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Synchronization of ovulation and fixed-time artificial insemination in beef cattle

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The main objective of the implementation of artificial insemination (AI) in cattle is to produce a sustained genetic progress in the herd. Although AI is an old reproductive biotechnology, its widespread implementation is very recent and is mainly because of the use of protocols that allows AI without oestrus detection, commonly called fixed-time artificial insemination (FTAI). The development of FTAI protocols also allowed the application of AI in larger, extensively managed herds and especially in suckled cows instead of restricting the breeding programmes to the heifers. Fixed-time AI treatments are widely used in South America, with about 3 000 000 cows inseminated in the last season in Argentina and about 8 000 000 in Brazil. The objective of this review is to present and describe the various treatments available and some of the factors that may affect pregnancy rates in beef cattle.

Keywords: beef cattle, fixed-time artificial insemination, progesterone, oestradiol, GnRH

Implications

The use of protocols that control follicular development and ovulation, commonly known as fixed-time artificial insemination protocols, has the advantage of being able to apply assisted reproductive technologies without the need for detecting oestrus. These treatments have been shown to be practical and easy to perform by the farm staff, and more importantly, they do not depend on the accuracy in oestrus detection. These treatments have been proven to be efficient, with repeatable results and are the best way of introducing the best genetics in a herd through artificial insemination.

Introduction

Artificial insemination has been used widely to reproduce the most valuable genetics. However, factors such as nutrition, management and oestrus detection efficiency affect the widespread use of this technology in most cattle operations. The most useful alternative to increase the number of cows inseminated is to apply protocols that allow for artificial insemination (AI) without the need for oestrus detection, usually referred to as fixed-time artificial insemination (FTAI). There are basically two types of FTAI protocols currently used in beef cattle, gonadotropin-releasing hormone (GnRH)-based and oestradiol-based protocols, in both cases combined with progestin devices. The preference for one of those protocols by practitioners is related to the availability of hormones in a given country; for example, oestradiol-based programmes are widely used in South America, whereas GnRH-based programmes are used in North America and Europe. The objective of this manuscript is to review the available protocols that synchronize ovulation in beef cattle and some of the factors that may affect pregnancy rates.

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Ovulation synchronization treatments for FTAI in beef cattle

Oestradiol and progestin treatments have been widely used over the past several years in oestrus synchronization programmes in beef cattle (Baruselli *et al.*, 2004) and are the preferred treatment for FTAI of beef cattle in South America. Treatments consist of insertion of a progestin-releasing device and the administration of 2 mg of oestradiol benzoate (EB) on Day 0 (to induce follicle atresia and synchronize follicular wave emergence), prostaglandin $F_{2\alpha}$ (PGF) at the time of progestin device removal on Days 7, 8 or 9 (to ensure luteolysis) and the subsequent application of 1 mg EB 24 h later or GnRH/LH 54 h later to synchronizeovulation (Bó *et al.* 2002a; Martinez *et al.*, 2002a). More recently, the treatment has been further simplified by replacing the second application of EB 24 h after device removal with 0.5 or 1 mg of oestradiol cypionate given at the time of progestin device

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removal, without affecting pregnancy rates (Colazo *et al.*, 2003; Bó *et al.*, 2013). A recent analysis from 266 978 FTAI performed in 1387 herds in Argentina reported a mean pregnancy per AI (P/AI) of 49.48%, ranging from 10.0% to 82.0% (L. Cutaia, unpublished observations). The most prevalent P/AI was between 51% and 60% (43% of the herds) followed by 41% to 50% in 29% of the herds. The mean number of animals FTAI on a given day was 192 and the most prevalent number of animals FTAI on a given day was 200 cows. As in the previous studies (Bó *et al.*, 2002a and 2007), factors that most affected pregnancy rates were body condition sore (BCS) and the number of cows in *postpartum* anoestrus at the time of treatment.

GnRH-based protocols have been used extensively for FTAI in dairy (Pursley *et al.*, 1995) and beef cattle (Geary *et al.*, 2001). The treatment consists of the administration of GnRH to induce LH release and ovulation of the dominant follicle, with emergence of a new follicular wave ~1.5 to 2 days later. Prostaglandin $F_{2\alpha}$ is given at 6 days (Twagiramungu *et al.*, 1995) or 7 days (Pursley *et al.*, 1995) to induce luteal regression, and a second GnRH is given to synchronize ovulation (Pursley *et al.*, 1995). The treatment protocol currently used in dairy cattle has been called Ovsynch (Pursley *et al.*, 1995) in which GnRH is given 56 h after PGF and cows are inseminated 16 h later (Brusveen *et al.*, 2008). CO-Synch protocols are more commonly used in beef cattle because cows are FTAI at the time of the second GnRH (Geary *et al.*, 2001). Recent studies have shown that the first GnRH resulted in ovulation in 44% to 54% of dairy cows (Bello *et al.*, 2006; Colazo *et al.*, 2009), 56% of beef heifers (Martinez *et al.*, 1999) and 60% of beef cows (Small *et al.*, 2009), and the emergence of a new follicular wave was synchronized only when treatment caused ovulation (Martinez *et al.*, 1999). If the first GnRH does not synchronize follicular wave emergence, ovulation following the second GnRH may be poorly synchronized (Martinez *et al.*, 2002a), resulting in disappointing pregnancy rates to AI (P/AI; Martinez *et al.*, 2002b). In addition, ~20% of heifers show oestrus before the injection of PGF, markedly reducing fertility to FTAI (Colazo *et al.*, 2004). Prevention of the early ovulations by addition of a progestin-releasing device to a 7-day GnRH-based protocol has improved P/AI in heifers (Martinez *et al.*, 2002a and 2002b) and beef cows (Lamb *et al.*, 2001). Therefore, most beef cows and heifers that are synchronized with a GnRH-based protocol also receive a progestin-releasing device between the administration of the first GnRH and PGF.

Another alternative to increase the number of cows that ovulate after the first GnRH is through a pre-synchronization with either one dose or two doses of PGF 14 days apart, and administration of the first GnRH 12 or 14 days after the second dose of PGF (Moreira *et al.*, 2001; Bartolome *et al.*, 2002). The objective is to get cows between Days 5 and 12 at the time of GnRH treatment. An interval of 11 days between the second PGF and the first GnRH resulted in higher P/AI than the previously used 14-day interval (Galvão *et al.*, 2007). Therefore, an interval of 10 to 12 days is preferable than the 14-day interval in dairy cows.

The effects of pre-synchronization with PGF before a CO-Synch protocol on oestrus synchrony, corpus luteum (CL), preovulatory follicle diameters, and P/AI has also been studied on beef heifers (Colazo *et al.*, 2004). Pre-synchronization reduced the proportion of heifers in oestrus before FTAI, suggesting that this may be useful in the successful application of GnRH-based protocols in beef heifers. However, P/AI was not affected by pre-synchronization in this study. Another study also examined the effects of pre-synchronization with a progestin device on follicle size and ovulation rate to an initial injection of GnRH in lactating beef cows subjected to a CO-Synch protocol (Small *et al.*, 2009). Pre-synchronization with a progestin device increased the proportion of cows responding to the first GnRH treatment, but P/AI was not affected. It would seem that there are several different pre-synchronization protocols that will increase the numbers of animals ovulating to the first injection of GnRH, and these may result in improved P/AI in GnRH-based FTAI protocols. However, additional studies are needed on beef cattle. The biggest concern in the application of pre-synchronization treatments in beef cattle is the necessity to manage cows two extra times and the period of time involved with these sequential treatments, making this approach impractical in many commercial beef operations.

The Ovsynch protocol itself has not been successfully used to synchronize beef cows in *postpartum* anoestrus, with pregnancy rates in anoestrous cows significantly lower (14.9%) than in cycling cows (46.3%; Fernandes *et al.*, 2001). Anoestrous is a common condition in extensively managed suckled beef herds (Bó *et al.*, 2007; Baruselli *et al.*, 2004) and the use of Ovsynch in beef herds has resulted in pregnancy rates as low as 15%, compared with 53% in cows treated with a progestin device and oestradiol (Baruselli *et al.*, 2004). Other trials have confirmed that Ovsynch protocol yields low conception rate in beef herds showing high percentage of anoestrous animals (Barros *et al.*, 2000; Diskin *et al.*, 2002). In dairy cows, this protocol appears to induce ovulation in a high percentage of anoestrous cows, but some of these cows have a subsequent short luteal phase (Gumen *et al.*, 2003; McDougall, 2010) resulting in lower conception rates than in cycling cows (Moreira *et al.*, 2001). Thus, although GnRH may induce ovulation in non-cycling cows, there is still likely to be a reduction in conception rates in beef herds that will depend on the percentage of the cows that are already cycling at the beginning of the breeding season. Thus, one of the best alternatives for treating beef cows in *postpartum* anoestrous is to combine a progestin device with the CO-Synch protocol, with FTAI and the second GnRH given 60 to 66 h after the removal of the progestin device (Busch *et al.*, 2008).

Another approach to increase progesterone concentrations during Ovsynch includes the administration of GnRH 6 or 7 days before Ovsynch. These treatments are called Double Ovsynch (Souza *et al.*, 2008) or G6G (Bello *et al.*, 2006) and have been reported to increase P/AI in high-producing dairy cows. Nevertheless, these treatments may be too complicated and too long to implement in pasture-managed beef cattle.

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Table 1 *Pregnancy rates in* Bos taurus *beef cows and heifers synchronized with progestin devices and estradiol with or without eCG (adapted from Menchaca* et al.*, 2013)*

	With a CL[1]	Without a CL[1]	Total
Cows ($n = 453$)			
With eCG	67.6% (25/37)[a]	64.9% (124/191)[a]	65.4% (149/228)[a]
Without eCG	63.6% (28/44)[a]	50.8% (92/181)[b]	53.3% (120/225)[b]
Heifers ($n = 749$)			
With eCG	48.7% (73/150)[a]	44.2% (102/231)[a]	45.9% (175/381)[a]
Without eCG	41.2% (54/131)[a]	32.1% (76/237)[b]	35.3% (130/368)[b]

eCG = equine chorionic gonadotropin.
[ab]Proportions within a column with different superscripts differ significantly ($P < 0.05$).
[1]Detected by ultrasonography at progestin device insertion.

One final alternative is to palpate cattle before initiating the GnRH-based programme; those with a functional CL are given PGF (and GnRH is administered 12 to 14 days later) and those with a large ovarian follicle or corpus hemorragicum are given GnRH (and the GnRH-based programme is started 8 days later; Bartolome *et al.*, 2002). However, to the best of our knowledge, these treatments have not been critically investigated in beef cows.

Treatments using equine chorionic gonadotropin (eCG) in beef cattle

The application of eCG at the time of removal of a progestin device has been extensively used in oestradiol-based FTAI programmes in *Bos indicus* cattle (Baruselli *et al.*, 2004) and in *Bos taurus* cattle with high incidence of *postpartum* anoestrus (Bó *et al.*, 2002a). Probably the most important effect of eCG is the stimulation of the growth of the dominant follicle that consequently increases ovulation rate (Sá Filho *et al.*, 2010a), especially in cows in *postpartum* anestrous and/or in low BCS (Bó *et al.,* 2002a and 2007; Sales *et al.*, 2011). Furthermore, treatment with eCG increased circulating progesterone concentrations in the subsequent oestrous cycle (Baruselli *et al.,* 2004; Sá Filho *et al.*, 2010b), which was associated with an increased diameter of the CL (Bó *et al.*, 2002b) and to the stimulation of progesterone production by the CL itself. It has been shown that treatment with eCG increases the expression of steroidogenic enzymes (P450scc, 3b-HSD and StAR) in the CL (reviewed in Baruselli *et al.*, 2012).

Optimization of follicle size may be an important consideration when treating beef cows in *postpartum* anoestrus. Cows with larger ovulatory follicles had a greater ovulation rate and resulted in a greater number of pregnancies per AI (P/AI) in beef cattle (Bó *et al.*, 2007; Perry *et al.*, 2007; Sá Filho *et al.*, 2010c). Furthermore, considering only those cows that ovulated following FTAI, the P/AI increased as the ovarian follicle size increased (Sá Filho *et al.*, 2010c). Therefore, in addition to the increased ovulation rate, ovulation of larger follicles could be responsible for other events, such as the improvement of endogenous E2 production, oocyte competence, CL diameter and concentration of progesterone in the subsequent oestrous cycle, which may benefit the fertility of beef cows following FTAI. Analysis from on-farm FTAI has shown that animals treated with progestin devices must have a BCS higher than 2.5 (scale 1 to 5) and ideally >3 to achieve pregnancy rates of 50% or higher (Bó *et al.*, 2007). Conversely, the addition of eCG allowed for pregnancy rates close to 50% in cows with a BCS of ⩽2.5 (Bó *et al.*, 2007). 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 body condition during the breeding season, pregnancy rates will most probably be 35% or less, even after the administration of eCG (Bó *et al.*, 2007, Butler *et al.*, 2011). In a recent review conducted after the FTAI of 453 suckled Hereford cows in Uruguay (Menchaca *et al.*, 2013, Table 1), the P/AI increased in cows and heifers that did not have a CL detected by ultrasonography at the time of insertion of a progestin device that were treated with eCG. Conversely P/AI was not different between those that had a CL and were treated or not with eCG at progestin device removal.

Restricted suckling or calf removal (CR) associated with progestin devices have also been used for the induction of cyclicity in beef cows (Williams *et al.*, 2002). However, the response to CR seems to be related to body condition of the cows. Two experiments were conducted to compare the effects of eCG treatment and temporary CR on ovulation and pregnancy rates in *postpartum* cows in moderate to low body condition and only 22% of them with a CL (Bó *et al.*, 2007). We found that both CR and eCG increased ovulation rates. Although the growth rate of the ovulatory follicle was greater in cows treated with eCG than in those not treated with eCG, the ovulatory follicle was smaller in CR cows, compared with those that were not CR. P/AI were increased in cows treated with eCG, whereas no differences were found between cows that were CR and those that were not. There was an interaction between CR and pregnancy rates that it was manifested as an improvement in P/AI when cows had >2.5 BCS and no improvement when cows were ⩽2.5 BCS. It was concluded that the use of eCG but not CR improved P/AI following FTAI in *postpartum* crossbred cows in moderate to low body condition. Results also suggest that

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the eCG-related increase in P/AI may be because of the final growth rate of the ovulatory follicle. On the contrary, the absence or little effect of CR on pregnancy rates contrasts with data from other studies conducted on Nelore (*B. indicus*) cows (Penteado *et al*., 2004; Sá Filho *et al*., 2009. Yet in another study conducted in Colombia on suckled Brahman cows (*B. indicus*) that were mostly in *postpartum* anoestrus (i.e. only 16% had a CL) and treated with progestin devices, EB and eCG, CR for 56 h and with the calves located >1 km away from the cows (to avoid contact between them) resulted in an increased P/AI (Castro Duarte and Osorno Chica, 2010). Therefore, the beneficial effects of CR may differ depending on the management, cyclicity and BCS of the herd. Moreover, to set up a CR programme creates logistical problems in several farms, especially in medium to small farms. Although data on the addition of eCG to GnRH-based treatments are limited because GnRH-based treatments are not commonly used in beef cattle in countries where oestradiol is available, the addition on eCG has shown an improvement in pregnancy rates in *B. indicus* cows in *postpartum* anoestrus treated with a CO-Synch programme with progestin devices (Pincinato, 2012) and in primiparous *B. taurus* cows (Small *et al*., 2009); however, no improvement in pregnancy rates has been reported in *B. taurus* cows in good BCS (Marquezzini *et al*., 2013).

The 5-day CO-Synch protocol in beef cattle

The 5-day CO-Synch is a GnRH-based treatment that has recently gained a lot of attention among practitioners and producers. Bridges *et al.* (2008) compared a 7-day CO-Synch protocol plus progestin device with FTAI at 60 h and a 5-day CO-Synch protocol plus a progestin device with FTAI at 72 h in *postpartum* beef cows. In that study, P/AI was 11% higher with the 5-day protocol. Similar results were recently reported by Whittier *et al.* (2013) that found a significantly higher P/AI in cows treated with the 5-day CO-Synch than in those treated with the 7-day CO-Synch.

It has been proposed that the higher pregnancy rates in the 5-day protocol is related to higher preovulatory oestradiol and luteal phase progesterone concentrations, especially in those cows not ovulating after the first GnRH (Bridges *et al*., 2014). Cows treated with the 7-day CO-Synch that did not ovulate after the first GnRH have a marginal reduction in the diameter of the dominant ovulatory follicle and a substantial reduction in preovulatory oestradiol and progesterone concentrations in the ensuing luteal phase than those ovulating after the first GnRH. Conversely, in cows treated with the 5-day CO-Synch protocol, endocrine and follicular characteristics were similar between cows that did or did not ovulate to the first GnRH (Bridges *et al*., 2014).

Additional studies have suggested that owing to a shorter interval between the first GnRH and induction of luteolysis in the 5-day protocol, two injections of PGF 6 to 24 h apart seemed to be necessary to induce complete regression of the GnRH-induced CL in cows (Kasimanickam *et al*., 2009). More recently, Kasimanickam *et al.* (2012) reported that beef heifers inseminated at 56 h in a 5-day CO-Synch protocol (plus a progestin device) had, on average, a 10.3% higher P/AI than heifers inseminated at 72 h.

On the basis of the most recent data reported in the literature, there are still two questions to be resolved in this protocol when it is applied in heifers: (1) the necessity of the first GnRH injection at the time of insertion of the progestin device, considering that only a few heifers ovulate and (2) the necessity of one or two injections of PGF at the time of removal of the progestin device. Colazo and Ambrose (2011) and Lima *et al.* (2011) showed that P/AI did not differ between dairy heifers receiving or not GnRH at the time of insertion of a progestin device. Rabaglino *et al.* (2010) found no differences in P/AI when one or two doses of PGF were used in dairy heifers. However, Peterson *et al*., (2011) reported a tendency for higher P/AI when two injections of PGF were given 6 h apart at progestin device removal in crossbred beef heifers. In addition, a more recent study reported a greater P/AI in dairy heifers receiving GnRH at progestin device insertion, but only when two PGFs were administered at progestin device removal and 24 h later (Lima *et al*., 2013).

Kasimanickam *et al.* (2014) have recently conducted a study involving a large number of beef ($n = 1018$) and dairy ($n = 1137$) heifers to determine the effects of GnRH injection at the time of insertion of a controlled internal drug release device (CIDR, Zoetis Animal Health) and the number of PGF doses at CIDR removal on P/AI in heifers synchronized with the 5-day CO-Synch protocol. The administration of GnRH at the time of insertion of the CIDR device significantly improved pregnancy rates in beef heifers, but not in dairy heifers. In addition, the administration of one or two PGF at CIDR removal did not have a significant effect on P/AI in both beef and dairy heifers. Thus, results can be interpreted to suggest that in beef heifers GnRH administration at the time of progestin insertion is required to maximize pregnancy rates, whereas increasing the number PGF treatments may not be necessary to achieve high pregnancy rates. A double dosage of PGF seems to be required to maximize pregnancy rates in mature beef cows (Bridges *et al*., 2012). In the latter studies, no differences in P/AI were found between the administration of two doses of PGF 8 h apart and the administration of the double dosage of PGF simultaneously with CIDR removal.

A recent study reported a comparison between the 5-day CO-Synch plus progestin protocol with the oestradiol-based protocol in suckled cows in *postpartum* anoestrus. Pregnancy per AI was comparable when 400 IU of eCG was given at the time progestin device removal in both the 5-day CO-Synch and the oestradiol-based protocol (5-day CO-Synch: 120/259, 46.3% *v.* oestradiol: 151/277, 54.5%). However, P/AI was lower in cows treated with the 5-day CO-Synch but not receiving eCG at progestin device removal (71/265, 26.8%; $P < 0.05$; Huguenine *et al*., 2013).

We have recently carried out an experiment to evaluate a new treatment based on oestradiol but with a prolonged proestrus that we named J-Synch (de la Mata and Bó, 2012).

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In the first study, 28 Angus crossbred beef heifers that were 16 and 17 months of age and were randomly divided into two groups. Heifers in Group 1 (J-Synch, $n = 14$) received 2 mg EB and an intravaginal device with 0.6 g of progesterone (Emefur 0.6 g, Merial Argentina SA) for 6 days, whereas those in Group 2 ($n = 14$) were treated with the 5-day CO-Synch and the same progesterone device. All heifers received 150 μg of D-cloprostenol (Emefur, Merial) at device removal and were FTAI and received GnRH 72 h later. All heifers were examined by ultrasonography to monitor follicular development and ovulation. The initiation of a new follicular wave occurred earlier ($P < 0.05$) in heifers treated with GnRH (2.1 ± 1.0 days) than in those treated with EB (3.7 ± 0.9 days). However, ovulation rate (91.6% *v.* 92.8%), the diameter of the ovulatory follicle (11.7 ± 0.2 *v.* 12.0 ± 0.5 mm), the interval from PGF to ovulation (97.1 ± 17.4 *v.* 95.1 ± 12.5 h) and P/AI (50.0% *v.* 57.1%) did not differ between heifers in the J-Synch group and those in the 5-day CO-Synch group. This treatment is still under investigation but in field trials conducted on 854 commercial beef heifers, overall P/AI with the J-Synch treatment average 53.7% (range: 35 to 71.8%). In another follow-up study on Holstein heifers that is currently underway, preliminary P/AI were 62.7% (37/59) for the J-Synch, 54.5% (30/55) for the 5-day CO-Synch and 53.4% (31/58; $P = 0.3$) for those in the control group, which were treated with the standard EB plus progestin protocol for 7 days (Ré *et al.*, 2014). In conclusion, these treatments proved to be efficient for synchronizing ovulation in heifers and it is necessary to conduct more studies on a large number of animals to determine whether this treatment increases P/AI compared with the traditional oestradiol plus progestin treatment currently used by most practitioners in South America.

The use of FTAI in commercial beef herds

One of the main advantages of implementing FTAI programmes in a beef herd is that more cows can be impregnated earlier in the breeding season to genetically improved bulls, resulting in heavier weaning weights (reviewed in Bó *et al.*, 2007). Fifty per cent of the cows could potentially become pregnant on the first day of the breeding season and result in a higher number of cows calving at the beginning of the calving season. Therefore, their calves will be older and heavier at weaning. Besides, the use of genetically superior bulls will also result in heavier calves at weaning.

The impact of FTAI has proven to be equally efficient for different beef operations in Argentina and Brazil (Baruselli *et al.*, 2004; Bó *et al.*, 2007) and examples will be shown in the following paragraphs.

The 'Estancia El Mangrullo' (Lavalle, Santiago del Estero, Argentina) is located in the semiarid region of Argentina, with seasonal rainfalls of 600 mm per year from November to December to May to June (summer and fall). Animals are all zebu-derived and a cross-breeding programme with Bonsmara (*B. taurus* adapted breed) has been implemented with the use of semen and embryos. A FTAI programme was implemented in heifers and suckled cows that resulted in pregnancy rates between 35% and 50%, with an overall pregnancy rate of 45.5% (2193/4816). Probably, the main aspect of applying this system was its effect on calving distribution as shown in Figure 1. The progression of calvings throughout the calving season was compared between years using Kaplan–Meier's method for comparison of survival curves. Survival curves across years were significantly different ($P < 0.01$). In year 1 (no FTAI), calvings were distributed over 6 months with a high number of cows calving from December to March (late calvers). This was changed with the limited use of FTAI in year 2. However, with a more aggressive FTAI programme, calvings began earlier, with a high proportion of heifers calving in September (i.e. 30 days before the cows) and a higher percentage of mature cows calving earlier in the breeding season (October onwards) in year 3.

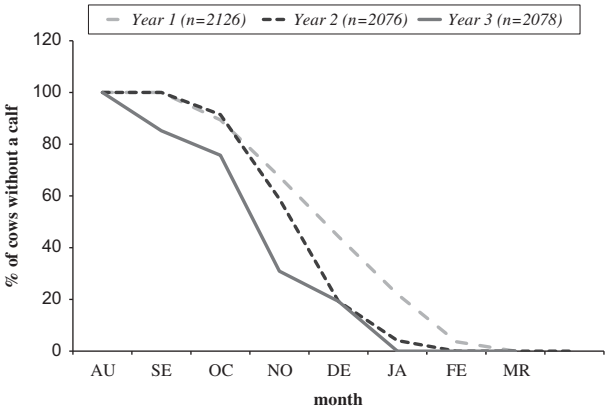


Figure 1 Survival curves for calving distribution at 'Estancia El Mangrullo' Santiago del Estero, Argentina in 3 consecutive years. Curves differ significantly among the 3 years ($P < 0.01$) (adapted from Bó *et al.*, 2007).

This improvement in the calving pattern distribution has been also shown after the application of FTAI programmes in large-scale beef operations with *B. indicus* cattle in Brazil. Specific details of these studies have been reported elsewhere (Bó *et al.*, 2007), but just as an example in 1 study involving 5579 suckled Nelore cows that were FTAI early in the *postpartum* period (i.e. 35 to 45 days *postpartum*) P/AI was 50.5% (2817/5579) and the overall pregnancy rate after two cycles of rebreeding with bulls was 80.7% (4390/5579). As in the previous example, the use of a progestin-based FTAI programme at the beginning of the breeding season increased the number of calvings early in the calving season and tighten the calving pattern. Apart from the effect of FTAI on the calving distribution, these studies have also shown an impact of FTAI on weaning weights, with improvements ranging between 29 and 35 kg compared with those calves obtained by natural breeding (Bó *et al.*, 2007).

Another programme worth mentioning is that applied at 'Estancia Santa Dominga', Los Lazos S.A. an FTAI programme was implemented in the Angus herd in 2000 and results obtained since the first programme are shown in Table 2.

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Table 2 *Number of cows FTAI and pregnancy rates over a 10-year period in Angus cows and heifers in 'Estancia Santa Dominga', Olavarria, Argentina*

Year	Number of cows AI	Pregnant	%
2000	528	259	49.1
2001	1169	697	59.6
2002	1905	1102	57.9
2003	1928	1179	61.2
2004	2021	1168	57.7
2005	2326	1345	57.8
2006	2534	1404	55.4
2007	2219	1242	56.0
2008	2683	1402	52.3
2009	2953	1429	48.4
2010	2784	1496	53.7
Total	23 050	12 723	55.2

FTAI = fixed-time artificial insemination; AI = artificial insemination.

The results shown involve 11 years of FTAI programmes with heifers and suckled cows that are 45 to 70 days *postpartum*. In this herd, animals have always been in adequate BCS (2.5 to 3.5 in 1 to 5 scale) at the beginning of the breeding season. As is shown in Table 2, pregnancy rates with FTAI were similar over the 11 years, thus showing stability of the programme when good management practices are applied.

Summary and conclusions

The use of protocols that control follicular development and ovulation has the advantage of being able to apply assisted reproductive technologies without the need for detecting oestrus. These treatments have been shown to be practical and easy to perform by the farm staff, and more importantly, they do not depend on the accuracy in oestrus detection. Treatments with GnRH or oestradiol and progestin-releasing devices have provided for FTAI in beef cattle, and the addition of eCG has been especially useful in increasing pregnancy rates in cows experiencing *postpartum* anoestrus. Shorter ovulation synchronization treatments that provide for a longer proestrus are an interesting new alternative for FTAI; however, more studies are needed to determine whether these treatments increase P/AI compared with the traditional EB plus progestin treatments currently used by most practitioners in South America. Finally, these treatments have been proven to be efficient, with repeatable results and are the best way of introducing the best genetics in a herd through artificial insemination.

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