Applied reproductive strategies in livestock: A Canadian perspective

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Commercial embryo transfer began in Canada in 1971 with the introduction of European breeds of cattle

Bovine *in vivo* embryo transfer throughout the world in 2016

	No. Flushes	Trans Embryos	Total Trans	%
N. America	53,536	360,020	271,045	52.1
S. America	8,953	49,815	45,648	8.7
Asia	12,689	105,685	77,542	14.9
Europe	20,497	127,980	112,306	21.6
Oceania	2,353	11,187	10,578	2.0
Africa	711	5,534	3,416	0.7
TOTAL	100,739	660,221	520,535	

Perry, 2017

Bovine *in vitro* embryo production throughout the world in 2016

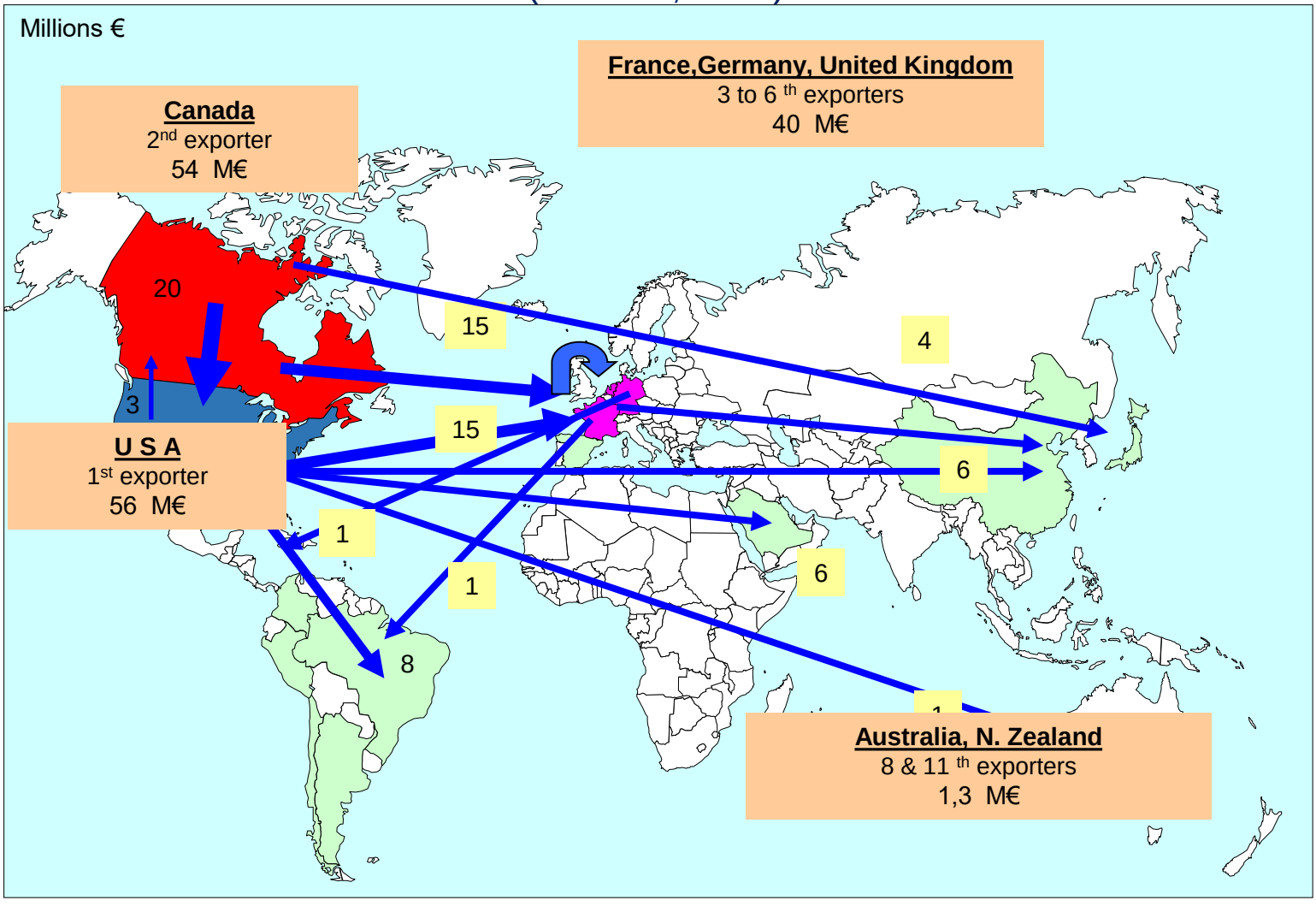
Region	Donors	Number of embryos Produced	Transferred
South America	60,696	369,820	282,887
North America	35,980	212,046	97,871
Europe	3,177	13,780	14,502
Asia (OPU)	3,177	9,438	4,414
(Abattoir)	35,335	56,740	22,930
Oceana	1,646	3,892	4,316
Africa	1,113	3,733	183
TOTAL	111,704	612,709	404,173

Embryo Transfer in Canada in 2017

Practitioners responding		63
Donors collected:	Dairy	6,639 (27% sexed semen)
	Beef	2,921
Transferable embryos collected		65,145 (6.8/donor)
Using sexed semen		10,139 (5.7/donor)
Number of embryos frozen		46,924
Embryos transferred fresh		16,748 (59.9% PR)
Embryos transferred frozen		27,064 (54.1% PR)
No. embryos exported		9,149
No. IVF embryos		20,389

But Canada has been a major player in semen exports

(Chillaud, 2007)

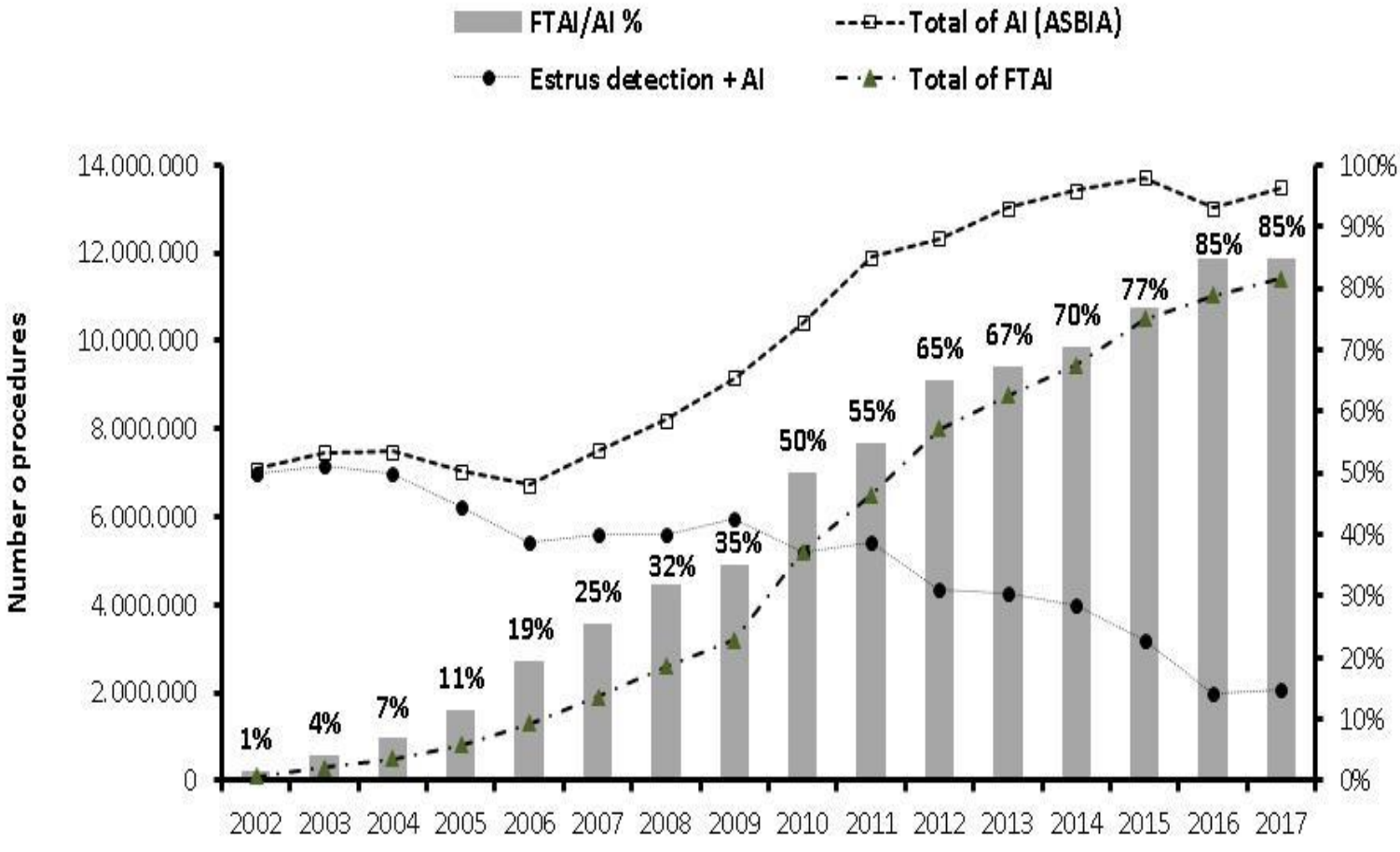


Artificial insemination in Canada

- 72 % of dairy producers use AI
- 5 % of beef producers use AI

Canada hasnot been a great user of AI in the beef industry

AI in Brazil over the last 15 years



Estrus detection is the most important factor affecting the widespread use of AI, especially in the beef industry

What are the alternatives?

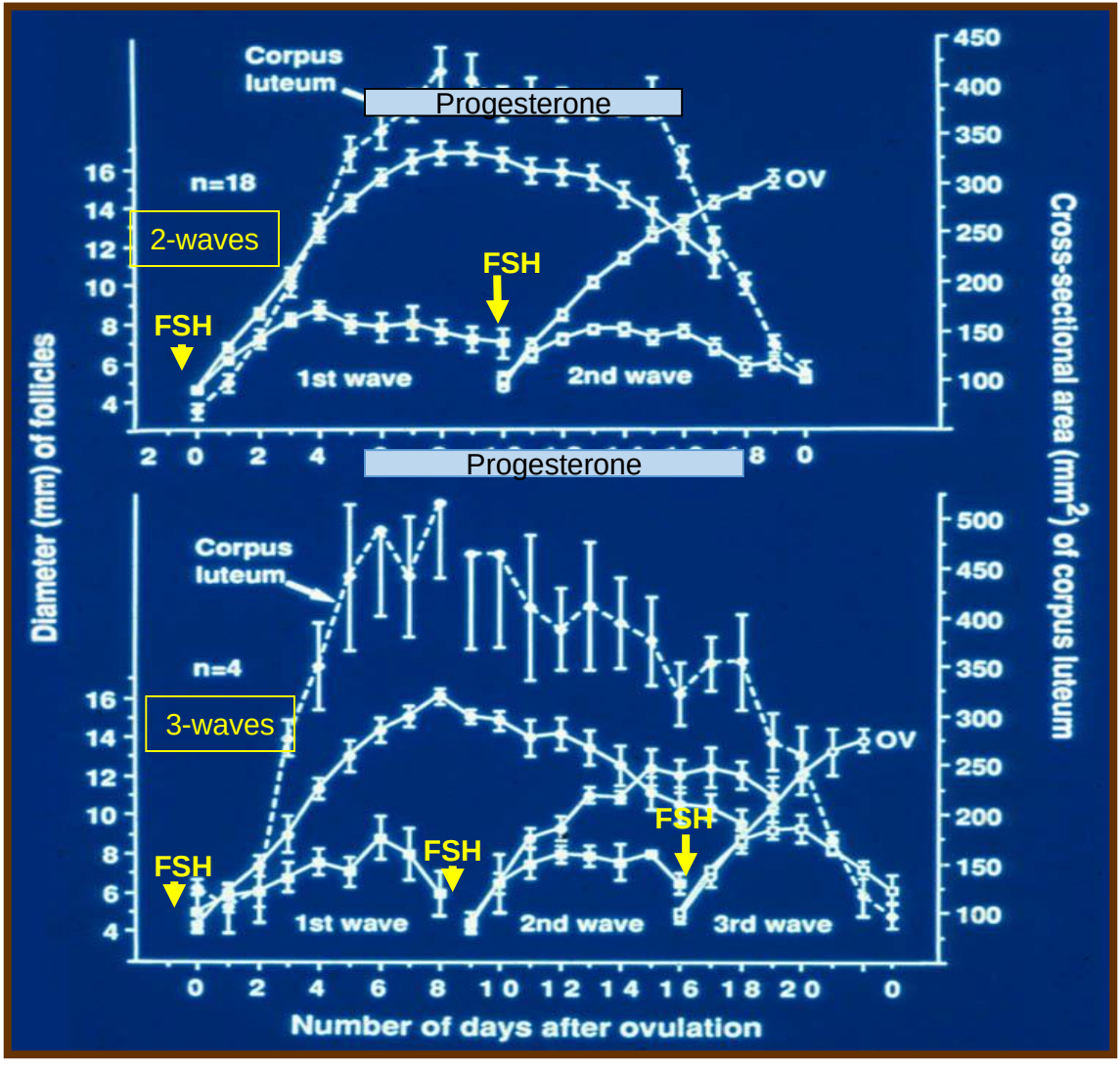
- Synchronize estrus to decrease the days required for estrus detection
- Treatments that eliminate the need for estrus detection (Fixed-time AI; FTAI)

Estrus synchronization

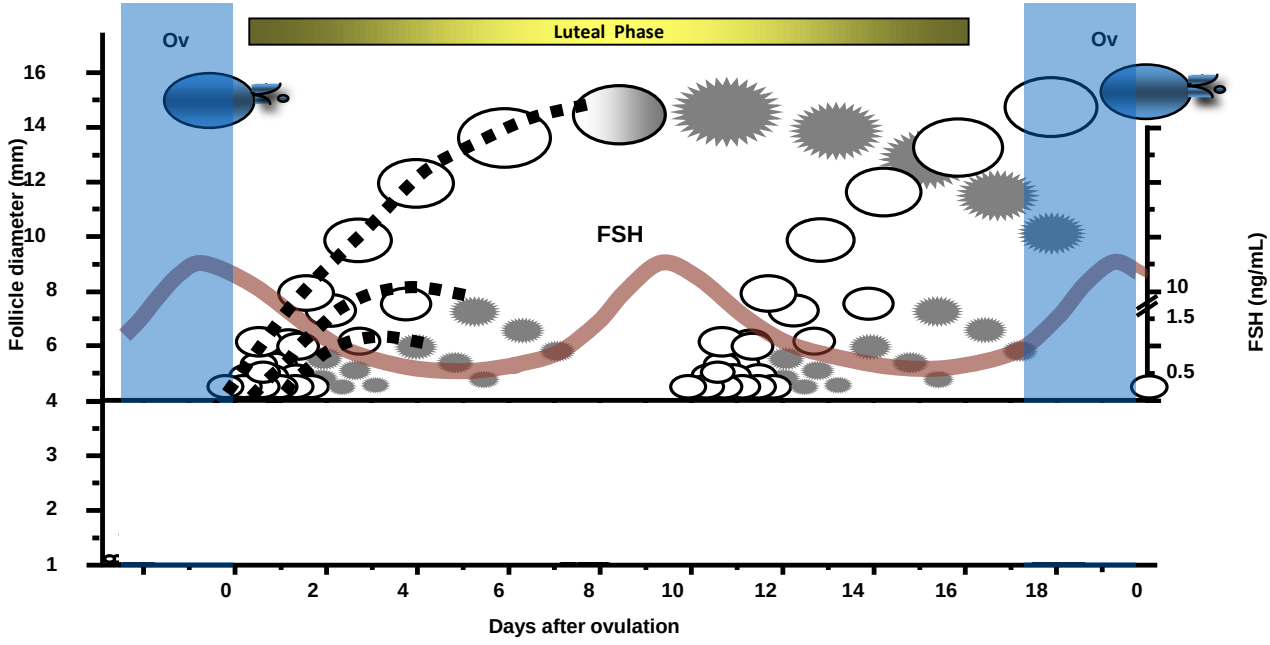
- Extend the luteal phase - Progestins
  - MGA (melengestrol acetate)
  - Progestin inserts
- Eliminate the corpus luteum - Prostaglandin
- Combinations of the above

* Still considerable variability in interval to estrus and estrus detection is required, why?

Follicular wave dynamics in cattle



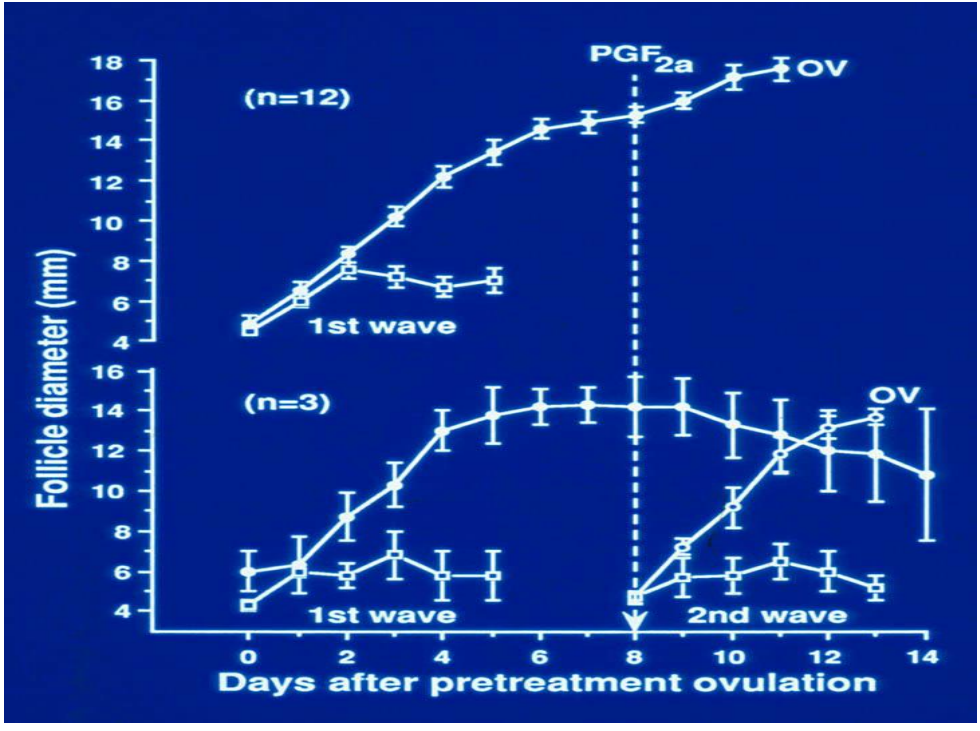
Traditional definition - follicle wave emergence…



Estrus Synchronization with PGF

Precision depends on:

1. Stage of development of the CL
2. Stage of development of the DF



Kastelic et al., 1991

Fixed-time AI (FTAI)

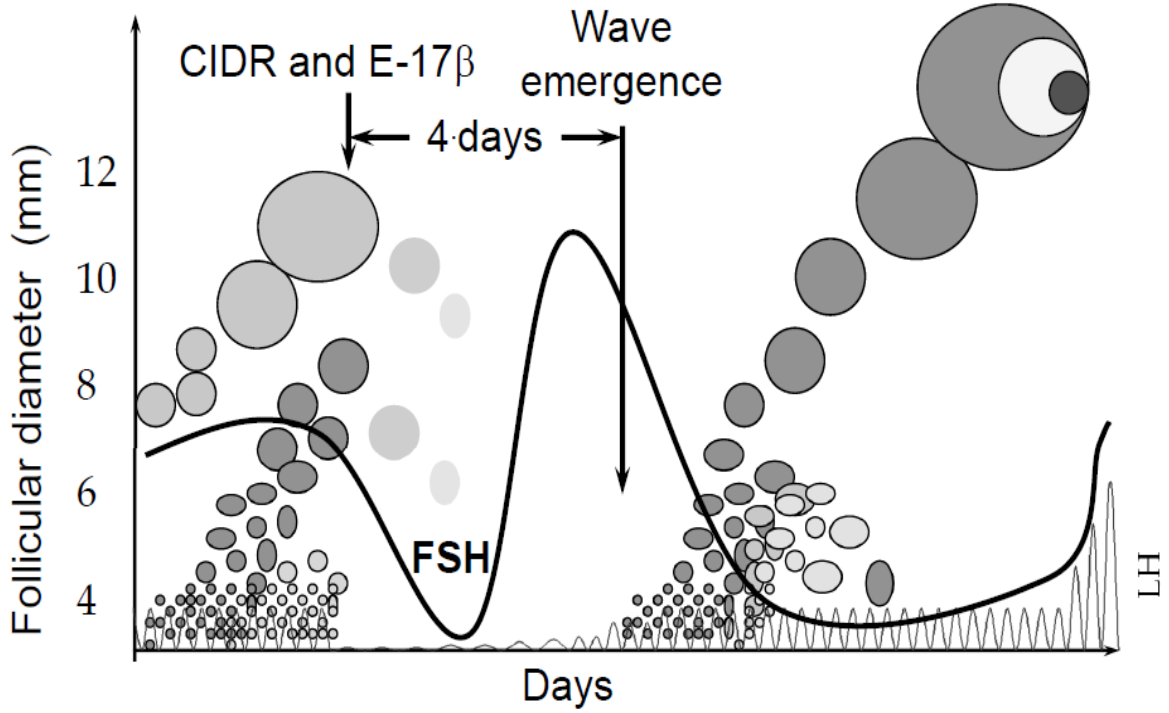
- Eliminates the need for estrus detection…
- However, follicular wave dynamics can have a profound effect on the successful application of FTAI
- Requires synchronous growth of a dominant follicle and synchronous ovulation at a predetermined time

Synchronization of the growth of a dominant follicle for FTAI

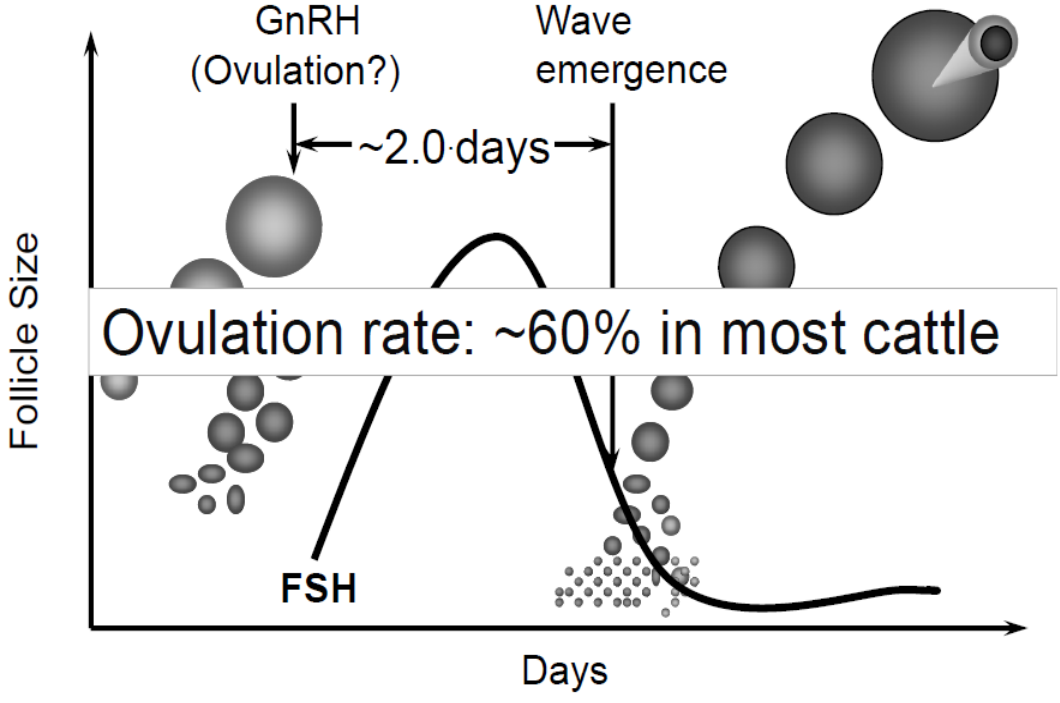
- Estradiol – 4 days
  (2.5 or 5 mg E-17β or 2 mg EB or EV)

- GnRH/pLH – 2 days
  (considerable variability)

Follicle wave emergence following treatment with estradiol and progestins



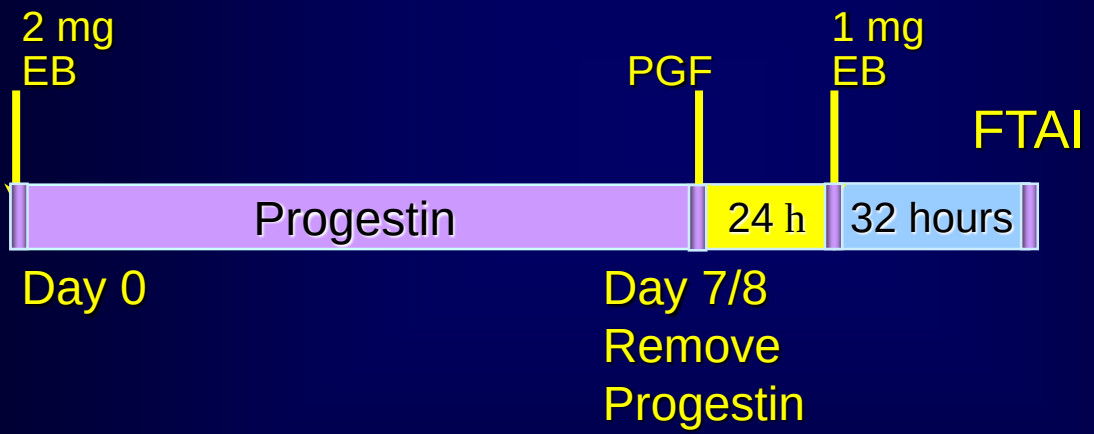
Follicle wave emergence - GnRH



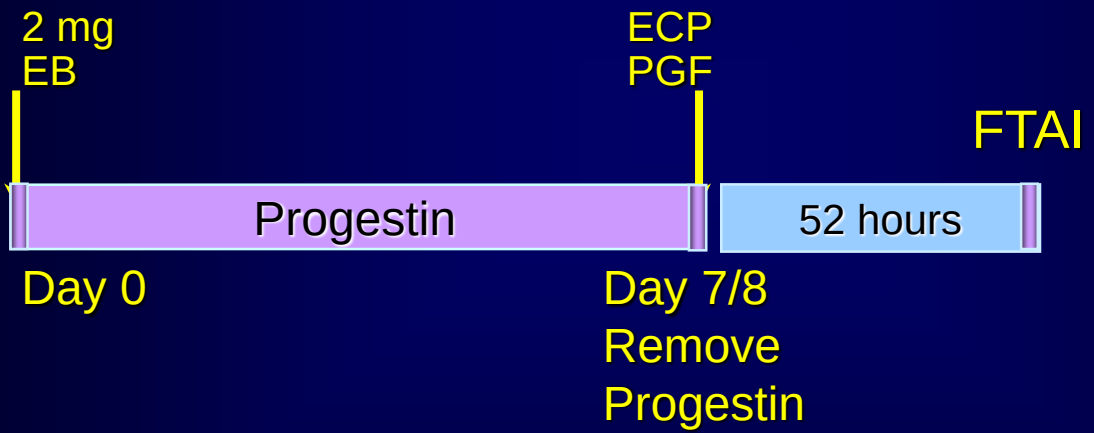
Synchronization of ovulation

- GnRH (100 ug)
- pLH (12.5 to 25 mg)
- EB (1.0 mg EB)
- ECP (0.5-1 mg)

Fixed-time AI with estradiol + progestin

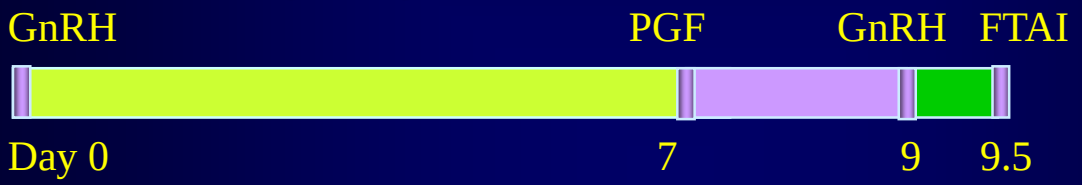


Fixed-time AI with estradiol in Brazil



GnRH-based protocols

Ovsynch protocol

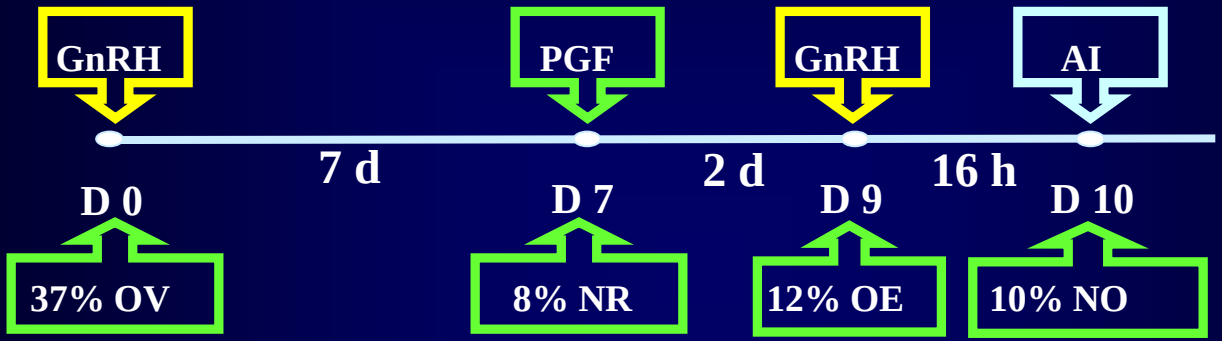


Cosynch protocol

Ovulation??

Early estrus??

Problems with 7-d Ovsynch



Conception Rate = 28-35%

A problem with synchronization

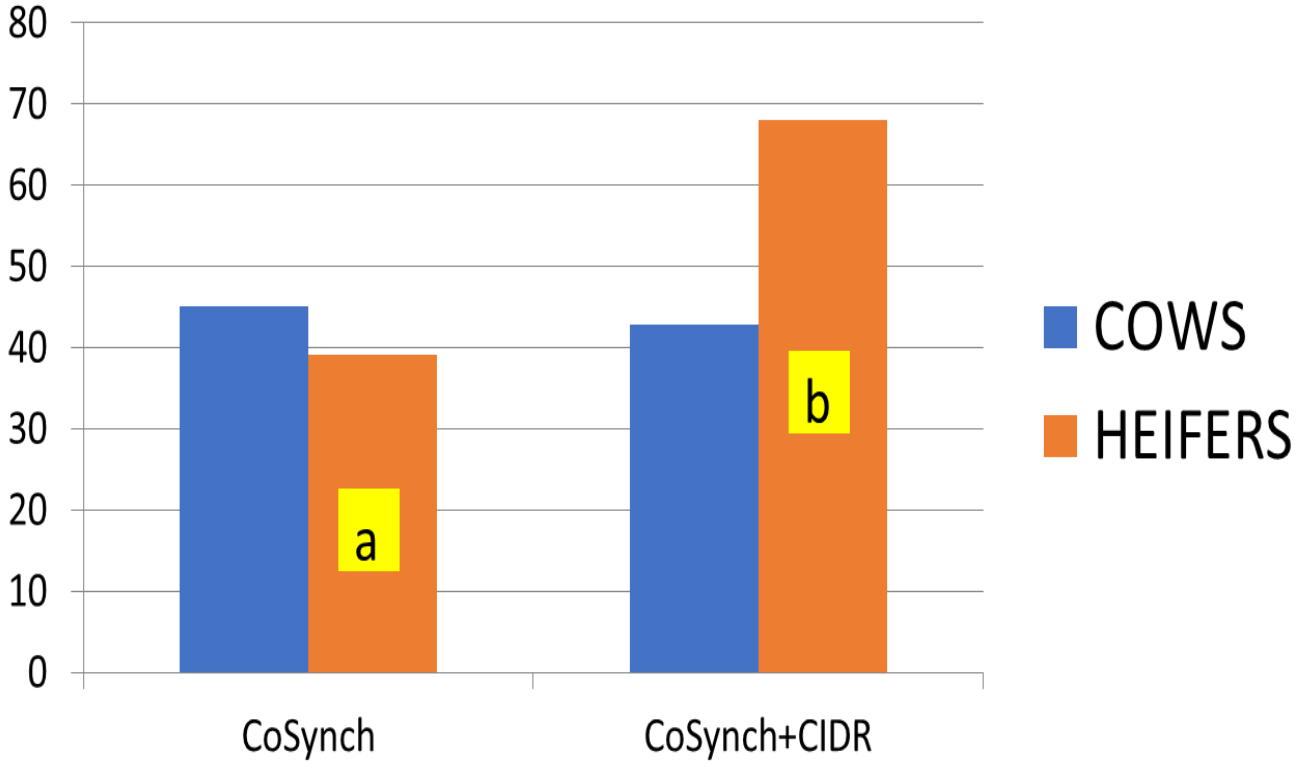
N = 744

Colazo et al., 2009; 2013; data not published

Increasing pregnancy rate in GnRH-based protocols

- Detect estrus - AI those showing estrus early
- Incorporate a progestin device (especially in heifers and anestrous cows)
- Presynch
  - 2 doses PGF
  - G6G
  - Double Ovsynch
  - Progestin presynchronization

Pregnancy rate with Cosynch vs Cosynch+CIDR

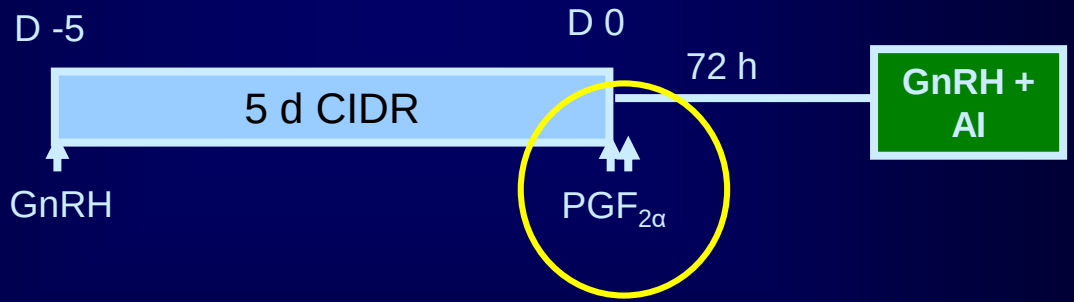


ab P<0.05

Martínez et al., 2000

Improving the fertility of GnRH-based protocols

5-d Cosynch + CIDR



Bridges et al., 2008

Proestrus length and fertility in beef heifers

Proestrus Length PGF to GnRH (days)	DF Diameter prior to Ovulation (mm)	DF Age (days)	Conception Rate (%)
1.0 ± 0.1	11.1 ± 0.2	5.4	**4**
1.0 ± 0.1	11.1 ± 0.2	5.1	**8**
2.2 ± 0.1	13.6 ± 0.2	6.6	**57**
2.0 ± 0.1	13.7 ± 0.2	6.1	**67**
3.3 ± 0.1	10.7 ± 0.1	5.1	**76**
4.7 ± 0.2	12.0 ± 0.3	6.0	**100**

Mussard et al., 2003a, 2003b, 2007, Bridges et al., 2009

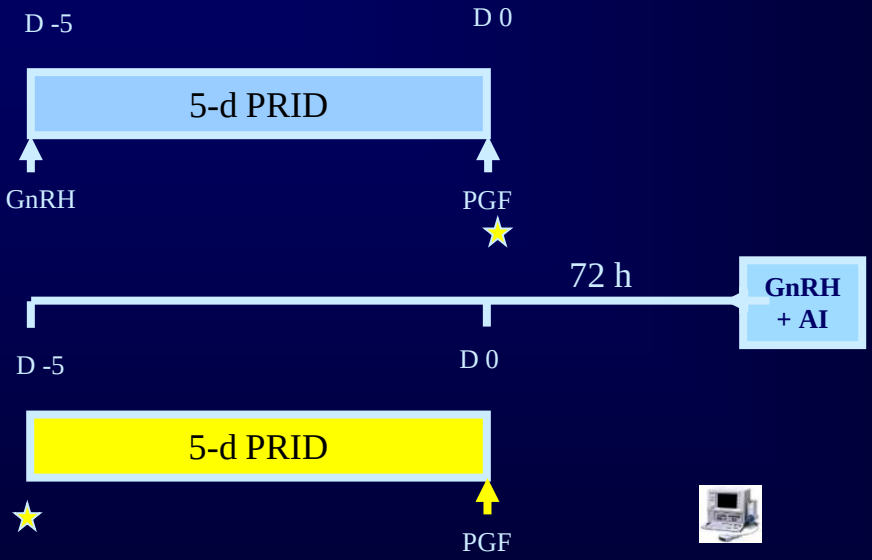
There is considerable debate as to whether 2 injections of PGF are required in the 5-day Co-synch plus CIDR protocol

Two injections would seem to be required only if the heifer ovulates to the first PGF, but…

Similarly, there is considerable debate as to whether the first GnRH is necessary

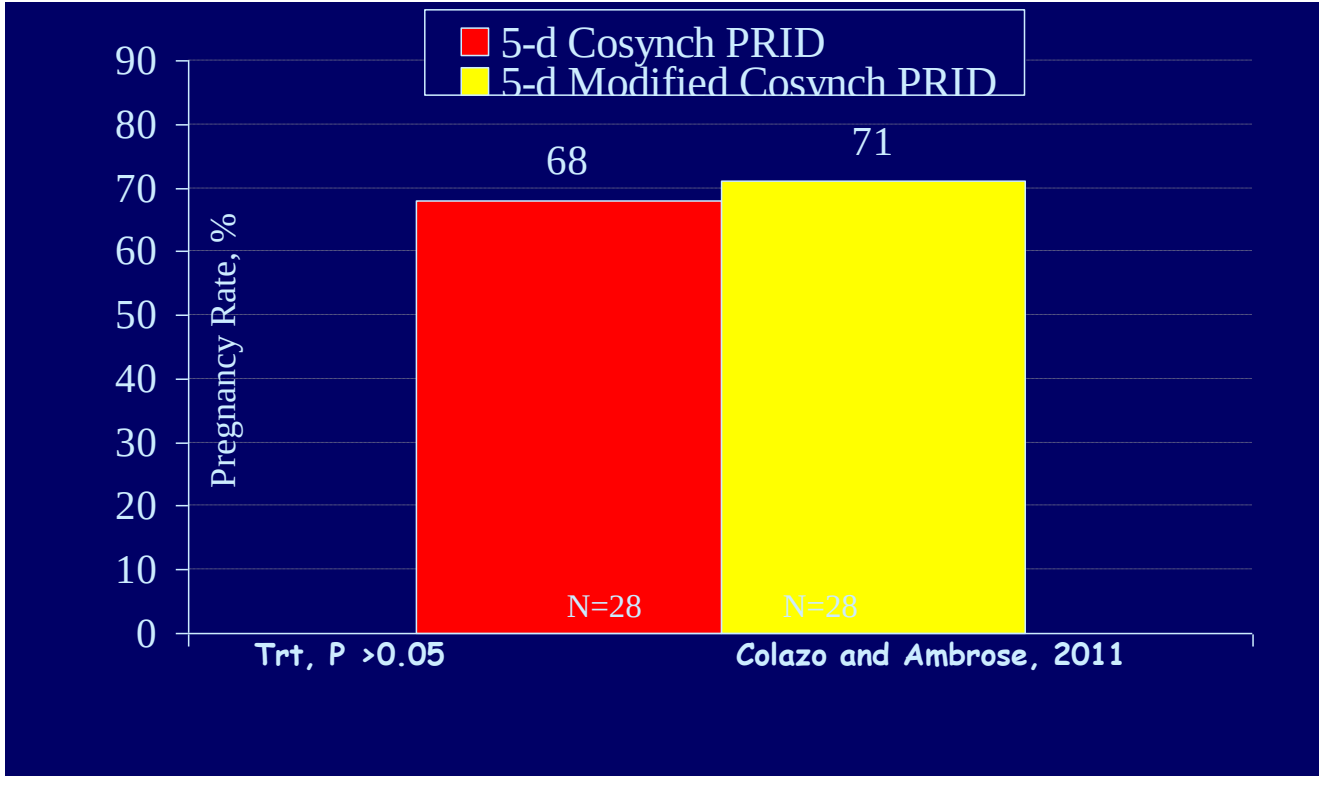
We have found that the first GnRH is necessary if there is a high incidence of anestrus in the group, and then 2 injections of PGF would be necessary

Modified 5-d Cosynch



Colazo and Ambrose, 2011

Pregnancy rate at 28 d following a modified 5-d protocol



Estrus detection with Estrotec ED patches and type of semen on P/AI with the Modified protocol

	Score 0	Score 1	Score 2	Score 3
				
	Unchanged	< 50% change	≥ 50% change	Missing
Sex-selected, %	36.1[a]	37.2[a]	59.8[b]	58.3[b]
Conventional, %	49.4[c]	58.3[cd]	69.6[d]	58.6[cd]

[a,b]Within a row , percentage without a common superscript differed (P<0.05).
[c,d]Within a row , percentage without a common superscript differed (P<0.01).

Colazo et al., 2017

J-Synch - a shortened estradiol-based protocol

Bo et al., 2016

Association between proestrus length and pregnancy rate with J-Synch in beef heifers

	Follicular diameter at FTAI (mm)	Tail-paint rubbed off (%)	Ovulated heifers at FTAI (%)	Pregnancy rate (%)
GnRH 48 h	12.2±0.1[a]	68.2%[a] (122/179)	1.7%[a] (3/179)	63.6%[c] (196/308)
GnRH 60 h	12.8±0.1[b]	71.4%[a] (120/168)	1.2%[a] (2/168)	63.1%[c] (183/290)
GnRH 72 h	12.9±0.2[b]	77.0%[a] (137/178)	10.7%[b] (19/178)	70.0%[d] (219/313)

a vs. b; $P<0.05$.
c vs. d; $P<0.1$.

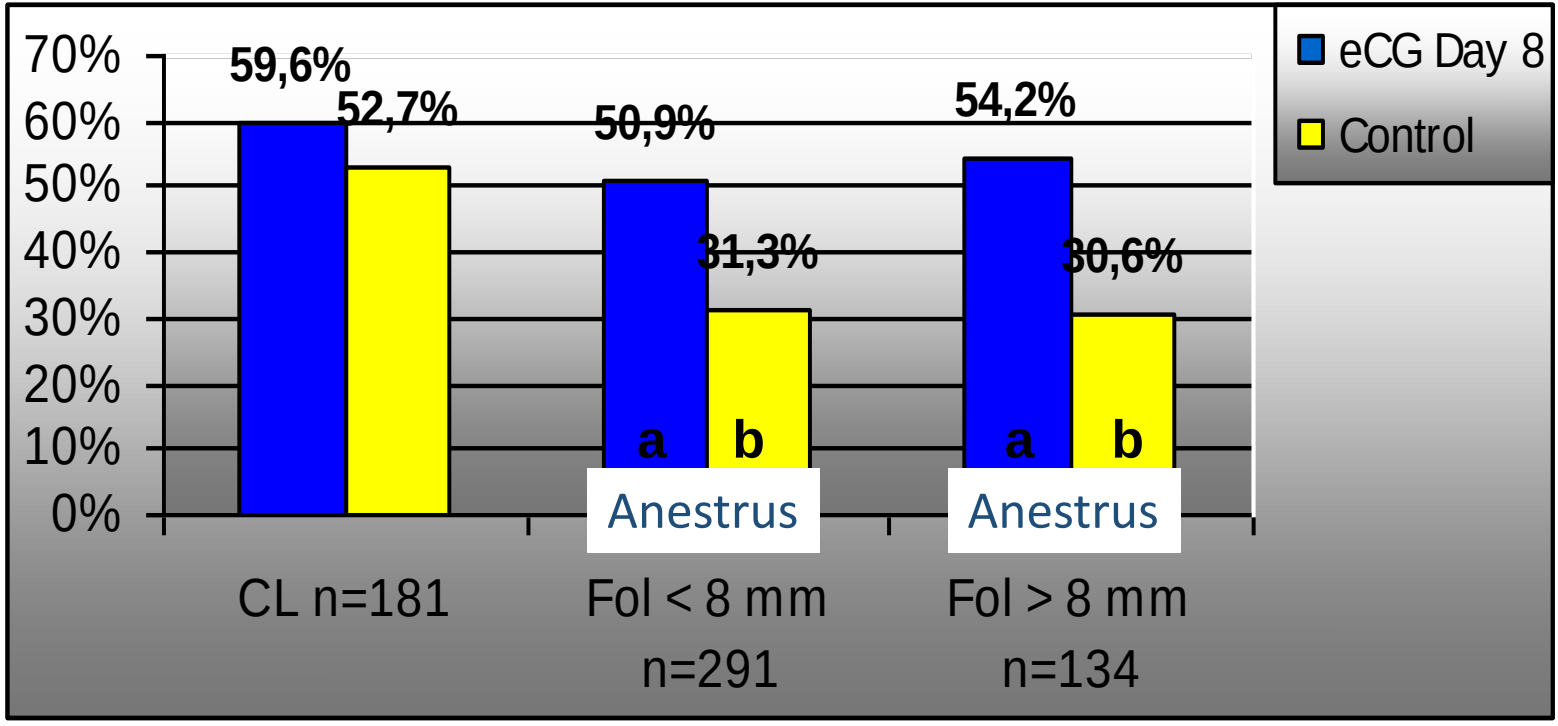
Nuñez et al., ICAR 2016

Equine chorionic gonadotropin (eCG)

Pregnant mare's serum gonadotropin PMSG)

- Complex glycoprotein produced by the endometrial cups on Days 36 to 130 of pregnancy in the mare ~45% carbohydate
- Binds to both LH and FSH receptors in the cow (Soumano et al., 1996)
- Long half-life due to sialic acid content (Murphy and Martinuk, 1991)

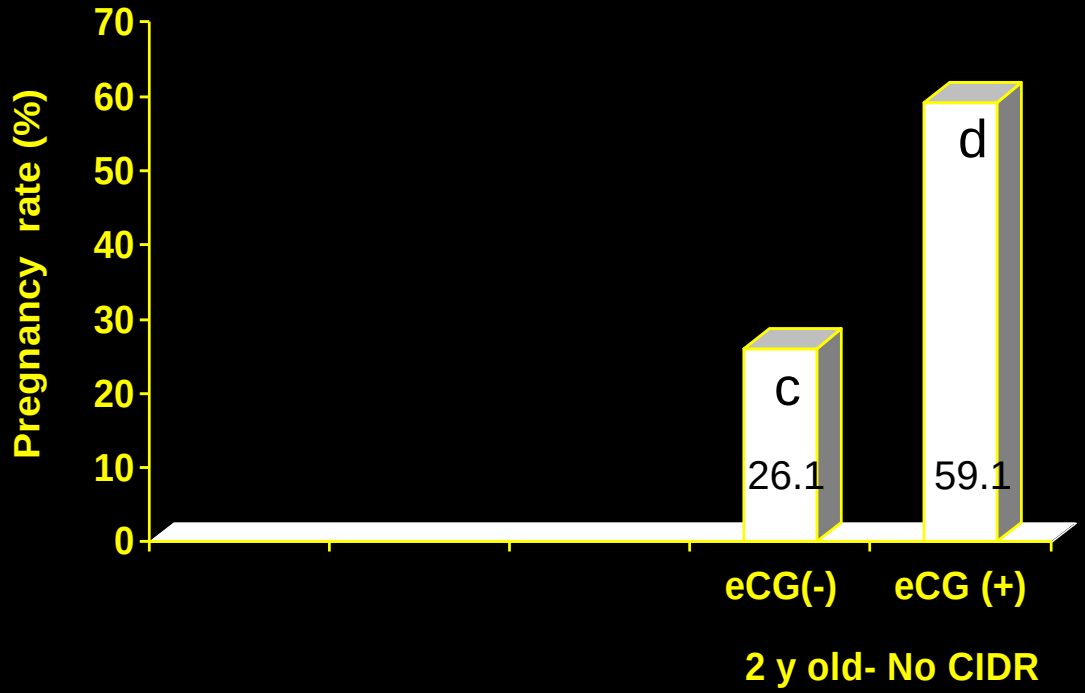
Pregnancy rates in suckled beef cows treated with eCG in a estradiol/progestin protocol



[ab] P<0.03

Cutaia et al., 2003

Non-presynch 2-y old cows
Effect of eCG on pregnancy rates



[cd]P<0.03

Small et al., 2009

Synchronization of embryo recipients with PGF (100 animals)

Ideal Situation

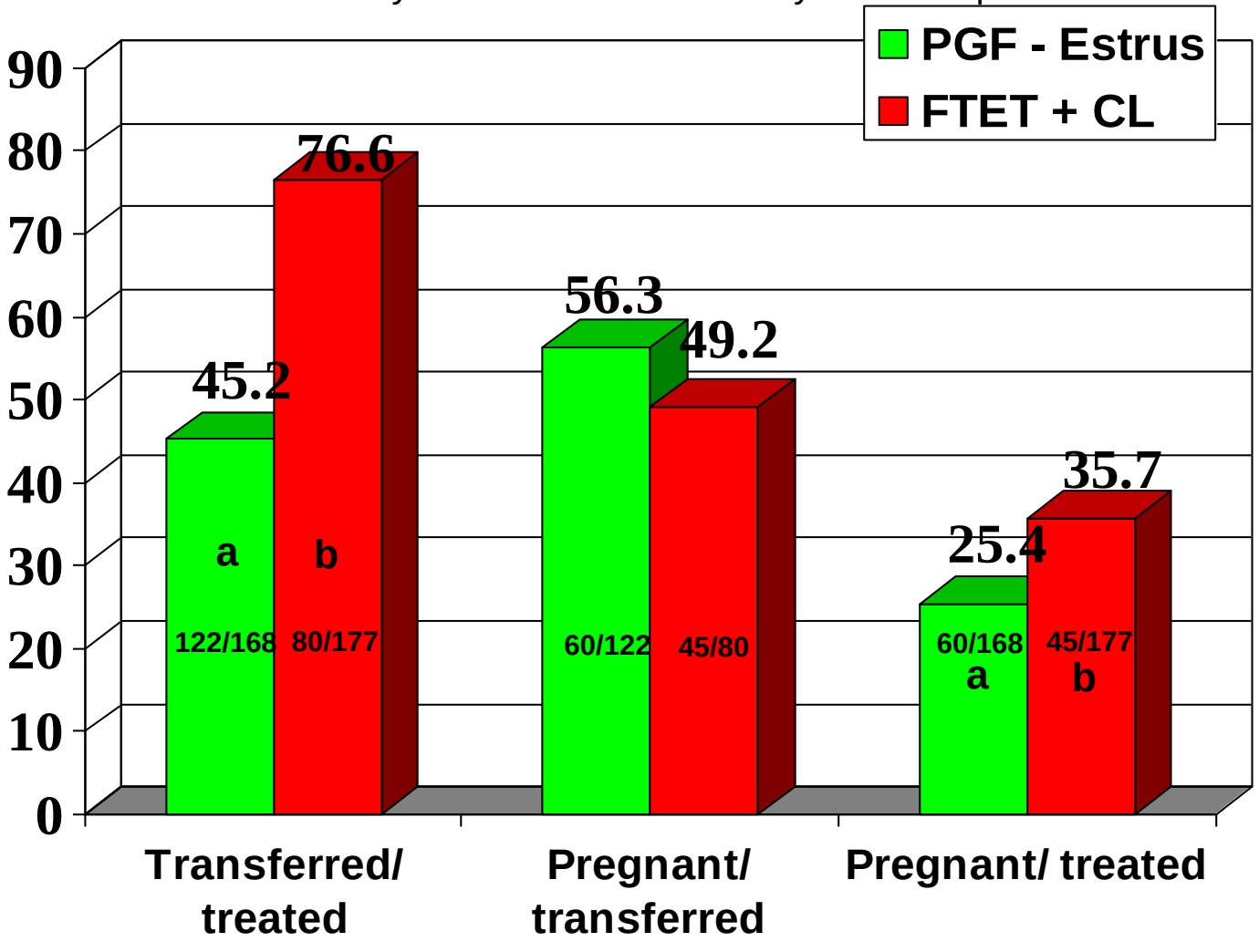
- In heat 48 to 72 h after the second PGF: 80
- Recipients with an “adequate” CL (75%): 60
- Recipients pregnant (58%): 35

Most common situation

- In heat 48 to 72 h after the second PGF: 65
- Recipients with an “adequate” CL (75%): 49
- Recipients pregnant (58%): 28

Alternative is fixed-time embryo transfer (FTET)

Pregnancy rates in recipients transferred 7 d after observation of a PGF-synchronized estrus or on Day 17 of a fixed-time embryo transfer protocol



Baruselli et al., 2000

Synchronization of recipients with GnRH ± Progestin

Group	Transfer/treated (%)	Concept Rate (%)	Preg Rate (%)
GnRH +PGF estrus detection	108/169 (63.9) [a]	67/108 (62.0) [a]	67/169 (39.6)
Ovsynch	150/165 (90.9) [b]	72/150 (48.0) [b]	72/165 (44.0)
Ovsynch + Progestin	152/165 (92.1) [b]	82/152 (53.9) [ab]	82/165 (49.7)

ab – $P < 0.01$

Field Trial (Ovsynch+CIDR) **980/1637 (60%)**

Beal and Hinshaw, 2001

Summary

- Estrus synchronization is a management tool that can help overcome problems associated with estrus detection
- Treatments that synchronize estrus and ovulation improve the efficiency of controlled breeding programs by:
  - eliminating the need for estrus detection
  - improving overall pregnancy rates by increasing the number of animals pregnant over those treated
- Both estradiol and GnRH are efficacious in fixed-time AI and fixed-time embryo transfer protocols, especially when GnRH is combined with a progestin device
- GnRH-based fixed-time AI protocols will result in satisfactory pregnancy rates in heifers and anestrous cows if a progestin is utilized between GnRH and PGF

Summary (cont)

- Presynchronization improves pregnancy rates to GnRH-based, fixed-time protocols by increasing the numbers of animals ovulating to the first GnRH.
- The addition of eCG to fixed-time protocols results in a larger ovulatory follicle and a larger, more functional CL and higher pregnancy rates in certain classes of livestock.
- eCG improves efficacy of the synchronization programs when treating anestrous/nutritionally challenged cows
- Treatment with eCG increased pregnancy rate in cycling 2-yr old cows in Canada
- eCG also tended to increase pregnancy rate in cows not ovulating to 1st GnRH injection

Summary (cont)

- 5-day Cosynch protocols can be used to increase pregnancy rates following FTAI by lengthening proestrus.
- Although administration of initial GnRH in 5-d Co-synch protocol increased P/AI in acyclic heifers, it was unnecessary in cyclic beef heifers.
- P/AI was greater in heifers inseminated with conventional than sex-selected semen.
- The Estrotec ED patches could be used to identify animals for FTAI with sex-selected semen
- The J-Synch protocol has proven to offer advantages over other estradiol-based protocols for both FTAI and FTET
- All FTAI protocols have been efficacious for FTET

Thank you