative to reduce the number of handlings. However, it is important that with this type of synchronization program, estrogen with a short half-life (E-17β or EB), in association with P4, be used to ensure a synchronized emergence of a new follicular wave. Currently 90% of the treatments used in South America are using ECP as an inducer of ovulation.

Duration of treatment with intravaginal devices with P4 and pregnancy rates

For management reasons, there is often a need to include very large herds of animals in FTAI programs. Assuming that the optimal time period for the FTAI is between 52 to 56 h after device removal (28) using EB or 48 to 52h using ECP, no more than 200 animals per day should be scheduled. To be able to inseminate larger numbers of animals, treatments can be staggered starting one or two days apart. Treatments can be scheduled to inseminate half of the animals in the morning and the other half in the afternoon. Alternatively the program can be started on the same day and the FTAI can be staggered by removing the device on different days. If the number of animals varies between 300 to 500, 7 and 8 day treatments can simply be performed (18, 33, 26). In three out of four studies, these protocols resulted in similar pregnancy rates and are presented in Table 2.

Table 2. Pregnancy rates after FTAI in heifers treated with P4 devices for 7 or 8 days.

	7 days	**8 days**	**P Value**
Colazo et al., 1999 (Heifers Bos taurus)	40/58 (68.9%)	39/62 (62.9)	>0.1
Colazo et al., 1999 (Heiferrs Bos indicus)	28/71 (39.4%)[a]	40/74 (54.1%)[b]	<0.08
Mujica y Ben, 1999 (Heifers Bos taurus)	68/115 (59.1 %)	59/115 (51.3 %)	>0.1
Chesta et al., 2003 (Heifers Bos indicus)	71/146 (46.6%)	77/146 (52.7%)	>0.1

Time of ovulation in suckled crossbreed cows treated with devices with different concentration of P4 and combined with ECP

The objective of the study was to evaluate the timing of ovulation in estrus synchronization treatments for FTAI, using intravaginal devices with different concentrations of P4 in Bos Indicus suckled cows. The trial was carried out in Rancatama cattle ranch, located in Apostles Misiones NE of Argentina). Eighteen crossbreed cows with calf, more than 90 days post calving and with a body condition between 2.5 and 3 (scale from 1 to 5) were included in the study. The cows were divided into 2 random groups to receive a DIB 0.5 (0.5g of P4, Syntex, GROUP DIB 0.5) or a DIB (1g of P4, Syntex, GROUP DIB). Both treatment groups received 2 mg of estradiol benzoate IM (EB, Syntex) on Day 0 along with the P4 devices. On Day 8 the devices were removed and all cows received 500 µg of Cloprostenol Sodium IM (Cyclase DL, Syntex Argentina) together with 1 mg of Estradiol Cypionate IM (Cipiosyn, Syntex Argentina) and 400 IU of eCG IM (Novormon, Syntex Argentina). Transrectal ultrasonography (Mindray DP 2200, 5Mhz) was performed on Days 0, 8 and 10 of the treatment. From that moment, the observations were repeated every 8 hours until the time of ovulation. The means were compared by ANOVA test. No significant differences were observed with the time of ovulation between the treatments evaluated (P> 0.05). However, the results of this work should be confirmed on a greater number of animals.

Table 3. Time and size of ovulation of the pre-ovulatory follicles (FPO) of suckled cows treated with devices with different concentrations of P4, used in estrus synchronization protocols.

Group	n	Ovulation Time (h after DIB removal)	POF Size (mm)
DIB 0.5	9	62.7 ± 1,8	11.2 ± 0.3
DIB	9	68.4 ± 2,9	11.8 ± 0.3

P> 0,1

Productive impact of the FTAI in different production systems

Undoubtedly, one of the main advantages of the implementation of FTAI program in a breeding herd lies in the fact that this technique is used to obtain heavier calves, as was previously presented (28). This is mainly due to the fact that on the first day of the breeding season we started with around 50% of pregnant animals. This, without doubt, significantly increases the calving rate the following year. In addition, the weight of the calves increases due to the genetic progress achieved by the use of genetically superior bulls (28). The impact of FTAI has proven to be equally efficient in different breeding plans in different areas of Argentina and Brazil (13).

In 2002, the implementation of FTAI programs began at "El Mangrullo" farm (Lavalle, Santiago del Estero, Argentina). This establishment is located in the semi-arid zone of Argentina, with a highly seasonal average annual rainfall of 600 mm, occurring from November-December to May-June. The animals were all Zebu crosses and a crossbreeding program with the Bonsmara breed has been carried out through the use of semen and embryos. Table 8 shows the evolution of the number of animals included in the FTAI programs and the results obtained in each category (13).

Table 4. Use of the FTAI in the El Mangrullo farm located in Lavalle, Northwest of the Province of Santiago del Estero.

Category	Year 2002/03	Year 2003/04	Year 2004/05	Total
Heifers	148/292 (50.7%)	341/619 (55.1%)	564/1233 (45.7%)	**1053/2144 (49.1%)**
Dry Cows	--	189/394 (47.9%)	--	**189/394 (47.9%)**
Suckled Cows	156/289 (54.0%)	345/790 (43.7%)	450/1199 (37.5%)	**951/2278 (41.7%)**
Total	**304/581 (52.3%)**	**875/1803 (48.5%)**	**1014/2432 (41.7%)**	**2193/4816 (45.5%)**

As can be seen in Table 4, a progressive FTAI program was carried out on heifers, suckled cows and dry cows with pregnancy rates ranging from 40 to 50%. It is worth mentioning that the summer of 2005 has been particularly dry, without rain from December to March and this undoubtedly affected the general pregnancy rates. However, it can be observed that with an aggressive FTAI program in a field in less favorable climatic conditions than the Humid Pampa, pregnancy rates to FTAI can be acceptably maintained. Perhaps the most important aspect of the application of this system has been the effect it had on calving distribution, as can be seen in Figure 3. It began with a distribution of the calving over 6 months in the 2002/03 season (not FTAI) with a high number of cows calving between December and March (calving tail). In the 2004/05 season calving took place over 5 months, but with an advancement in the calving distribution, with a greater number of animals calving in the months of September to December and few animals calving in January.

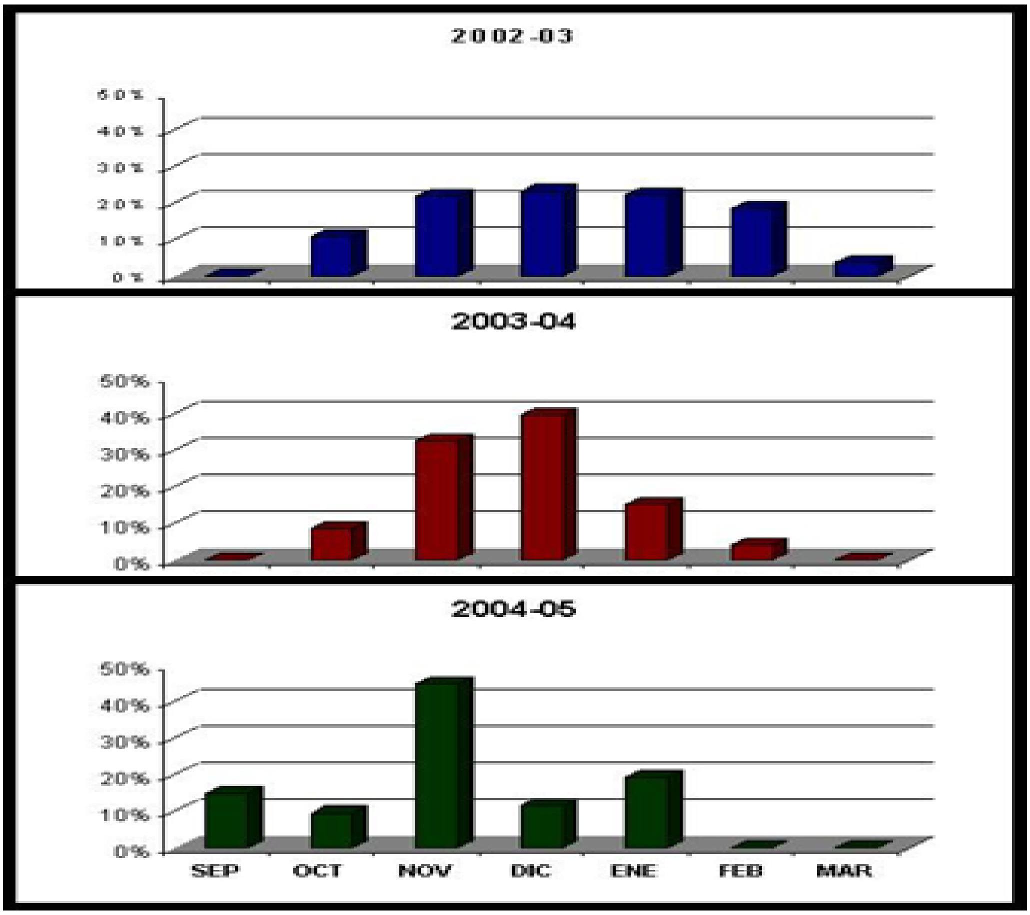

Figure 3. Distribution of the births in the "El Mangrullo" farm in Santiago del Estero, Argentina.

In conjunction with this trial, in 2004, the impact of the application of the FTAI on the weaning weight of calves originating from natural mating compared with that of calves originating from FTAI was evaluated, similar to the comparison made in a previous publication using Angus cows (28). For this, only a subgroup of cows was used, from which all the birth data could be recovered. The cows of the Natural Service Group were served with 3% of Bonsmara bulls during a period of 90 days. The cows in the FTAI Group were treated with a standard protocol that included DIB devices for 8 days at the start of the mating season and then followed up with bulls after FTAI. During the calving season all cows were monitored and calves born were identified with a tagging system. Table 5 shows the weaning weights of the calves produced by FTAI or by natural mating. The weight of the calves were adjusted to 180 days to determine which proportion of the difference in weight between the groups can be attributed to the time of birth and which proportion can be attributed to genetic improvement by the bulls used in the FTAI.

Table 5. Weight difference at weaning of calves crosses zebu x Bonsmara born by FTAI or natural mate. "El Mangrullo" farm, 2004.

	n	Weight at weaning (kg) (Media ±EE)	Adjusted Weight-180 days (kg) (Media±EE)
FTAI	138	178.1±1.9[a]	184.2±1.6[a]
Natural Mate	181	149.4±1.5[b]	173.8±1.4[b]
Difference		28.7	10.4

[ab] (P=0,00001)

As can be seen from Table 5, the calves of the FTAI Group were heavier at weaning than the calves of the Natural Mating Group. Part of this difference (18.3 Kg) was attributed to the fact that the calves of the FTAI Group were born earlier than the calves of the Natural Mating Group. On the other hand the difference of 10.4 kg, in the weight of the calves from the FTAI Group, can be attributed to genetic improvement through the use of semen from genetically superior bulls which resulted in genetic advancement of the calves produced.

Another case is the "Santa Dominga" farm of Los Lazos S.A., located in the town of Olavarría in the Province of Buenos Aires, Argentina. At this establishment the herd consist of pure Angus cattle and the establishment is located in the Pampa Humid with an annual rainfall of 1200 to 1500 mm distributed throughout the year. Cows are always inseminated when in a BCS > 2.5. Cows and heifers are treated with a protocol with CIDR-B for 8 days, along with the application of 2 mg of EB on Day 0, PGF on Day 8 (when the CIDR-B is removed), 1 mg of EB on Day 9 and are FTAI between 52 and 56 h after the CIDR-B was withdrawn. Approximately 15 days after the FTAI, bulls are introduced for 90 days. Ultrasound was performed 30 days after the FTAI to determine the percentage of pregnancy at the FTAI and then the rectal examination at 60 days after the bulls were removed to determine the percentage of pregnancy per bull. At this establishment, in the year 2002, it was demonstrated that the calves originating from FTAI were 34.6 Kg heavier than those produced by natural service and due to this the use of the FTAI was intensified. The results of the FTAI in the following years are shown in Table 6.

Table 6. Pregnancy rates in cows and heifers FTAI in "Santa Dominga" farm, located in Olavaría, Province of Buenos Aires.

Year	**N**	**Pregnant**	**%**
2000	528	259	49.05
2001	1169	697	59.62
2002	1905	1102	57.85
2003	1928	1179	61.15
2004	2021	1168	57.70
Total	**7551**	**4405**	**58.30**

Similarly, the pregnancy rates obtained from FTAI in 2002 and 2003, in the different categories of animals, were evaluated (Tables 7 and 8). The consistency in the pregnancy data obtained in the different categories can also be appreciated.

Table 7. Pregnancy rates in cows and heifers after FTAI in "Santa Dominga" farm, located in Olavarría, Province of Buenos Aires. Year 2003.

Herd	**Category**	**n**	**Pregnant**	**%**
1	Heifers	200	119	59.50
2	Heifers	179	112	62.50
3	Heifers	165	85	51.50
4	Heifers	171	95	55.50
5	Cows	196	134	68.37
6	Cows	175	98	56.00
7	Cows	201	133	66.16
8	Cows	168	113	67.20
9	Cows	226	136	60.17
Total		**1681**	**1025**	**60.97**

Table 8. Pregnancy rates in cows and heifers after FTAI in "Santa Dominga" farm, located in Olavarría, Province of Buenos Aires. Year 2004.

.

Herd	Category	N	Pregnant	%
1	Heifers	91	56	61.5
2	Heifers	200	109	54.5
3	Heifers	199	99	49.7
4	Heifers	206	125	60.7
5	Cows	203	124	61.1
6	Cows	197	131	66.5
7	Cows	198	146	73.3
8	Cows	204	106	52.0
9	Cows	285	152	53.7
10	Cows	149	67	45.0
11	Cows	89	53	59.6
Total		**2021**	**1168**	**57.7**

Finally, a thesis (Burtre et al., 2017) was conducted to compare the impact of FTAI with synchronization (FTAI), synchronization followed by natural mating using bulls (SINCRO) and natural mating without synchronization (Bull) on reproductive and productive efficiency in breeding cows. The work was carried out in three establishments in North Patagonia (Department of Pichi Mahuida, Río Negro). 353 Cows were used that were randomly assigned to the following groups: 1) Bull: On day 0, about 5% of bulls were introduced to cows for a period of 90 days; 2) SINCRO: On day 0 the cows were synchronized by receiving an intravaginal device (IVD) containing 0.5 g progesterone (DIB® 0.5 g of P4, Syntex, Argentina) and 2 mg of estradiol benzoate (Gonadiol®, Syntex, Argentina) IM. On day 8 the IVD were removed, 500 µg of cloprostenol sodium (Ciclase® DL, Syntex, Argentina), 400 IU of eCG (Novormon®, Syntex, Argentina) and 0.5 mg of estradiol cypionate (Cipiosyn®, Syntex, Argentina) were administered IM to each cow after which the bulls were introduced at rate of 5% to the cows; 3) FTAI: Received the same hormonal protocol as the SINCRO group, but FTAI were performed on the cows, 52 to 56 hours after the IVD were removed (day 10), using frozen-thawed semen. On day 13 these cows were included in the same herd as the animals from the other groups with a total of 5% bulls. The bulls used were clinically evaluated and certified to be fit for service. Pregnancy was diagnosed by ultrasound on days 55 and 150. At one establishment the calves (n = 48) were identified and weighed. The statistical analysis was performed with logistic and linear distribution. The response variables were percentage of pregnancy during the first 25 days of breeding (PP25D), percentage of general pregnancy (PPG), average weight of weaning calves (Weight). The results are shown in Table 9.

Table 9. Pregnancy rate, first 25 days of breeding, percentage of general pregnancy, and average weight of the calves.

	Preg 25 days (PP25D)		**General Preg. (PPG)**		**Weight (kg±SD)***
	% (n/n)	**RP (IC 95%)**	**% (n/n)**	**RP (IC 95%)**	**Kg (±DS)**
BULL	25.5 (35/137)[a]	-1.28 (±1.28)	83.9 (15/137)[a]	-24.1(±24.1)	191±18.2[a]
SINCRO	54.1 (60/111)[b]	-0.35 (±0.35)	94.6 (105/111)[b]	-23.3(±23.3)	204±28.8[b]
FTAI	58.1 (61/105)[b]	Reference	96.2 (101/105)[b]	Reference	216±19.8[c]

(P<0,05)

Final considerations

The trials presented in this summary indicate that it is possible to achieve good results with the use of FTAI in beef herds. The inconvenience of heat detection can also be eliminated with the use of FTAI. Whilst the successful application of AI not only has to overcome the problem of heat detection, it also has to deal with the problem of anestrus and nutritional stress. The results presented also suggest that treatments with P4 releasing devices can improve the reproductive performance of cows, due to their beneficial effect on the pulse frequency of LH, follicular growth and ovulation. Furthermore treatments with progestin-releasing devices, estradiol and eCG have provided possibilities for the application of FTAI in suckled cows and to induce cyclicity in cows that are in anestrus.

The beneficial effect of the implementation of a system of this type depends to a large extent on optimal nutritional- and herd health management. BCS is perhaps one of the most determining factors of the pregnancy rate by FTAI and should be adequate (> 2.5 on the scale from 1 to 5) at the start of a heat synchronization treatment program in order to obtain acceptable results.

The use of FTAI programs in a beef herd can increase the weaning weight of the calves, due to the anticipation of births. It also allows for genetic improvement of a herd through the use of bulls with proven superior genetic characteristics. Finally, the selection of the most appropriate program for a particular breeding establishment will also depend on other factors such as the availability of skilled labor and available facilities, but fundamentally it will depend on the objectives of the establishment.

References

1- Alberio, R.H., Butler, H.M., Palma, G., Mihura, H., Torquati, O. 1984. Efecto de un destete temporario sobre la reactivación sexual posparto de vacas de cría multíparas. Rev. Arg. Prod. Anim. 4:307-318.

2- Alberio, R.H., Butler, H.M., Palma, G., Schiersmann, G.C.S., Algorta, D., Ortiz, A. 1984. Actividad reproductiva y fertilidad luego de un destete temporario en vacas de cría multíparas con diferentes estados corporales. Rev. Arg. Prod. Anim. 4:555-566.

3- Alberio, R.H., Butler, H.M., Palma, G., Schiersmann, G.C.S., Mihura, H. 1984. Efecto de un destete temporario sobre la reactivación sexual posparto de vacas de cría primíparas. Rev. Arg. Prod. Anim. 4:933-940.

4- Arteche, A.C., Rocha, D.C., Moreira, R., Cardozo, L.D., Borges J.B.S., Mattos R.C., Gregory, R.M. 2003. Inseminación artificial a tiempo fijo de vacas tratadas con CIDR, benzoato de estradiol, asociado a eCG o destete temporal. V Simposio Internacional de Reproducción Animal, Huerta Grande, Córdoba; 378 abstr.

5- Baruselli PS, Reis EL, Marques MO, Nasser LF & Bó GA. 2004 The use of treatments to improve reproductive performance of anestrus beef cattle in tropical climates. Animal Reproduction Science 82-83 479-486..

6- Balla E., Maraña-Peña, D., Peres, L.C., Pincinato, D., Borges, L.F.K., Bó, G.A. 2005. Efecto del tratamiento con dispositivos intravaginales Triu-B por 8, 9 y 10 días en programas de IATF en vaquillonas cebú. VI Simposio Internacional de Reproducción Animal, Córdoba, Argentina, abstr.

7- Barreiros, T.R.R., Seneda, M.M., Reis, E.L., Baruselli, P.S., Barros, C.M. 2003. Efeito do desmame temporário na sincronização da ovulação para inseminação artificial em tempo fixo. Acta Scientiae Veterinariae 31, 238-239 abstr.

8- Bo G.A, Caccia M., Martinez M., Mapletoft R.J. 1996 Follicular wave emergence after treatment with estradiol benzoate and CIDR-B vaginal devices in beef cattle. 13th Int Congr Anim Reprod, Sydney, Australia; 7:22 abstr.

9- Bó, G.A. y Baruselli, P.S. 2002. Programas de Inseminación Artificial a Tiempo Fijo en el Ganado Bovino en Regiones Subtropicales y Tropicales. Capítulo XXXI. En: Avances en la Gandería doble propósito, C. Gonzalez-Stagnaro, Eleazar Soto Belloso y Lílido Ramírez Iglesia (Editores); Fundación Girarz, Maracaibo, Venezuela; 499-514.

10- Bó, G.A., Baruselli, P.S., Moreno, D., Cutaia, L., Caccia, M., Tríbulo, R., Tríbulo, H., Mapletoft, R.J. 2002. The control of follicular wave development for self-appointed embryo transfer programs in cattle. Theriogenology; 57:53-72.

11- Bó GA, Cutaia L, Chesta P, Balla E, Pincinato D, Peres L, Maraña D, Avilés M, Menchaca A, Veneranda G & Baruselli PS 2005 Implementacion de programas de inseminación artificial en rodeos de cría de Argentina. Proc VI Simposio Internacional de Reproducción Animal, June 24-26 2005, Córdoba, Argentina, pp 97-128.Bó,
12- G.A., Cutaia, L., Brogliatti, G.M., Medina, M., Tríbulo, R., Tríbulo, H. 2001. Programas de inseminacion artificial a tiempo fijo en ganado bovino utilizando progestágenos y estradiol. Resúmenes Cuarto Simposio Internacional de Reproducción Animal, Huerta Grande, Córdoba; 117-136.
13- Bó, G.A., Cutaia, L., Tribulo, R. 2002. Tratamientos hormonales para inseminación artificial a tiempo fijo en bovinos para carne: algunas experiencias realizadas en Argentina. Primera Parte. Taurus; 14: 10-21.
14- Bó, G.A., Cutaia, L., Tribulo, R. 2002. Tratamientos hormonales para inseminación artificial a tiempo fijo en bovinos para carne: algunas experiencias realizadas en Argentina. Segunda Parte. Taurus; 15:17-32.
15- Bretón, G.A., Monje, A.R., Barbagelata, M. 1991. Efecto del destete precoz y del enlatado sobre el comportamiento de vacas y terneros "cola" de parición. Producción Animal, Información Técnica Nº 3. EEA Concepción del Uruguay, pp 232.
16- Burke, J.M., de la Sota, R.L., Risco, C., Staples, C.R., Thatcher, W.W. 1996. Evaluation of timed insemination using a gonadotropin-releasing hormone agonist in lactating dairy cows. J Dairy Sci; 79:1385.
17- Cavalieri J, Coleman C, Rodrigues H, Macmillan KL, Fitzpatrick LA. 2002. The effect of timing of administration of oestradiol benzoate on characteristics of oestrus, timing of ovulation and fertility in Bos indicus heifers synchronised with a progesterone releasing intravaginal insert. Aust. Vet. J. 80:217-223.
18- Cesaroni, G., Butler, H., Mc Dermott, E., Cano, A. 2000. Preñez de vaquillonas inseminadas a tiempo fijo después de un tratamiento con CIDR asociado con GnRH o con benzoato de estradiol aplicado 0 o 24 hs postratamiento. Taurus; 6:20-25.
19- Maraña D, Cutaia L, Peres L, Pincinato D, Borges LFK & Bó GA 2006 Ovulation and pregnancy rates in postpartum bos indicus cows treated with progesterone vaginal devices and estradiol benzoate, with or without eCG and temporary weaning. Reproduction Fertility and Development 18 116-117.
20- Colazo MG, Kastelic JP, Mapletoft RJ. Effects of estradiol cypionate (ECP) on ovarian follicular dynamics, synchrony of ovulation, and fertility in CIDR-based, fixed-time AI programs in beef heifers. Theriogenology 2003; 60:855-65.
21- Colazo MG, Kastelic JP, Martinez MF, Whittaker PR, Wilde R. Fertility follawing fixed-time AI in CIDR treated beef heifers given GnRH or estradiol Cypionate and fed diets supplemented with flax seed or sunflower seed. Theriogenology, 2004; 15; 61:1115-24.
22- Colazo, M.G., Bó, G.A., Illuminanti, H., Meglia, G., Schmidt, E.E., Bartolomé, J. 1999. Fixed-time artificial insemination in beef cattle using CIDR-B devices, progesterone and estradiol benzoate. Theriogenology; 51:404 abstr.
23- Cutaia, L., Tríbulo, R., Moreno, D., Bó, G.A. 2003. Pregnancy rates in lactating beef cows treated with progesterone releasing devices, estradiol benzoate and equine chorionic gonadotropin (eCG). Theriogenology 59, 216 abstr.
24- Cutaia, L, Veneranda, G, Tribulo, R, Baruselli, PS, Bó GA. 2003. Programas de Inseminación Artificial a Tiempo Fijo en Rodeos de Cría: Factores que lo Afectan y Resultados Productivos. V° Simposio Internacional de Reproducción Animal. Huerta Grande, Córdoba; 119-132.
25- Cutaia, L., Moreno, D., Villata, M.L., Bó, G.A. 2001. Synchrony of ovulation in beef cows treated with progesterone vaginal devices and estradiol benzoate administered at device removal or 24 hours later. Theriogenology; 55:408 abstr.
26- Chesta, P., Cutaia, L., Bó GA. 2003. Efecto del tratamiento con un DIB por 7 u 8 días sobre los porcentajes de preñez en vaquillonas cruza índicas inseminadas a tiempo fijo. V° Simposio Internacional de Reproducción Animal. Huerta Grande, Córdoba; 387 abstr.
27- Fernandez Francia, G., Lares S., Formía, N., Giovaninni R., Videla Dorna, I., de la Sota L. 2005. Eficacia de la utilización de benzoato de estradiol aplicado a las 0 o 24 horas del retiro de un dispositivo intravaginal con progesterona sobre la tasa de preñez en

vaquillonas para leche. VI Simposio Internacional de Reproducción Animal, Córdoba, Argentina, abstr.

28- Geary, T.W., Whittier, J.C., Downing, E.R., LeFever, D.G., Silcox, R.W., Holland, M.D., Nett, T.M., Niswender, G.D. 1998. Pregnancy rates of post partum beef cows that were synchronized using Syncro-Mate B or Ovsynch protocol. J Anim Sci; 76:1523-1527.

29- Macmillan, K.L., Peterson, A.J. 1993. A new intravaginal progesterone releasing device for cattle (CIDR-B) for estrus synchronization, increasing pregnancy rates and the treatment of post-partum anestrus. Anim Reprod Sci; 33:1-25.

30- Marcantonio, S.A. 2003. El mercado del semen bovino en Argentina. Taurus 19:11-17.

31- Makarechian, M.P., Arthur, F. 1990. Effects of body condition and temporary calf removal on reproductive performance of range cows. Theriogenology 34:435-442.

32- Maraña Peña D, Cutaia, L., Borges Kruel, L.F., Pincinato, D., Peres Coelho L, Bó, G.A. 2005. Efecto de la aplicación de eCG y destete temporario sobre la tasa de ovulación en vacas posparto tratadas con DIB y benzoato de estradiol. VI Simposio Internacional de Reproducción Animal, Córdoba, Argentina, abstr.

33- Martínez MF, Kastelic JP, Adams GP, Janzen E, McCartney D, Mapletoft RJ. 2000. Estrus synchronization and fertility in beef cattle given a CIDR and estradiol or GnRH. Can. Vet. J. 41, 786-790.

34- Martínez, M.F., Kastelic JP, Adams GP, Mapletoft RJ. 2002. The use of a progesterone-releasing device (CIDR) or melengestrol acetate with GnRH, LH or estradiol benzoate for fixed-time AI in beef heifers. J Anim Sci; 80:1746-1751.

35- Moreno, D., Cutaia, L., Villata, M.L., Ortisi, F., Bó, G.A. 2001. Follicle wave emergence in beef cows treated with progesterone releasing devices, estradiol benzoate and progesterone. Theriogenology 55, 408 abstr.

36- Pace, M.M., Sullivan, J.J. 1980. Effect of Synchro-Mate-B treatment (SMB) and calf separation on beef cattle estrus and pregnancy rates. J. Anim. Sci. 51 (Suppl. 1):312.

37- Pursley, J.R., Wiltbank, M.C., Stevenson, J.S., Ottobre, J.S., Garverick, H.A, Anderson, L.L. 1997. Pregnancy rates per artificial insemination for cows and heifers inseminated at a synchronized ovulation or synchronized estrus. J Dairy Sci; 80:295-300.

38- Randel, R.D. 1981. Effect of once-daily suckled on postpartum interval and cow-calf performance of first-calf Brahman X Hereford heifers. J. Anim. Sci. 53:755-757.

39- Reeves, J.J., Gaskins, C.T. 1981. Effect of once-a-day nursing on rebreeding efficiency of beef cows. J. Anim. Sci. 53:889-891.

40- Rivera G.M., Goñi C.G., Chaves M.A., Ferrero S.B., Bó G.A. 1998. Orarian follicular wave synchronizatión and induction of ovulation in postpartum beef cows. Theriogenology 49: 1365-1376.

41- Roche, J.F. 1974. Synchronization of estrus in heifers with implants of progesterone. J Reprod Fertil; 41:337-334.

42- Ross PJ, Aller JF, Callejas SS, Butler H, Alberio RH. 2004. Estradiol benzoate given 0 or 24 h after the end of a progestagen treatment in postpartum suckled beef cows. Theriogenology; 62:265-273.

43- Smith, M.F., Burrell, W.C., Shipp, L.D., Sprott, L.R., Songster, W.N., Wiltbank, J.N. 1979. Hormone treatments and use of calf removal in postpartum beef cows. J. Anim. Sci. 48:1285-1292.

44- Sorroarain, N. Vaca RJA, Fernández Francia MG, Lares SF, de La Sota RL, Baldo A. 2005. eficiencia de la utilización de benzoato de estradiol a las 0 ó 24 horas del retirado el dispositivo intravaginal con progesterona para inducir la ovulación en vacas multíparas para carne. VI Simposio Internacional de Reproducción Animal, Córdoba, Argentina, abstr.

45- Stagg K., Diskin M.G., Sreenan J.M., Roche J.F.1995. Follicular development in long-term anestrus suckled beef cows fed two levels of energy postpartum. Anim. Reprod. Sci.. 38: 49-61.

46- Tervit, H.R., Smith, H.F., Goold, P.G., Jones, K.R., Vandien, J.J.D. 1982. Reproductive performance of beef cows following temporary removal of calves. Proc. N. Zeal. Soc. Anim. Prod. 42:83-89.

47- Wiltbank M.C., Gumen A., y Sartori R. 2002. Physiological classification of anovulatory conditions in cattle. Theriogenology 57: 21-52.