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USING SYNCHRONIZED ESTRUS PROTOCOLS WITH CYCLING AND NON-CYCLING HOLSTEIN DAIRY CATTLE UNDER INTENSIVE MANAGEMENT

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ABSTRACT: The Study compared two synchronized estrus protocols for the treatment of cycling and non-cycling Holstein dairy cattle. The experiment included two farms belonging to El-Bayoumi's dairy farms located at Zayan Village, Belqas, Dakahlia, Egypt (GPS: 31.4412° N, 31.5364° E). 916 and 1467 Holstein cows were treated with hormone-based protocols, and 2849 and 2435 animals were bred based on standing heat detection, making the overall total 3765 and 3902 animals for Farm-1 and Farm-2, respectively. In Farm 1, 335 cows were treated with PG, resulting in a 20.3% conception rate (CR), 71.6% open rate (OP), 3.3% abortion rate (AB), and an average NSPC of 4.5.

In contrast, 621 cows under CIDR-Sync achieved 23.8% CR, 64.9% OP, 6.4% AB rate, and a lower NSPC of 3.7. Across both protocols, CIDR-Sync accounted for approximately 65% of all pregnancies. In Farm 2, 996 PG-treated cows had a 17.8% CR, 77.6% OP rate, 2.7% AB rate, and NSPC of 5.4, whereas 428 CIDR-Sync cows reached a 19.9% CR, 74.5% OP rate, 4.9% AB rate, and NSPC of 4.8. CIDR-Sync contributed about 30% of total pregnancies in Farm 2. In both farms, CIDR-Sync produced modest gains in conception rates (≈2–3.5%) and improved insemination efficiency (≈0.7–1 fewer service), albeit with slightly higher abortion rates. In conclusion, the CIDR-enhanced synchronization program outperforms $PGF_2\alpha$ alone by modest but economically significant margins. Dairy operations, especially those facing challenges with silent estrus or suboptimal progesterone (P4) levels, may therefore derive substantial reproductive benefits from adopting the CIDR-Sync protocol.

Keywords: Conception rate, Synchronization protocols, CIDR-Synch, PGF2α, Holstein Cattle

INTRODUCTION

Reproductive management is a key factor influencing the profitability of dairy herds. It directly affects calving intervals, milk production efficiency, herd replacement rates, and the timing of conception during lactation, all of which play a critical role in overall herd performance and economic returns (Giordano *et al.*, 2012). Cycling cows are those that exhibit normal reproductive cycles and have an active corpus luteum (CL) present at the beginning of treatment. Non-cycling (anestrous) cows do not have a functioning CL and typically have low P4 levels (Murugavel *et al.*, 2003). A 2022 meta-analysis of nearly 20,000 dairy cow records highlighted that early embryonic loss could reach ~ 27%, reinforcing the importance of hormonal support during synchronization (Albaaj *et al.*, 2023). One of the causes of poor fertility in high-producing dairy cows is inadequate P4, and 60-85% of dairy cows showed a suboptimal circulating P4 for pregnancy (Stronge *et al.*, 2005). On dependence on evaluating the effect of P4 supplementation throughout the course of the Ovsynch protocol in cyclic and acyclic Holstein Friesian dairy cows, we recorded an increase in the conception rate when P4 was used with the Ovsynch protocol.

Estrus synchronization is a significant reproductive control method in the dairy cattle sector, where many animals are bred through artificial insemination. Estrus synchronization lowers the cost of estrus detection and eliminates mistakes. Manipulation of the length of the luteal phase of the estrus cycle is the core premise of estrus synchronization (Osawa *et al.*, 2009).

Timed artificial insemination (TAI) protocols such as Ovsynch, that are composed of GnRH, $PGF_2\alpha$ and GnRH injections, and P_4/progestogen-

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based protocols have been successfully used in the past to enhance the fertility of normal estrus, anestrus cows and cows with ovarian cysts (Sales *et al.*, 2019). In a large trial (n=2207 Holsteins), cows synchronized with Ovsynch plus a CIDR device had significantly better conception than cows on Ovsynch alone. CIDR-Ovsynch cows reached 35.9% pregnancy / AI at 28 days vs only ~19–20% for Ovsynch alone (odds ratios ≈1.9–1.5) (El-Tarabany, 2016).

Repeat breeding is an important reproductive disorder that causes great economic losses in farm animals. It is typically characterized by animals that are sub-fertile, having failed to conceive after being inseminated or mated three or more times, despite showing no apparent abnormalities or pathological conditions in the reproductive tract (El-Khadrawy *et al.*, 2011). The Ovsynch procedure was successful in detecting estruses, facilitating AI, and assisting producers in improving reproductive efficiency by causing precise ovulations (Hussien *et al.*, 2021). Reproductive efficiency in lactating dairy cows is suboptimal due to inadequate service risk and reduced pregnancies per AI (P/AI) (Norman *et al.*, 2009). Timed AI programs have been developed to increase the service risk; however, fertility is still suboptimal when uncomplicated protocols, such as Ovsynch, are used (Rabiee *et al.*, 2005).

Injection of estradiol and P4 or GnRH-based TAI protocol for cattle is followed by the emergence of a new follicular wave. After injection of $PGF_2\alpha$ and removal of the MGA, the second injection of estradiol or GnRH results in acceptable pregnancy rates following TAI, although synchronous ovulation of the grown dominant follicles has not been demonstrated via ultrasonography (Hernández-Coronado *et al.*, 2023). Successfully using the Ovsynch protocol by inducing ovulation to synchronize follicle growth in the 1st two days of the program so that a young antral follicle is recruited; maintaining high P4 concentrations during the development of the ovulatory follicle while also inducing lysis of the ovulatory follicle (Jeong *et al.*, 2013).

MATERIALS AND METHODS

The present study was conducted at El-Bayoumi's Dairy Farm, a privately managed facility located in Zayan Village, Belqas, Dakahlia, Egypt (GPS: 31° 26′ 28″ N, 31° 32′ 11″ E). Data collection spanned a seven-month period from September 2020 through September 2021.

Animals:

A total of 916 and 1467 Holstein cows were subjected to hormone-based protocols, while 2849 and 2435 animals were bred through standing heat detection, resulting in overall totals of 3765 and 3902 animals for Farm-1 and Farm-2, respectively. Experimental units were heifers to six parity cows; 350 to 620kg live body weight were subjected to this study. There were no abnormalities in the reproductive tract of these animals. This study was carried out following the guidelines set by the Scientific Research Ethics and Animal Use Committee (SRE & AUC), Faculty of Agriculture- Menoufia University, Egypt. [Approval №: 30 – SRE & AUC-MUAGR - 07-2025]

Feeding and housing system:

Cows were housed in a free-stall barn. They were fed a total mixed ration (TMR) twice daily, formulated to support high-yield performance and meet NRC requirements for energy and protein, while clean water and mineralized salt licks were continuously accessible. Cows were milked three times daily, and feed management followed strict TMR protocols, consistent mixing, minimal sorting, and routine dry-matter testing, to ensure nutrient uniformity and efficient intake.

Diagnosis of estrus:

Rectal palpation and transvaginal ultrasonography revealed no abnormalities in the animals' reproductive tracts. The diagnosis is based on heat detection signs. The diagnosis was confirmed by ultrasound.

Estrus synchronization Protocols:

I- PG ($PGF_2\alpha$) for cycling animals:

The PGF2α protocol is suitable only for cycling animals that have a functional corpus luteum. This method involves administering PGF2α to induce luteolysis and synchronize estrus. Animals are monitored for heat, and artificial insemination (AI) is performed after heat detection. Animals that do not exhibit estrus are injected again with PGF2α, and AI is performed by fixed-time at 72- or 96-hour post-2nd injection. Layout 1 – PGF2α Protocol with Heat Detection and Timed AI: [Day 0] PGF2α injection → [Days 1–14] Heat detection & AI → [Day 11–14] PGF2α injection (only for animals not inseminated) → Wait 72 hours → Timed AI OR → Wait 96 hours→ TAI.

II- CIDR-Synch for non-cycling animals: The CIDR-sync protocol is suitable mainly for non-cycling animals. It begins with the insertion of a CIDR device and injection of GnRH on day zero. On the day of removal (day 7), prostaglandin (PGF2α) is administered. This is followed by GnRH injection at about 36 hours after CIDR removal and 16–20 hours before timed AI. This protocol provides highly precise synchronization of ovulation and helps restore cyclicity in non-cycling animals. Layout 2 – CIDR + GnRH + PGF2α Protocol with Timed AI: [Day 0] Inject CIDR + GnRH. Wait 6-8 days, then remove CIDR and inject PGF2α. After 36 hours, inject GnRH and wait 16-20 hours for TAI.

Pregnancy diagnosis: Pregnancy diagnosis was performed 60 days after TAI using both transrectal ultrasonography and rectal palpation.

Statistical analysis: Statistical analyses were performed using SAS (SAS, 2002). The reproductive efficiency indicators (REIs) following TAI in the experiment and the combined reproductive efficiency indicators (REIs) were compared between the groups using Chi-square analysis (α=0.05).

RESULTS AND DISCUSSION

Table 1 and Figure 1 show that in Farm-1, a total of 956 Holstein dairy cows were subjected to two hormonal synchronization protocols, PG (Prostaglandin $F_2α$ alone) and CIDR-Sync (Controlled Internal Drug Release with PG). Of these, 335 cows were treated with the PG protocol, resulting in sixty-eight pregnancies, corresponding to a conception rate (CR%) of 20.30%. The open rate in this group was 71.64% (240 cows), while 3.28% (11 cows) aborted, and 4.78% (16 cows) were classified as under-culled animals. The number of services per conception (NSPC) for the PG group was relatively high at 4.5 (Figure 2). The development of the Ovsynch protocol, a hormonal protocol that synchronizes ovarian function, thereby allowing for TAI without the need to detect estrus, radically changed reproductive management by providing a management tool for increasing the AI service rate (Pursley *et al.,* 1997).

This result was in accordance with the addition of CIDR to the Ovsynch protocol (G-CIDR-PG) improved the conception rates in postpartum Japanese Black beef cows. In the post-partum suckled Japanese Black beef cows, they recorded that incorporating a CIDR with the Ovsynch protocol (72.5%) significantly improved conception rates compared with the traditional Ovsynch group (47.7%) (Kawate *et al.,* 2004). In contrast, others reported no significant difference between Select-Ovsynch (34.3%) and CIDR-Synch (32.7%) regimes (Mendonça *et al.,* 2012).

Administration of GnRH and a CIDR insert 7 days after estrus resulted in ovulation of the first wave dominant follicle, an increase in P4 concentrations, and a precise synchronization of ovulation after CIDR Insert removal (Ando *et al.,* 2005). Cycling cows almost always have higher fertility than truly anestrous cows. For example, pregnancy loss between 28 and 56 days was much higher in noncycling (31%) than in cycling cows (16%) (Stevenson *et al.,* 2006). $PGF_2α$ depends on the presence of a functional corpus luteum. If absent, as is often the case in silent or anestrous cows, $PGF_2α$ administration does not induce estrus, compromising synchronization success (El-Sayed *et al.,* 2019). CIDR-Sync mitigates this limitation by mimicking the luteal phase and creating a hormonal environment conducive to ovulation (Flores *et al.,* 2025).

In contrast, the CIDR-Sync group (n = 621) achieved significantly better reproductive performance. A total of 148 cows were conceived, resulting in a CR% of 23.83%, which was higher than the PG group.

Table 1: Estrus-synchronized Protocol Summary for Holstein dairy cows in farm-1

Protocol Code	Pregnant	Open	Abortion	Other#	Total	NSPC
	Conception rate (CR%)	Open rate %	Abortion rate (AB %)	%	%	
PG	**68**	**240**	**11**	**16**	**335**	**4.5**
	20.30%	71.64%	3.28%	4.78%	**35.04%**	
CIDR-Sync	**148**	**403**	**40**	**30**	**621**	**3.7**
	23.83%	64.90%	6.44%	4.83%	**64.96%**	
Total	**216**	**643**	**51**	**46**	**956**	**3.57**

Other=Animals that were culled, sold, or removed due to health issues, low productivity, or reproductive failure.

The open rate was reduced to 64.90% (403 cows), though the abortion rate increased to 6.44% (40 cows). The percentage of cows under "culled animals" remained comparable at 4.83% (30 cows). Importantly, the NSPC decreased to 3.7 (Figure 2), indicating improved insemination efficiency. Overall, CIDR-Sync contributed 64.96% of total pregnancies, compared to 35.04% for PG, clearly demonstrating its superior effectiveness in Farm-1.

Table 2 and Figure 1 present data from Farm-2, where 1,424 Holstein cows were synchronized using the same two hormonal protocols. The PG group consisted of 996 cows, among which 177 conceived, yielding a CR% of 17.77%, which was notably lower than the PG group in Farm-1. The open rate was 77.61% (773 cows), the abortion rate was 2.71% (27 cows), and 1.91% (19 cows) were categorized as others. The overall pregnancy rate was slightly higher for CIDR-Sync than for A 21.0% pregnancy rate following treatment with the Ovsynch protocol in dairy cows (Keskin *et al.*, 2010). The NSPC for PG-treated cows on Farm-2 was higher at 5.4 (Figure 2), reflecting reduced reproductive efficiency. An important aspect of the reproductive efficiency of lactating dairy cows is fertility to 1st and 2nd services. Pregnancy rate to 1st service improved with the Ovsynch protocol, which includes gonadotropin-releasing hormone (GnRH) to synchronize the follicular wave, Prostaglandin F2α (PGF2α) 7 days later to regress the CL, and GnRH 48 h later to induce ovulation with a timed AI (TAI) at 16 h after the last treatment with GnRH (Fricke & Wiltbank, 2022).

Table 2: Estrus-synchronized Protocol Summary for Holstein dairy cows in farm-2

Protocol Code	Pregnant	Open	Abortion	Other#	Total	NSPC
	Conception rate (CR%)	Open rate (OP%)	Abortion rate (AB %)	%	%	
PG	**177**	**773**	**27**	**19**	**996**	**5.4**
	17.77%	77.61%	2.71%	1.91%	**69.94%**	
CIDR-Sync	**85**	**319**	**21**	**3**	**428**	**4.8**
	19.86%	74.53%	4.91%	0.70%	**30.06%**	
Total	**262**	**1092**	**48**	**22**	**1424**	**5.27**

Other= Animals that were culled, sold, or removed due to health issues, low productivity, or reproductive failure.

Protocols combining GnRH and P4 (CIDR) aim to ensure a strong luteal phase. Administering GnRH during the early luteal period induces ovulation of the dominant follicle and formation of an accessory CL, raising circulating P4 2–4 days later (Jeong *et al.,* 2016).

A combined GnRH + CIDR regimen creates both an endogenous and exogenous source of P4, improving luteal function (larger or more CL, higher P4) after insemination. Meta-analyses and field trials confirm fertility benefits. Supplemental P4 via a CIDR in timed-AI programs significantly increased pregnancy per AI (P/AI) by about 8–10% (risk ratios ≈1.10 by day 60) (Bisinotto *et al.*, 2015). Similarly, recent reviews report that early luteal P4 or GnRH/hCG treatments improve CR, especially in sub-fertile herds (López-Gatius & Garcia-Ispierto, 2022). Dairy cows given a CIDR from days 3.5–18 post-AI had a much higher pregnancy rate (51.1%) than untreated controls (39.3%, OR≈1.74) (Jeong *et al.*, 2016). GnRH use has raised fertility: giving a GnRH agonist in the early luteal phase notably improved conception in repeat-breeder cows (Hassanein *et al.*, 2024).

The CIDR-Sync group on Farm-2 included 428 cows, with eighty-five pregnancies recorded, resulting in a CR% of 19.86%. The open rate was 74.53% (319 cows), the abortion rate rose to 4.91% (21 cows), and only 0.70% (3 cows) were categorized under “other”. In high-producing Holsteins, cows on a CO-Synch + CIDR regimen had a much higher overall pregnancy rate (56.5%, 1st + 2nd AI) than those on standard Ovsynch, and their calving interval was ~425.9 days vs 475.3 days for Ovsynch cows. Supplementing Ovsynch with a 7-day P4 insert improved fertility and shortened the calving interval by ~50 days (Azevedo *et al.*, 2014). In 167 postpartum Holsteins, supplementing Ovsynch with a CIDR for 5 days (OVP5) or 7 days (OVP7) raised P4 profiles and tended to improve pregnancy rates. On day thirty post-AI, pregnancy rates were 39.7% (Ovsynch alone), 42.6% (OVP5) and 45.5% (OVP7), though differences were not statistically significant. The authors note that numerically higher conception and lower pregnancy loss occurred with the 5-day CIDR, concluding that “OVP5 can be used to increase pregnancy rate”. Pregnancy per AI did not differ between the CIDR and non-CIDR groups (regardless of luteal status) (Shahzad *et al.*, 2019). In other words, adding a CIDR in this context yielded similar fertility to standard Ovsynch, highlighting that benefits may vary with protocol details and cow status (Sauls-Hiesterman *et al.*, 2020). The NSPC was 4.8 (Figure 2), indicating a modest improvement over the PG group, though still higher than CIDR-treated cows in Farm-1. The CIDR-Sync protocol in Farm-2 accounted for 30.06% of total pregnancies, compared to 69.94% for PG, due to the larger group size despite lower efficiency.

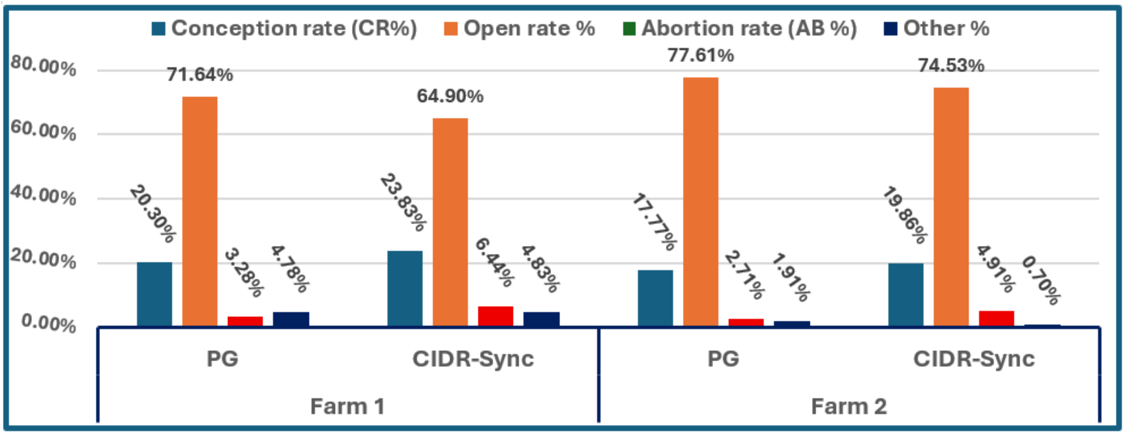

Figure 1: Comparison between estrus-synchronization protocols in two farms.

A comparison between the two farms reveals both Inter-farm and intra-protocol differences. In both farms, the CIDR-Sync protocol outperformed PG in terms of conception rate and insemination efficiency. But Farm-1 consistently achieved higher reproductive performance across all measured parameters. For the PG protocol, the CR% in Farm-1 was 20.30%, compared to 17.77% in Farm-2. Similarly, for CIDR-Sync, Farm-1 recorded a CR% of 23.83%, compared to 19.86% in Farm-2. The variation between two farms may be due to technician skill, and insemination timing, especially for heat detection and diagnosis of reproductive status, and pregnancy. Management and physiological factors such as negative energy balance, heat stress, technician skill, and insemination timing may have influenced reproductive outcomes (Butler, 2000; Wolfenson *et al.*, 2000).

In terms of insemination efficiency, Farm-1 achieved better NSPC values: 4.5 (PG) and 3.7 (CIDR-Sync), compared to 5.4 and 4.8 in Farm-2, respectively (Figure 2). These differences indicate more efficient estrus response and fertility performance in Farm-1. While CIDR-Sync consistently led to improved CR% and reduced NSPC across both farms, its impact was more pronounced in Farm-1. Notably, although the abortion rate for CIDR-Sync was higher than PG in both farms, this did not negate its overall superiority in terms of conception and breeding efficiency. Heat stress impairs follicular quality and increases early embryonic loss, which may explain the slightly elevated abortion rates in CIDR-Sync groups (Farm-1: 6.44%; Farm-2: 4.91%) compared to PG groups (Farm-1: 3.28%; Farm-2: 2.71%) (Roth *et al.*, 2022). Cycling cows: Supplementing CIDR in cyclic cows can also affect fertility. In a large field trial (Ovsynch protocol with or without CIDR), overall, the benefit of CIDR was most pronounced in cows with low P4 before PGF_2 α (i.e., likely non-cycling cows). In that study, cows having low P_4 at $PGF_2α$ (regardless of prior cycling status) had much higher pregnancy rates with CIDR (36%) than without (18%). This implies that adding P4 mainly helped cows that were effectively anestrous at treatment (Stevenson *et al.*, 2006).

The consistent numerical advantage of CIDR-Sync across farms (Farm-1: CR = 23.83%, NSPC = 3.7; Farm-2: CR = 19.86%, NSPC = 4.8) over PG (Farm-1: CR = 20.30%, NSPC = 4.5; Farm-2: CR = 17.77%, NSPC = 5.4) is in line with its mechanism of action. CIDR-Sync introduces exogenous P4, which promotes synchronization of follicular waves, improves endometrial function, and enhances ovulation and embryo survival (Consentini *et al.*, 2025; Mann & Lamming, 2001).

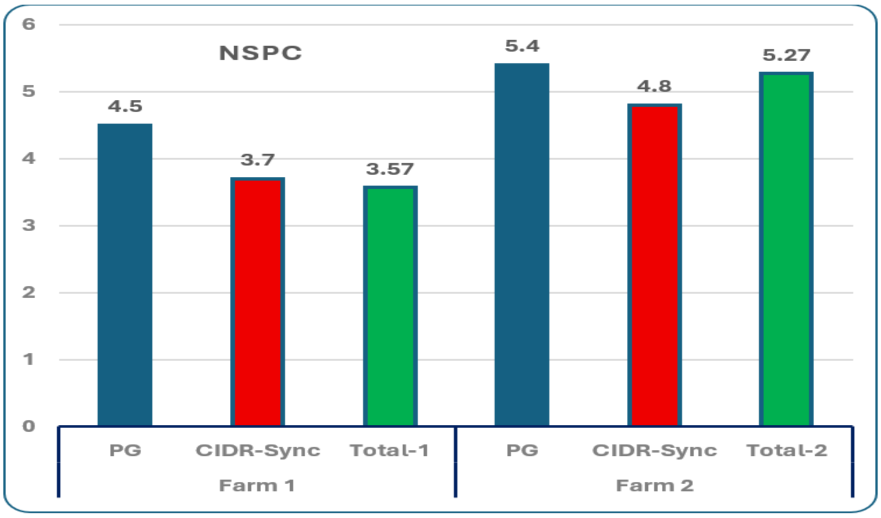

Figure 2: NSPC for estrus-synchronization protocols in two farms.

However, the chi-square test for abortion rate differences also showed no statistical significance. Cows anestrous at breeding start had lower breeding probability and conception, and took longer to conceive, than herd-mates that were cycling (McDougall & Compton, 2005). High-producing dairy cows often require a greater NSPC due to several interrelated metabolic and reproductive factors. One major contributor is the negative energy balance experienced during early lactation, which leads to hormonal imbalances, delayed ovulation, and impaired follicular development (Butler, 2000). Additionally, cows with high milk yield frequently exhibit subtle or silent estrus behaviors, reducing the accuracy of insemination timing and consequently lowering conception rates (Lucy, 2001). Metabolic stress in these cows can also affect oocyte quality, uterine environment, and early embryo survival (Diskin & Kenny, 2014). These physiological limitations underscore the importance of adopting advanced reproductive strategies, such as estrus synchronization protocols, to improve conception efficiency in high-yielding herds.

Ultimately, while not statistically significant, the 2.5–3.5% higher conception rate and ~1 less service per conception observed with CIDR-Sync protocols are economically meaningful in commercial dairy systems. These results align with recent studies showing that P4-supplemented protocols improve ovulatory response, luteal function, and pregnancy outcomes, especially in non-cycling cows (Consentini *et al.,* 2025; Fishman-Holland *et al.,* 2019; Roth *et al.,* 2022). In 716 Holsteins, adding an 8-day PRID (P4-device) to a 7-day Ovsynch protocol (PRID synch) increased pregnancy per AI at 1st pregnancy check from 31.7% (control) to 38.9%. Pregnancy per AI remained higher in the PRID group at the 2nd check (34.6% vs. 28.9%). Pregnancy loss was unchanged. This study found a clear ~7 percentage-point gain in conception by supplementing Ovsynch with P4 (Hölper *et al.,* 2023). In one field trial, 1st-service pregnancy to Ovsynch+ CIDR was 64% in anestrous cows vs only 27% with Ovsynch alone (Bisinotto *et al.,* 2015). In lactating dairy cows using 1.55 g P4 inserts (PRID) found pre-AI supplementation increased P/AI in non-presynchronized cows (41.3% vs. 25.1%), and post-AI supplementation significantly lowered pregnancy loss at 32–60 days (6.1% vs. 11.4%) (Colazo *et al.,* 2013). In summary, while both protocols contributed to reproductive outcomes in cycling and non-cycling cows, the CIDR-Sync protocol significantly improved fertility indicators compared to $PGF_2\alpha$ alone. These improvements were more substantial in Farm-1, suggesting the possible influence of farm-level management practices or animal condition on protocol efficacy.

2- Comparison between farms for REIs via χ^2 Test:

Table 3 shows that cows treated with CIDR-Sync consistently achieved higher conception rates (Farm-1: 23.83%, Farm-2: 19.86%) and lower numbers of services per conception (NSPC) (Farm-1: 3.7, Farm-2: 4.8) than those treated with PG alone (Farm-1 CR: 20.30%, NSPC: 4.5; Farm-2 CR: 17.77%, NSPC: 5.4).

The superiority of CIDR-Sync in improving fertility is consistent with known physiological mechanisms. The CIDR device delivers exogenous P4, which primes the hypothalamic-pituitary-ovarian axis, enhances follicular wave synchronization, and improves uterine receptivity at the time of insemination (Bó *et al.,* 2003). P4 supports the development of dominant follicles and contributes to endometrial modifications favorable to embryo survival (Mann & Lamming, 2001; Roth *et al.,* 2022). In contrast, the $PGF_2\alpha$ protocol depends on the presence of a functional corpus luteum (CL). In cows that are anestrous or lack a CL, $PGF_2\alpha$ does not initiate a new cycle or estrus behavior, leading to poor synchronization and lower fertility (El-Sayed *et al.,* 2019). This explains the higher NSPC and lower CR% in the PG groups, particularly in Farm-2, where NSPC reached 5.4 and CR% was only 17.77%.

Table 3: χ^2 Test Summary for REIs between farms.

REIs	*χ^2 Value*	*df*	*p-value*
Pregnant	1.754	1	0.185 ns
Open	2.091	1	0.148 ns
Abortion	1.022	1	0.312 ns
Other#	0.614	1	0.433 ns
Total Protocol Use	0.581	1	0.446 ns

ns=non-significant differences (P ≤0.05) # Other Animals that were culled, sold, or removed due to health issues, low productivity, or reproductive failure.

Chi-square analysis showed no statistically significant differences (P > 0.05) in any reproductive parameter across farms, confirming the consistency of protocol effects in different management conditions.

Although both farms operated under distinct conditions, no significant statistical variation was found between them. Nevertheless, reproductive outcomes may still be influenced by heat stress, technician skill, estrus detection efficiency, and nutritional management (Butler, 2000; Wolfenson *et al.*, 2000). For instance, negative energy balance in early lactation delays ovarian resumption, reducing PG responsiveness (Butler, 2000), while heat stress impairs follicular quality and embryo survival (Wolfenson *et al.*, 2000). The consistency of CIDR-Sync's performance despite these varying conditions highlights its reliability. Even in challenging circumstances, it induced estrus in non-cycling cows, reduced NSPC by 0.8–0.9, and improved CR% by 2.5–3.5 percentage points compared to PG alone.

3- Within-Farm Protocol Comparison for REIs via χ^2 Test:

Table 4 assessed the effectiveness of two synchronization protocols, PG (PG $F_2\alpha$) and CIDR-Sync, on reproductive outcomes in Holstein dairy cows exhibiting silent estrus. Across two farms, though numerical improvements were observed in the CIDR-Sync groups across both farms, Farm-1: CIDR-Sync led to a 23.83% pregnancy rate (148/621) vs. 20.30% for PG (68/335); the difference was not significant ($\chi^2 = 2.401$, p = 0.1213). Farm-2: CIDR-Sync had 19.86% pregnancy (85/428) vs. 17.77% for PG (177/996); again, not significant ($\chi^2 = 1.053$, p = 0.3048). These findings suggest consistency and robustness in CIDR-Sync's reproductive performance under different environmental and managerial conditions.

Table 4: Within-Farm Protocol Comparison for reproductive efficiency indicators (REIs).

Farm	Protocols Compared	Pregnant (n)	Open (n)	Chi-square	p-value
Farm-1	PG vs. CIDR-Sync	68 vs. 148	240 vs. 403	2.401	0.1213ns
Farm-2	PG vs. CIDR-Sync	177 vs. 85	773 vs. 319	1.053	0.3048ns

ns = non-Significant differences (P ≤0.05); #(df= 1)

3- Across-Farm Protocol Comparisons for REIs via χ^2 Test:

3-1 PG Comparison Across Farms:

Table 5 shows that there is no significant difference in PG performance between farms (P > 0.05).

This suggests farm conditions did not significantly affect the efficacy of the PG protocol for cyclic animals.

Table 5: Within-Farm PG Protocol Comparison for REIs.

Farm	Pregnant	Open	χ^2	p-value
1	68	240	1.762	**0.1844ns**
2	177	773		

ns = non-Significant differences (P ≤0.05); # (df= 1)

3-2 CIDR-Sync Comparison Across Farms:

Table 6 shows that the difference in pregnancy rate between farms for the CIDR-Sync protocol was statistically significant (p = 0.0385), indicating farm-related factors, especially technician skill and insemination timing, may influence the success of CIDR-Sync more than PG.

Table 6: Within-Farm CIDR-Sync Protocol Comparison for REIs.

Farm	Pregnant	Open	χ^2	p-value
1	148	403	4.281	**0.0385***
2	85	319		

* Significant differences ($P \leq 0.05$); # (df= 1)

CYDR-Sync relies on exogenous P_4 to initiate and regulate the luteal phase, improving follicular wave synchronization and endometrial receptivity (Mann & Lamming, 2001). Its effectiveness is known to be sensitive to: Body condition and energy balance postpartum, Uterine health and inflammation, Compliance with timing of insertion/removal, Heat stress and seasonal variation, and technical consistency in insemination. The significant difference between farms under CIDR-Sync may reflect variation in these factors, such as better nutritional programs, more accurate insemination timing, or better estrus monitoring in Farm-1, where higher pregnancy rates (23.83%) were achieved. In contrast, PG protocol's dependence on the presence of a functional CL makes it less influenced by fine management differences, since cows not responding simply fail to cycle, regardless of subtle farm conditions (El-Sayed *et al.*, 2019).

Conclusion

The CIDR-Sync protocol outperformed $PGF_2\alpha$ alone on both farms, achieving 2.5-3.5% higher pregnancy rates and a reduction in services per conception by 0.8-0.9. While PG outcomes were consistent across farms (χ^2 = 1.762, p = 0.1844), the effectiveness of CIDR-Sync varied significantly (χ^2 = 4.281, p = 0.0385), suggesting that management, environmental, or physiological differences may influence its performance. Under CIDR-Sync, the overall gain in reproductive efficiency and potential reduction in days open represent a meaningful economic advantage. Therefore, dairy operations, particularly those dealing with silent estrus or low P_4 levels, are likely to benefit from implementing the CIDR-Sync protocol.

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استخدام بروتوكولات التزامن الهرموني في أبقار الهولشتاين الحلابة النشطة تناسلياً وغير النشطة تحت نظام إدارة مكثف

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الملخص:

تضمنت الدراسة مقارنة بين بروتوكولين للتزامن الهرموني في علاج الأبقار الحلابة من سلالة الهولشتاين ذات الدورة الشبقية النشطة وغير النشطة. أُجريت التجربة في مزرعتين تابعتين لمزارع البيومي للإنتاج الحيواني، وتقعان في قرية زيان، مركز بلقاس، محافظة الدقهلية، مصر بإحداثيات GPS: 31.4412° شمالاً، ٣١,٥٣٦٤° شرقاً. تم علاج ٩١٦ و١٤٦٧ بقرة باستخدام بروتوكولات هرمونية في المزرعتين الأولى والثانية على التوالي، بينما تم تلقيح ٢٨٤٩ و٢٤٣٥ بقرة بناءً على الكشف عن الشبق القائم على الوقوف، ليصبح المجموع الكلي ٣٧٦٥ و٣٩٠٢ بقرة لكل من المزرعتين، على التوالي.

في المزرعة الأولى، بلغ عدد الأبقار التي تم علاجها ببروتوكول $PGF_2\alpha$ نحو ٣٣٥ بقرة، وكانت نسبة الإخصاب (CR) 20.3%، ونسبة عدم الحمل 71.6% (OP) ، ونسبة الإجهاض 3.3% (AB)، بمتوسط عدد مرات تلقيح حتى حدوث الحمل (NSPC) بلغ ٤,٥مرة. بينما حقق بروتوكول CIDR-Sync باستخدام ٦٢١ بقرة نسبة إخصاب بلغت ٢٣,٨%، ونسبة عدم الحمل ٦٤,٩%، ونسبة الإجهاض ٦,٤%، بمتوسط عدد مرات تلقيح ٣,٧ مرة. وبلغت مساهمة بروتوكول CIDR نحو ٦٥% من إجمالي حالات الحمل بالمزرعة الأولى.

أما في المزرعة الثانية، فقد تم علاج ٩٩٦ بقرة ببروتوكول $PGF_2\alpha$ ، وحققت نسبة إخصاب بلغت ١٧,٨%، ونسبة عدم الحمل ٧٧,٦%، ونسبة الإجهاض ٢,٧%، بمتوسط عدد مرات تلقيح ٥,٤ مرة. في حين أظهرت ٤٢٨ بقرة عُولجت ببروتوكول CIDR-Sync نسبة إخصاب ١٩,٩%، ونسبة عدم حمل ٧٤,٥%، وإجهاض بنسبة ٤,٩%، بمتوسط عدد مرات تلقيح ٤,٨ مرة. وقد ساهم هذا البروتوكول في حوالي ٣٠% من إجمالي حالات الحمل في المزرعة الثانية.

بوجه عام، أظهر بروتوكول CIDR-Sync تحسنًا طفيفًا في نسب الإخصاب (بنسبة تتراوح بين ٢–٣,٥%) وتحسينًا في كفاءة التلقيح (بنحو ٠,٧–١ مرة أقل من التلقيحات)، على الرغم من الارتفاع الطفيف في نسب الإجهاض. وخلصت الدراسة إلى أن بروتوكول التزامن المعزز بجهاز CIDR يتفوق على استخدام $PGF_2\alpha$ فقط بفوارق بسيطة لكنها ذات أهمية اقتصادية. لذا، فإن تطبيق بروتوكول CIDR-Sync قد يُحقق فوائد تناسلية ملحوظة، لا سيما في المزارع التي تعاني من مشكلات مثل الشبق الصامت أو انخفاض مستويات البروجستيرون.(P4)

الكلمات المفتاحية: نسبة الإخصاب، بروتوكولات تزامن الشياع ، بروتوكولCIDR-Synch ، هرمون البروستاجلاندين ($PGF_2\alpha$)، أبقار الهولشتاين.