The Influence of Different Hormonal Therapies on the Reproductive, Productive and Economic Efficiency of Early Postpartum Dairy Cows

Abstract
A total of 174 multiparous Holstein dairy cows were randomly divided into seven groups to investigate the effects of different hormonal therapies on the reproductive, productive, and economic efficiency of early postpartum dairy cows. Our results show that cows treated with GnRH (gonadotropin-releasing hormone) had significantly (P< 0.05) greater total milk yield than comparable untreated cows, and produced higher total and net returns. Reproductive parameters were also improved for the GnRH- treated cows. Additionally, we found that estrogen treatment has a positive impact on the productivity and profitability of cows receiving this treatment compared to control cows. In conclusion, GnRH and estrogen are the best hormonal therapies of those tested for improving the reproductive, productive, and economic efficiency of dairy cattle.

Keywords
Hormonal therapy; Reproductive; Productive; Economic; Efficiency; Dairy cattle

Introduction
The reproductive status of a dairy herd has a large bearing on production profitability. Reproductive problems can result in excessively long lactation, long dry periods, or both, and are therefore costly to dairy producers [1].

The main goals for postpartum reproductive health in dairy cattle are for the uterus to become completely involuted and free of infection, and for the cows to be cyclic by the time they enter the postpartum breeding period (after 50 to 60 days lactation). The outcomes of good reproductive performance are the occurrence of pregnancy, normal time from calving to conception, and a reasonable number of inseminations [2].

Foote and Rick [3] reported that injection of GnRH (gonadotropin-releasing hormone) at 13 to 14 days postpartum helped cows undergoing slow involution of the reproductive system with no other clinical problems. It may also reduce the number of days to the first estrus without altering reproductive performance [4]. Gaines [5] showed little or no positive impact on the subsequent fertility of cows treated with GnRH in the postpartum period. Furthermore, none of the following treatments administered to lactating dairy cows approximately 11 days postpartum sped up initiation of cyclic activity compared to control (saline-treated) cows: 500 µg GnRH, 10 mg estradiol, 500 µg GnRH plus 10 mg estradiol, or 500 µg GnRH plus 10 mg estradiol plus 25 mg prostaglandin (PGF2 alpha) [6].

Elsheikh and Elzubeir [7] showed that double injection of PGF2 alpha during the first week, as well as a single or double injection of PGF2 alpha during the second or third week postpartum, minimized the days between calving and subsequent effective insemination, and accelerated the uterine involution. Therefore the use of PGF2 alpha during the early postpartum period improved the reproductive efficiency of cross-bred dairy cows. The same authors reported that reproductive efficiency of cross-bred dairy cows was improved when PGF2 alpha was injected during the first three weeks postpartum.

Results obtained by Bajcsy et al. [8] indicated that using 50 IU of oxytocin intramuscularly enhances uterine contractility if treatment is given on the first day postpartum. Oxytocin administration immediately after delivery reduces the occurrence of retained fetal membranes in cattle, subsequently reducing the incidence of endometritis and improving the reproductive efficiency [9].

Despite numerous studies investigating the effects of hormonal therapies immediately after parturition on reproductive parameters, there are few studies concerned with the effects on economic parameters of dairy cow production. Here, we evaluate the profitability of different drugs and drug combinations aimed at maximizing the productive, reproductive, and economic efficiency of dairy cattle farming.

Materials and Methods
This study was carried out between August 2012 and August 2013 and aimed to evaluate the effects of some hormonal treatments on the reproductive performance of postpartum Holstein dairy cows.

Animals and study area
A total of 174 Holstein dairy cows of mixed parity belonging to a private farm about 80 km south of Alexandria were used in the present study. The cows were healthy and calved normally. Animals were grouped and fed according to milk yield, days
in lactation, age, parity and body condition score. Cows were housed in open barns and provided with shelter, drinking water, and water mists during the summer season. The animals were fed concentrates consisting of 40% yellow corn, 13% wheat bran, 12% whole cotton seed, 30% soybean cakes and 5% minerals and vitamins, plus silage or berseem clover according to the season. The amount of feed depended on the production and parity. This diet was formulated to meet or exceed all National Research Council recommendations for lactating cows [10]. The total mixed ration was placed in front of the cows five times per day for a total of 20 or more hours per day. Cows were milked three times daily (at 2 am, 10 am and 6 pm). The milk produced by each cow was recorded automatically through an electronic milk meter fixed to each milking unit in the parlor; the data were transported to a networked computer system that totaled the average milk yield per cow, per day, per week, per month and per lactation season (ALPRO herd management system, DeLaval, Tumba, Sweden).

Cows were artificially inseminated 12 h after the onset of visible estrus; imported frozen semen from regularly tested sires that was provided by a variety of companies (ABS, WWS, Alta Genetics and Semex) was used to avoid inbreeding. Insemination data were collected from the farm, and reproductive performance information was found in the dairy record of the herd.

**Detection of estrus**

Estrus was detected by use of pedometer and observation twice daily, and confirmed by careful rectal palpation. The cows in estrus showed clinically normal genitalia and transparent estrus mucus without any turbidity or flacks, and were artificially inseminated toward the end of estrus with good quality frozen semen.

**Pregnancy diagnosis**

The animals were rectally examined for pregnancy diagnosis at sixty days post insemination.

**Treatments**

A total of 174 normally parturated Holstein cows were randomly divided into seven groups:

i. **Group 1 (GnRH-treated animals):** Twenty-five normally parturated dairy cows were injected intramuscularly with 0.02 mg of buserelin (5 ml Receptal, Intervet International B.V. Boxmeer, Holland) at day 14 postpartum.

ii. **Group 2 (PGF2 alpha-treated animals):** Twenty-two normally parturated dairy cows were injected intramuscularly with 25 mg dinoprost (5 ml Lutalyse, Pharmacia & Upjhn Co, Kalamazoo, MI) at day 14 postpartum.

iii. **Group 3 (Ergometrin-treated group):** Nineteen normally parturated dairy cows were injected intramuscularly with 1 mg methyl ergometrin hydrogen maleate (5 ml Methergin, Novartis Pharma S. A. E, Cairo under license from Novartis Pharma AG, Basel, Switzerland) immediately after parturition (within two hours).

iv. **Group 4 (Oxytocin-treated group):** Twenty-four normally parturated dairy cows were injected intramuscularly with 50 IU oxytocin (5 ml Oxytocin, ADWIA Co, 10th of Ramadan city, Egypt) immediately after calving (within two hours).

v. **Group 5 (Estrogen-treated group):** Twenty-one normally parturated cows were injected intramuscularly with 5 mg estradiol benzoate (1 ml Folone, Misr Co. for Pharma. Ind, S.A.E) immediately after calving (within two hours).

vi. **Group 6 (Estrogen followed by Oxytocin treated group):** Eighteen normally parturated cows received 5 mg estradiol benzoate at 12 hours after parturition followed by intramuscular injection with 50 IU oxytocin six hours later.

vii. **Group 7 (Non-treated group):** Twenty normally parturated cows did not receive any treatment.

**Data Collection**

All data collected including information concerning date of parturition, veterinary diagnosis and treatments, estrus detection, inseminations and pregnancy diagnosis were entered directly into a computer database. Data entered included all management procedures in the form of cow cards; from those cow cards we obtained the following parameters which were used to measure reproductive performance in the herd;

**Parameters Under Investigation**

I. **Days open:** For cows that conceived, days open were calculated as the days between calving and subsequent effective insemination [11].

II. **First service conception (S/C) rate (%) and all service conception (SC) rate (%):** These rates were defined as the percentage of inseminations that resulted in a confirmed pregnancy [12].

III. **Days to first insemination:** This parameter measures the days between calving and the first subsequent insemination.

IV. **Total milk yield (kg):** The actual amount of milk produced by each cow, either treated or untreated, throughout its calving interval.

V. **Total fixed costs:** The total fixed costs of dairy production included the depreciation of buildings, animals, equipment, and the dairy parlor. The depreciation rates were calculated for the building and dairy parlor by dividing the estimated sale price of the building by 25 or 15 years, respectively. The animal depreciation was calculated by subtracting the value of the animal as meat from the purchase value and dividing by 13, which represented the estimated production lifetime of the
animal in years, according to the fixed line method of Sankhayan [13].

VI. **Total costs**: Total costs included the actual costs of feed, veterinary visits, labour, insemination (one straw costs 75 EGP), and treatment. Total costs were calculated throughout the calving interval of both treated and untreated cows. The calving interval was included as a factor in the comparison of the total costs of diseased and healthy cows [14]. The extended calving intervals of diseased cows required greater feed, labour and total veterinary management costs when compared to healthy cows.

VII. **Total returns**: Total returns reflect the summation of milk returns and calf returns. Milk returns were calculated as the price of 1 kg of milk (EGP) multiplied by the total milk yield produced by the cow throughout its calving interval. Calf returns were calculated as the value of each calf sold (EGP).

VIII. **Net return**: Net return was calculated as the difference between total returns and total costs.

**Statistical Analysis**

Productivity (days lactating and total milk yield), cost (insemination, veterinary visits, treatment, and total costs), and returns (total returns and net return) were compared across different treatment groups in different experiments. The statistical model included the effect of treatment and lactation order. Non-significant treatment by lactation order interactions were removed from the final model. Each treatment was analysed separately by a general linear model. All analyses were performed using the Statistical Analysis System computer package [15].

The following statistical model was applied:

\[ Y_{ij} = \mu + T_i + e_{ij} \]

Where \( Y_{ij} \): observed value, \( \mu \): overall mean, \( T_i \): treatment effect and \( e_{ij} \): unexplained error term.

Cox’s proportional hazard analysis was performed using the PHREG procedure in SAS to examine the effect of treatment on the hazard ratio of pregnancy. Dummy variables were created for the effect of treatment on median days to first service and median days open. The resulting data was determined by Kaplan–Meier survival analysis (LIFETEST procedure). First-service conception rates and all-service conception rates were analysed using the Chi-squared test.

**Results**

**GnRH-treatment**

Table 1 shows the effects of GnRH treatment on the relative pregnancy rates of all cows. When all cows were considered and the diagnostic categories were excluded, the relative pregnancy rate of cows receiving treatment was higher than that of control cows. Treatment with GnRH increased the pregnancy rate by 73% relative to control cows.

The reproductive, productive, and costs parameters are presented in Table 2. The median number of days to first insemination or days open for the control group was greater (90 and 180 d; \( P<0.05 \)) than that for cows receiving GnRH treatment (76 and 153 d, respectively). The first S/C and all S/C rates for cows treated with GnRH showed greater values (58 and 96%; \( P<0.05 \)) than for untreated cows (33 and 84%, respectively).

Measurements of productivity (milk production and days in milk) are depicted in Table 2. GnRH-treated cows remained in lactation for significantly shorter periods (349.54 d; \( P<0.05 \)) than untreated cows (385.08 d). Even with longer lactation periods, untreated control cows had a smaller total milk yield (10663.20 kg; \( P<0.05 \)) than those treated with GnRH (11756.30 kg).

The insemination cost for cows receiving GnRH was significantly less (132.45 EGP; \( P<0.05 \)) than that for untreated cows (185.32 EGP). Veterinary visit costs as well as total fixed costs were the same for both groups. However, feed and total costs were significantly (\( P<0.05 \)) less for cows treated with GnRH than those for the control group. The feed costs were 15220.12 EGP for GnRH-treated cows and 13190.45 EGP for control cows. Consequently, the total costs for GnRH-treated cows were significantly lower (15355.90 EGP; \( P<0.05 \)) than those for untreated cows (17260.44 EGP).

As shown in Table 3, returns parameters were represented by milk returns, calf sales, total returns, and net return. Cows treated with GnRH showed significantly (\( P<0.05 \)) higher milk returns (23512.60 EGP) than untreated cows (21326.40 EGP). Therefore, the total returns for cows receiving GnRH were significantly (\( P<0.05 \)) greater (25512.60 EGP) than those for the control group (23326.40 EGP). Due to higher total returns and lower total costs for cows treated with GnRH, the net profit of this group was significantly greater (8156.70 EGP; \( P<0.05 \)) than the net profit of the control group (4065.96 EGP).

**Prostaglandin F2 alpha treatment**

Table 4 shows that PGF2 alpha increased pregnancy rates by 66% relative to the control. The median days to first insemination, median days open, and the first S/C rates were not significantly different between the treated and control groups (Table 5). However, all S/C rates of the untreated group were significantly (\( P<0.05 \)) higher (84%) than those of the treated group (72%).

The productive parameters represented by total milk yield and days in milk are shown in Table 5. Days in milk were not significantly different between the treated and untreated groups. In contrast, the total milk yield of the untreated cows was significantly (\( P<0.05 \)) greater (10663.20 kg) than that of cows treated with PGF2 alpha (8869.90 kg). The insemination costs for cows receiving PGF2 alpha were significantly lower (11756.30 kg).

**Table 1:** Effect of postpartum gonadotropin releasing hormone injection on the relative rate of pregnancy.

| Criteria | HRP | 95% CI | Probability |
|----------|-----|-------|-------------|
| Control  |     |       | 0.04        |
| GnRH     | 1.73| 1.21-2.89 | 0.05        |

*HRP*: hazard ratio of pregnancy
Table 2: Reproductive, productive, and costs parameters of GnRH-treated groups and those controls.

| Criteria | MDI (CI) | MDO (CI) | 1st S/C rates (%) | All S/C rates (%) | DIM (days) | TMY (Kg) | Insemination cost (EGP) | VS | Feed cost (EGP) | TFC (EGP) | TC (EGP) |
|----------|----------|----------|-------------------|-------------------|------------|----------|--------------------|----|----------------|-----------|---------|
| Control  | 90 (80, 110) | 180 (170, 195) | 33b | 84b | 385.08 ± 9.69a | 10663.20 ± 85.09a | 185.32 ± 8.12a | 100 | 15220.12 ± 116.24a | 185.5 ± 56.25 | 17260.44 ± 113.33a |
| GnRH    | 76 (70, 85)b | 153 (140, 168)b | 58a | 96a | 34.95 ± 9.74b | 11756.30 ± 74.43a | 132.45 ± 7.13b | 100 | 13190.45 ± 120.07b | 185.5 ± 56.13 | 15355.90 ± 109.38b |

Means within the same column carrying different letters are significantly different (P < 0.05). Means are expressed as LSM (least squares means) ± SE (standard error).

Table 3: Returns parameters of GnRH-treated group and those untreated.

| Criteria | Milk returns (EGP) | Calf returns (EGP) | Total returns (EGP) | Net return (EGP) |
|----------|-------------------|--------------------|---------------------|-----------------|
| Control  | 21326.40 ± 143.26b | 2000 | 23326.40 ± 147.26b | 4065.96 ± 189.35b |
| GnRH    | 23512.60 ± 156.28a | 2000 | 25512.60 ± 156.28a | 8156.70 ± 176.47a |

Means within the same column carrying different letters are significantly different (P < 0.05).

Table 4: Effect of prostaglandin F2 alpha administration immediately after calving on fertility, productive, and costs parameters of dairy cows.

| Criteria | HRP | 95% CI | Probability |
|----------|-----|-------|-------------|
| Control  | 0.04 |       |             |
| Prostaglandin F2 alpha | 1.66 | 1.11-2.38 | 0.01 |

Table 5: Returns parameters of GnRH-treated group and those untreated.

| Criteria | Milk returns (EGP) | Calf returns (EGP) | Total returns (EGP) | Net return (EGP) |
|----------|-------------------|--------------------|---------------------|-----------------|
| Control  | 21326.40 ± 143.26b | 2000 | 23326.40 ± 147.26b | 4065.96 ± 189.35b |
| GnRH    | 23512.60 ± 156.28a | 2000 | 25512.60 ± 156.28a | 8156.70 ± 176.47a |

Means within the same column carrying different letters are significantly different (P < 0.05).

of the control cows were not significantly different (185.32 EGP; P>0.05) when compared to the treated cows (190.45 EGP).

Feed costs of the control cows were higher (15220.12 EGP; P<0.05) than those of treated cows (14879.23 EGP). Total fixed costs were the same for both groups and total costs were not significantly different (17260.44 EGP for control cows and 17024.68 EGP for treated cows).

Table 6 shows the returns from milk and calf sales and the net return obtained. Milk returns for untreated cows were significantly (P<0.05) greater (21326.40 EGP) than for cows treated with PGF2 alpha (17739.80 EGP). Similarly, the total returns for the control cows were significantly greater than for the treated cows (23326.40 EGP vs. 19739.80 EGP; P<0.05), as were the net returns (4065.95 EGP vs. 2715.12 EGP; P<0.05).

Ergometrin treatment

As presented in Table 7, ergometrin increased the pregnancy rates by 54% relative to control. Reproductive parameters are shown in Table 8. The median days to first service for control cows was significantly higher (P<0.05) than for those treated with ergometrin. Nevertheless, median days open of ergometrin-treated cows was greater (P>0.05) than of control cows. The first S/C and all S/C rates for the control cows were significantly higher than for those receiving ergometrin treatments (33 and 84% vs. 7 and 57%, respectively).

Milk yield of both treated and untreated cows throughout their lactation period is presented in Table 8. Total milk yield of the cows treated with ergometrin over their lactation period (420.78 d) was significantly lower (8213.60 kg; P<0.05) than that of control cows (10663.20 kg; 385.08d lactation). Insemination costs for the cows treated with ergometrin were significantly greater than for untreated cows (225.46 EGP vs. 185.32 EGP, respectively). Veterinary visits and total fixed costs were the same for both treated and untreated cows. Feed costs and total costs were significantly less for cows treated with ergometrin than for those untreated (Table 8). Feed costs for control cows were the same for both treated and untreated cows.
Means within the same column carrying different letters are significantly different (P < 0.05).

Table 6: Returns parameters of prostaglandin F2 alpha-treated group and those untreated.

| Criteria               | Milk returns (EGP) | Calf returns (EGP) | Total returns (EGP) | Net return (EGP) |
|------------------------|--------------------|--------------------|---------------------|------------------|
| Control                | 21326.40 ± 143.26a | 2000               | 23326.40 ± 147.26a  | 4065.96 ± 189.35a |
| Prostaglandin F2 alpha | 17739.80 ± 165.28B | 2000               | 19739.80 ± 165.28B  | 2715.12 ± 194.47B |

Table 7: Effect of postpartum ergometrin injection on the relative rate of pregnancy.

| Criteria | HRPa | 95% CI | Probability |
|----------|------|--------|-------------|
| Control  | 1.54 | 1.13-3.16 | 0.04 |
| Ergometrin | 1.54 | 1.13-3.16 | 0.01 |

Table 8: Effect of ergometrin treatment after calving on fertility, productive, and costs parameters of dairy cows.

| Criteria | MDI (CI)a | MDO (CI)b | 1st S/C rates (%)a | All S/C rates (%)a | DIM (days) | TMY (Kg) | Insemination cost (EGP) | VS | Feed cost (EGP) | TFC (EGP) | TC (EGP) |
|----------|-----------|-----------|-------------------|-------------------|------------|----------|-----------------------|----|---------------|-----------|---------|
| Control  | 90(89, 110)b | 180(170, 195) B | 33a              | 84a               | 385.08 ± 9.69B | 10663.20 ± 85.09a | 185.32 ± 8.12B | 100 | 15220.12 ± 116.24a | 185.5 ± 56.25a | 17260.44 ± 113.33a |
| Ergometrin | 78(68, 95)B | 249(235, 263) a | 7B                | 57B               | 420.79 ± 11.44a | 8213.60 ± 67.43B | 225.46 ± 9.7a | 100 | 15023.22 ± 135.12B | 185.5 ± 56.25a | 17032.68 ± 134.56a |

Oxytocin-treatment

As shown in Table 10, oxytocin increased the relative rate of pregnancy by 70% relative to control. According to Table 11, median days to first insemination was significantly higher for the control group than for cows treated with oxytocin (90 d vs. 77 d; P<0.05). Median days open for oxytocin-treated cows was significantly different compared to control cows. The first S/C and all S/C rates for untreated cows were significantly greater compared to treated group (P<0.05; 33% and 84% vs. 25% and 66%, respectively).

Productivity in terms of milk yield for both treated and untreated cows throughout their lactation period is presented in Table 11. Oxytocin-treated cows yielded less milk than untreated cows (P<0.05; 8968.3 kg and 447.52 d vs. 10663.20 kg and 385.08 d, respectively). Regarding costs parameters, feed costs of the control cows were significantly lower (P<0.05; 15220.12 EGP) than of those receiving oxytocin treatment (16011.54 EGP). Therefore, total costs for the cows treated with oxytocin were significantly greater (P<0.05; 18231.99 EGP) than for untreated cows (17260.44 EGP).

Veterinary visits and total fixed costs were the same for both treated and untreated groups.

Profitability measures are presented in Table 12. Milk returns for control cows were significantly greater (P<0.05; 21326.40 EGP) than for those treated with oxytocin (17936.60 EGP). Total returns were significantly greater (P<0.05) than those for oxytocin-treated cows (19936.60 EGP). Net return for the group receiving oxytocin was significantly lower (P<0.05; 1704.61 EGP) than that for control group (4065.96 EGP).

Estrogen-treatment

According to Table 13, the rate of pregnancy was greater relative to control when cows were treated with estrogen (86%). Reproductive performance was significantly improved by estrogen treatment. Median days to first insemination and median days open were significantly improved (64 d and 102 d vs. 90 d and 180 d, respectively) for cows treated with estrogen compared to control cows. Moreover, the first S/C and all S/C rates for control cows were significantly less than for those treated with estrogen (33% and 84% vs. 53 and 94%, respectively).

Milk yield of the estrogen-treated cows over their lactation period was higher than for control cows (11337.70 kg over 353.78 d vs. 10663.20 kg over 385.08 d). Insemination costs of the control cows were greater than those receiving estrogen (185.32 EGP vs. 170.45 EGP), but this difference was not significant. Feed costs of the untreated cows were significantly greater than those receiving estrogen (15220.12 EGP vs. 14986.56 EGP; P<0.05). Veterinary visits, total fixed costs, and total costs were the same for both treated and untreated cows (Table 14).

Table 15 shows the returns parameters of both treated and untreated groups.

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Table 9: Returns parameters of ergometrin-treated group and those untreated.

| Criteria       | Milk returns (EGP) | Calf returns (EGP) | Total returns (EGP) | Net return (EGP) |
|----------------|--------------------|--------------------|---------------------|------------------|
| Control        | 21326.40±143.26a   | 2000               | 23326.40±143.26a    | 4065.96±189.35a  |
| Ergometrin     | 16427.20±168.21B   | 2000               | 18427.20±168.21B    | 1223.52±159.14B  |

Means within the same column carrying different letters are significantly different (P < 0.05).

Table 10: Effect of postpartum oxytocin hormone injection on the relative rate of pregnancy.

| Criteria | HRP* | 95% CI  | Probability |
|----------|------|---------|-------------|
| Control  |      |         | 0.04        |
| Oxytocin | 1.70 | 1.00-2.88| 0.05        |

*hazard ratio of pregnancy

Table 11: Effect of oxytocin treatment immediately after calving on fertility, productive, and costs parameters of dairy cows.

| Criteria | MDI (CI)a | MDO (CI)a | 1st S/C (%) a | All S/C rates (%) a | DIM (days) | TMY (Kg) | Insemination cost (EGP) | VS Feed cost (EGP) | TFC (EGP) | TC (EGP) |
|----------|-----------|-----------|---------------|--------------------|------------|----------|------------------------|------------------|-----------|---------|
| Control  | 90 (80, 110)a | 180 (170, 195) a | 33a             | 84a                | 385.08±9.69B | 10663.20±85.09a | 185.32±8.12B | 100       | 15220.12±116.24a | 1855±56.25a | 17260.44±113.33a |
| Oxytocin | 77 (65, 83)B | 184 (175, 198) a | 25B             | 68B                | 447.52±12.35a | 8969.30±82.22B | 265.45±13.45a | 100       | 16011.54±135.12B | 1855±56.25a | 18231.99±129.12a |

Means within the same column carrying different letters are significantly different (P < 0.05).

Table 12: Returns parameters of oxytocin-treated group and those untreated.

| Criteria       | Milk returns (EGP) | Calf returns (EGP) | Total returns (EGP) | Net return (EGP) |
|----------------|--------------------|--------------------|---------------------|------------------|
| Control        | 21326.40±143.26a   | 2000               | 23326.40±143.26a    | 4065.96±189.35a  |
| Oxytocin       | 17936.60±189.47B   | 2000               | 19936.60±189.47B    | 1704.61±193.45B  |

Means within the same column carrying different letters are significantly different (P < 0.05).

Estrogen followed by oxytocin treatment

The reproductive parameters of the cows injected with estrogen followed by oxytocin were significantly improved. The rate of pregnancy was 74% relative to control (Table 16). However, as shown in Table 17, median days to first insemination and median days open were significantly greater for treated cows than for untreated cows (174 d and 258 d vs. 90 d and 18 d, respectively; P<0.05). First S/C and all S/C rates of untreated cows were significantly higher than those of treated with estrogen-oxytocin combination (33% and 100% vs. 15% and 69%, respectively; P<0.05). Productivity of control cows was higher than of treated cows. Total milk yield of the control cows was significantly higher than of treated cows over their lactation periods (10663.20 kg and 385.08 d vs. 8743.90 kg and 423.78 d, respectively; P<0.05). Insenemization costs of the estrogen-oxytocin treatment were significantly higher than of the control (225.69 EGP vs. 185.32 EGP).

As presented in Table 17, feed costs and total costs of the estrogen-oxytocin treatment group were significantly greater than of untreated cows (15945.23 EGP and 18125.92 EGP vs. 15220.12 EGP and 17260.44 EGP; P<0.05).

Table 18 shows the returns parameters of both treated and untreated cows. Milk returns for untreated cows were higher than for treated cows (21326.40 EGP vs. 17487.80 EGP; P<0.05). Total returns show the same trend. As a result of higher total returns and lower total costs for the control cows, the net return was considerably higher than for treated cows (4065.96 EGP vs. 1361.88 EGP; P<0.05).

Discussion

We described the effects of various hormonal therapies on the reproductive, productive, and economic efficiency of normal postpartum cows. To date, there are few studies dealing with the productive and economic effects of such therapies.

The reproductive performance of the group treated with...
GnRH was significantly improved when compared to untreated cows. Our results are supported by those of Fernandes et al. [16], who reported that GnRH accelerated the rate of uterine involution, suggesting that fertility in dairy cows may be enhanced by improving the uterine environment more quickly postpartum. In addition, Nash et al. [17] demonstrated that the administration of 250 µg GnRH at 14 days postpartum may induce early cyclic activity and subsequently improve fertility, giving a shorter interval from calving to conception, higher conception rate, and lower services per conception. Similarly, Peters and Bosu [18] noticed that treatment with GnRH at 15 days postpartum may help cows that are free from puerperal infections. The interval from parturition to conception was significantly reduced, and improvement in some other reproductive parameters was observed in GnRH-treated cows between day 10 and day 12 postpartum (Labib et al.) [19].

Regarding the productivity of treated and untreated cows, El-Tahawy and Fahmy [14] reported a positive impact on the milk yield of cows receiving GnRH. The increase in productivity of GnRH-treated cows reflected on the returns for these cows when compared to untreated ones.

The reproductive performance of cows treated with PGF2 alpha was not significantly different from that of untreated cows. Contrary to our data, Young et al. [20] reported that exogenous PGF2 alpha administered during the early postpartum period in cows from 14 to 28 days might influence uterine involution and shorten the time for return to optimum fertility after calving, which significantly improves conception rate at first service.

Table 14: Effect of administration of estrogen immediately after parturition on fertility, productive, and costs parameters of dairy cows.

| Criteria | MDI (CI) | MDO (CI) | 1st S/C rates (%) | All S/C rates (%) | DIM (days) | TMY (Kg) | Insemination cost (EGP) | VS | Feed cost (EGP) | TFC (EGP) | TC (EGP) |
|----------|----------|----------|-------------------|-------------------|-----------|---------|------------------------|----|---------------|-----------|---------|
| Control  | 90 (80, 110) | 180 (170, 195) | 33B | 84B | 385.08 ±6.99a | 1066.32 ±85.09B | 185.32 ±8.12a | 100 | 15220.12±116.24a | 1855±56.25a | 17260.44±113.33a |
| Estrogen | 64 (52, 78) | 102 (87, 119) | 53a | 94a | 353.78 ±8.35B | 11337.70 ±54.43a | 178.45 ±10.45a | 100 | 14986.56±144.12B | 1855±56.25a | 17120.10±139.12a |

Means within the same column carrying different letters are significantly different (P < 0.05).

Table 15: Returns parameters of estrogen-treated group and those untreated.

| Criteria | Milk returns (EGP) | Calf returns (EGP) | Total returns (EGP) | Net return (EGP) |
|----------|-------------------|-------------------|---------------------|-----------------|
| Control  | 21326.40±147.26B | 2000 | 23326.40±147.26B | 4065.96±189.35B |
| Estrogen | 22675.40±134.50a | 2000 | 24675.40 ±134.50a | 7555.30 ±135.16a |

Means within the same column carrying different letters are significantly different (P < 0.05).

Table 16: Effect of postpartum estrogen followed by oxytocin injection on the relative rate of pregnancy.

| Criteria | HRP | 95% CI | Probability |
|----------|-----|-------|-------------|
| Control  | 0.04 |
| Estrogen-oxytocin | 1.74 | 1.16-2.23 | 0.04 |

Hazard ratio of pregnancy

Table 17: Effect of estrogen treatment followed by oxytocin on fertility, productive, and costs parameters of postpartum dairy cows.

| Criteria | MDI (CI) | MDO (CI) | 1st S/C rates (%) | All S/C rates (%) | DIM (days) | TMY (Kg) | Insemination cost (EGP) | VS | Feed cost (EGP) | TFC (EGP) | TC (EGP) |
|----------|----------|----------|-------------------|-------------------|-----------|---------|------------------------|----|---------------|-----------|---------|
| Control  | 90 (80, 110) | 180 (170, 195) | 33a | 100a | 385.08 ±9.69B | 1066.32 ±85.09B | 185.32 ±8.12a | 100 | 15220.12±116.24a | 1855±56.25a | 17260.44±113.33a |
| Estrogen-oxytocin | 174 (160, 183) | 258 (223, 274) | 69B | 423.78 ±5.54a | 8743.90 ±64.23B | 225.69±9.23a | 100 | 15945.23±144.12a | 1855±56.25a | 18125.92±139.12a |

Means within the same column carrying different letters are significantly different (P < 0.05).

Table 18: Returns parameters of estrogen-oxytocin treated group and those untreated.

| Criteria | Milk returns (EGP) | Calf returns (EGP) | Total returns (EGP) | Net return (EGP) |
|----------|-------------------|-------------------|---------------------|-----------------|
| Control  | 21326.40±147.26B | 2000 | 23326.40±147.26B | 4065.96±189.35B |
| Estrogen-oxytocin | 17487.80±164.45a | 2000 | 19487.80±147.26a | 3650.96±189.35a |

Means within the same column carrying different letters are significantly different (P < 0.05).

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Moreover, Benmarad and Stevenson [21] observed improvement in fertility in cows given PGF2 alpha (25 mg lutalyse) between day 20 and 24 postpartum. They also found that the interval from calving to conception was decreased in all cows treated with PGF2 alpha, especially for cows with an abnormal puerperium. Further, services per conception were reduced in both normal and abnormal cows given PGF2 alpha. Improvement in fertility was associated with increased frequency and occurrence of ovulation and estrus before first service and the reestablishment of estrus cycles of normal duration before 6 weeks postpartum. Heuwers et al. [22] reported that the strategic administration of PGF2 alpha to cows in the postpartum period increased efficiency of estrus detection and decreased the interval to first service and the number of days open. Elsheikh and Elzubeir [7] showed that double injection of PGF2 alpha during the first week, single or double injection of PGF2 alpha during the second or third week postpartum minimized the days open and accelerated the uterine involution, therefore the use of PGF2 alpha during early postpartum period improved the reproductive efficiency of cross-bred dairy cows. Also, the same authors reported in their later work (2005) that reproductive efficiency of cross-bred dairy cows was improved when prostaglandin F2 alpha was injected during the first three weeks postpartum.

In agreement with our results, it was previously shown that the administration of PGF2 alpha or a combination of PGF2 alpha and prostaglandin (PG)E2 at 21 to 35 days postpartum had no beneficial effect upon measured fertility variables, except for a tendency to shorten the interval from calving to first in semination [23]. Another study reported a reduction in conception rate in primiparous cows after postpartum administration of PGF2 alpha [24], in agreement with our data.

Likewise, ergometrin-treated cows showed no improvement in their reproductive performance when compared to untreated cows. In contrast, it has been reported that injecting ergometrin directly after parturition in dairy cows reduces the incidence of retained fetal membranes and improves reproductive performance [25]. Similarly, Hussein and Metwelly [26] concluded that methyl ergometrin injection directly after parturition in dairy cows decreased the incidence of retained fetal membranes and improved the reproductive performance of treated cows compared to control. They also found that methyl ergometrin was superior to oxytocin.

Further, for oxytocin-treated cows, Metwelly and EL-Bwab [27] injected oxytocin directly after parturition in dairy cows and recorded a significant increase in reproductive performance (calving-estrus interval, days open, services per conception and total conception rate) in treated cows. Additionally, Hussein and Metwelly [26] showed that oxytocin injection directly after parturition in dairy cows decreased the incidence of retained fetal membranes and improved the reproductive performance of treated cows compared to control. On the other hand, Convey et al. [28] suggested that hormones released at suckling, such as oxytocin, may depress gonadotropin secretion and/or inhibit ovarian activity. Results obtained by Bajcsy et al. [8] indicated that using oxytocin 50IU intramuscularly enhanced uterine contractility if treatment occurred on the first day postpartum. Data of another experiment revealed that oxytocin administration immediately after delivery reduced the occurrence of retained fetal membranes in cattle, subsequently reduced the incidence of endometritis and improved the reproductive efficiency.

Foote and Hunter [29] supported the results of our study concerning estrogen treatment. They demonstrated that the postpartum interval was reduced in cows treated with estrogen as 10 mg estradiol-17β compared to control animals. Similarly, Ulberg and Lindley [30] and Saiduddin et al. [31] reported that treatment of anestrous postpartum dairy cows with estrogen from 15 to 30 days postpartum tended to shorten the postpartum interval. In agreement with our data, El-Tahawy and Fahmy [14] found that milk yield and returns parameters for estrogen-treated cows were greater than for untreated cows.

In order to attempt to achieve a more reliable response to oxytocin, estrogenic substances have also been given, in the hope of both increasing the sensitivity of the myometrium to oxytocin and enhancing the natural uterine defence mechanisms [32]. For these reasons, the synthetic estrogens stilboestrol-dipropionate and estradiol monobenzoate have been widely applied to cows with retained fetal membranes in the form of parenteral injection or uterine infusion and pessary, and their use has sometimes been followed by injection of oxytocin.

In conclusion, the results of this study suggest that GnRH and estrogen are the best hormonal therapies and are more profitable than other treatments tested. They have a positive influence on the reproductive, productive, and economic efficiency of dairy cattle, increasing net returns and decreasing health costs.

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