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Onset of Luteal Activity in Foaling and Seasonally Anoestrous Mares Treated with Artificial Light

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Koskinen, E., E. Kurki and T. Katila: Onset of luteal activity in foaling and seasonally anoestrous mares treated with artificial light. Acta vet. scand. 1991, 32, 307–312. – Sixty-four mares (27 foaling, 37 barren or maiden), mainly Finnhorses, were subjected to treatment with 14.5 h of light and 9.5 h of darkness, starting at the beginning of December. The onset of cycling in non-foaling mares was estimated by weekly serum progesterone determinations. All of the non-foaling mares cycled in the middle of March. They started to cycle on average in the middle of February, 11.1 weeks after the beginning of the trial. There were statistically significant differences in relation to breed (Finnhorses started to cycle 2 weeks later than warm blooded, $p < 0.02$) and in relation to age (brood mares with mean age 10 years, started to cycle 10 days later than those 3 years old, $p < 0.03$). However, there was no statistical significant relation to previous lactation, although lactating mares lactating up to the previous autumn started to cycle 7 days later than dry mares ($p < 0.15$).

Artificial insemination of 14 mares in the 2nd oestrus of the year, in March, resulted in 12 foalings in the subsequent year (86 %).

The following winter, all pregnant mares (N = 27) were exposed to the same kind of light treatment, starting on 1st December. The 1st mare foaled at the end of January. The time from foaling to 1st post partum ovulation was significantly longer (17.0 days) in foalings taking place within 10 weeks from the beginning of the light treatment period, than in foalings occurring after more than 10 weeks of lighting (12.1 days) ($p < 0.01$).

light treatment; progesterone determination; horses.

Introduction

The mare is a seasonal breeder, exhibiting ovarian inactivity in winter. However, the high demand for foals born early in the year has led to demands for shortening the winter anoestrus. Various kinds of hormone treatments have been tried, for decades, but the most promising results have been achieved by treatment with artificial light.

Since the early investigations of *Burkhardt* (1947) and *Nishikawa* (1959), there have been numerous studies demonstrating the effect of lighting on ovarian activity in anoestrous mares. In many mares it was possible to change the breeding season from early summer to winter through exposure to artificial light during a few months before mating (*Loy* 1968, *Cooper & Wert* 1975, *Kooistra & Ginther* 1975).

Although the mechanism is still largely unknown, it is believed that the increase in light inhibits pineal secretion of melatonin, thus stimulating GnRH secretion, one of the first events leading to heat season (*Sharp* 1988).

Various kinds of lighting programmes have been used. In early studies positive results were obtained using a method in which the artificial daily lightperiod was gradually increased during winter (*Burkhardt* 1947, *Loy* 1968, *Sharp & Ginther* 1973, *Cooper & Wert* 1975). In later studies, light treatment has been started suddenly, with no gradual transition (*Palmer* 1979). Exposure to light for 15 to 16 h a day has been found effective (*Freedman et al.* 1979, *Scraba & Ginther* 1985). However, *Palmer et al.* (1982) found a photo-sensitive phase in the morning, 9.5–10.5 h after dusk, during which light is necessary for effective stimulation. *Palmer* (1979) concluded that the stimulant effect of lighting is essentially affected by the time during each 24 h cycle when exposure to light takes place. *Scraba & Ginther* (1985) found that a fixed, 1 h of artificial light at 4 a.m. was stimulatory for mares otherwise exposed to natural daylight.

Light intensity has varied in different trials. In some studies, only the electrical power of the bulbs have been reported; in others, light intensity has been measured in lux or foot-candles (1 foot-candle = 10.8 lux). According to *Oxender et al.* (1977) one 250 W bulb in each box stall is effective. *Oxender* measured a light intensity of 160 lux at a height of 150 cm in the centre of the box. *Palmer et al.* (1982) used a 200 W bulb per 20 m^2 box. In the study of *Kooistra & Ginther* (1975) 4 200 W bulbs per 30 m^2 box were needed to achieve light intensities of 13–43 foot-candles at the eye level of mares (depending on mare's location in the stall). *Kenney et al.* (1975) recommended a 200 W bulb in each stall, or at least 2 foot-candles of light.

The time of the year when light treatment should be started has been studied by *Scraba & Ginther* (1985). Pony mares which had been subjected to light treatment on November 1st and December 1st started to cycle at the beginning of April. Control mares started to cycle in the middle of May.

When 5 mares were exposed to 16 h of light from 11th December, they started cycling 59 ± 7 days later (*Oxender et al.* 1977). It is now common practice to expose thoroughbred mares to 16-h light per day from the time of winter solstice. The mares will begin to cycle 6 to 12 weeks later (*Allen* 1985).

Early breeding of horse mares leads to foaling during the winter, a time of profound anestrus for many mares. There is a risk of new conception being delayed because mares sometimes become anoestrous immediately after foaling or after the first post-partum ovulation (*Palmer & Driancourt* 1983) or, more often, because the average time from foaling to first ovulation is longer during early spring than during summer (*Loy* 1980). It has been shown that such problems can be prevented by exposing pregnant mares to light from the beginning of the 10th month of pregnancy (*Palmer & Driancourt* 1983).

Foaling rates after winter breeding using light therapy are probably similar to summer breeding rates. *Cooper & Wert* (1975) achieved a high foaling rate of 63 % after breeding during a single oestrus period from December to February using light treatment.

The purpose of this study was to investigate the effectiveness of artificial light treatment on the reproduction of Finnhorse mares in the northern climate of Finland, where winter days are short.

Materials and methods

The experiments were carried out at the Equine Research Station, between 1988 and 1989. During the study, non-pregnant and pregnant mares were kept in separate stalls, 9 m^2 and 13.5 m^2, respectively. Light therapy started in the 1st week of December and lasted until the beginning of May, when natural light exceeded artificial light. One 36-W fluorescent tube per stall was used. The intensity of light was 70–150 lux at the level of a mare's eye, depending on the location of the mare in the stall. The lights were turned on at 6 a.m. and off at 8:30 p.m., i.e. there were 14.5 h of light and 9.5 h of darkness. Between 8 a.m. and 4 p.m., the mares were in paddocks for 4 h.

The data were analysed statistically using the students t-test[1]. The dependent variables were number of weeks from the beginning of the year (Experiment 1) and the interval from parturition to first ovulation (Experiment 2). The independent variables were breed (Model 1), age (Model 2) and lactation (Model 3) in Experiment 1 and the length of light treatment in Experiment 2.

Experiment 1

Records from 37 anoestrous mares, representing 28 Finnhorses and 9 Standardbred and saddlehorse mares, were used. The 13 youngest were 3 year old and not yet in training (12 Finnhorses and 1 warm blooded). The mean age of the mares above 3 years old was 10.3 years (SD = ± 4.4 years and the range was 4 to 18 years). Five mares were lactating at the beginning of the trial (1 Finnhorse mare, and 4 warm blooded mares). During the study, no mares were subjected to training. The animals were fed 7–9 kg of timothy hay, oats and concentrates according to the needs, to keep weights in balance.

The onset of cycling was determined by weekly serum progesterone determinations. Progesterone was determined in serum samples by a direct RIA method[2]. Cycling was considered as beginning when there had been 2 successive elevated (> 10 nmol/l) progesterone concentrations. In 1988, 14 mares were inseminated during the 2nd oestrus, during light treatment, with a stallion of known fertility.

Experiment 2

Twenty-seven pregnant mares (22 Finnhorses and 5 Standardbreds) were subjected to light treatment from the beginning of December 1988. Because the 1st mare foaled at the end of January and the last at the beginning of June 1989, the length of light treatment varied from 2 to 6 months pre partum. The mean age of the mares was 11.7 years (SD = ± 4.3 years and ranged from 4 to 20 years). Seven mares were nulliparous. The remaining 20 mares had foaled on average 3.9 times (SD = ± 2.2 times and ranged from 1 to 10 times). The first ovulation after foaling was detected by daily rectal palpation and ultrasonic scanning. The day of disappearance of the ovulatory follicle was regarded as the day of ovulation.

Results

Experiment 1

Non-foaling mares. All mares subjected to light treatment cycled in the middle of March. Cycling started, on average, during the 2nd fortnight of February, 11.1 weeks (SD = ± 1.6 weeks and range 8 to 14 weeks, N = 37) after the beginning of the light treatment (Table 1). Differences relating to breed were statistically significant. In mares 4–8 years of age, 6 Finnhorses started to cycle 11.8 ± 1.5 weeks and 5 warm blooded horses started 9.8 ± 0.8 weeks after the beginning of the trial ($p < 0.02$, model 1). Differences relating to age were statistically

[1] GLM procedure in SAS, SAS Institute Inc., SAS Circle, Box 8000, Cary, NC 27512–8000, U.S.A.

[2] Farmos Diagnostica, Turku, Finland.

Table 1. Cumulative percentage frequencies of onset of cycling in anoestrous mares in different weeks after the beginning of light treatment.

Month	Week	Finnhorses 3-yr olds N = 12 Cum %	Finnhorses > 3-yr olds N = 16 Cum %	Finnhorses All N = 28 Cum %	Warm blooded All N = 9 Cum %
Jan	8	8	6	7	0
Feb	9	8	6	7	22
Feb	10	67	13	36	67
Feb	11	83	44	61	89
Feb	12	92	63	75	100
Mar	13	92	88	89	100
Mar	14	100	100	100	100

significant in Finnhorses. Twelve 3 years old mares and mares over 3 yeas old (aged 10 ± 4.6 years, N = 16) cycled 10.5 ± 1.4 and 11.8 ± 1.6 weeks after the beginning of the trial, respectively ($p < 0.03$, Model 2). The difference between lactating and dry warmblooded mares was not significant. Four lactating mares and 5 dry mares started to cycle 10.8 ± 1.0 and 9.8 ± 0.8 weeks after the beginning of the trial, respectively ($p < 0.15$, Model 3).

Foaling rate. Insemination of 14 mares in the 2nd oestrus of the year (1988) resulted in 12 foalings in the subsequent year (86 %).

Experiment 2

Interval from parturition to 1st ovulation. The time from foaling to the 1st post partum ovulation for foalings within and after 10 weeks from the beginning of the light treatment were 17.0 days ± 6.8 days, ranging from 12–32 days, N = 7 and 12.1 days ± 2.5 days, ranging from 9–18 days, N = 20, respectively ($p < 0.01$).

Discussion

Our programme of 14.5 h of light and 9.5 h of darkness has been found effective by other investigators (*Palmer et al.* 1982, *Scraba & Ginther* 1985).

Onset of cycling occurred markedly earlier in this study than usual in our mares. All mares cycled in the middle of March rather than at the beginning of June as our mares normally do (*Koskinen & Katila* 1991). The time from parturition to first ovulation also fell from 17 days to 12 days after 10 weeks of light treatment. Later in Spring, light treatment did not appear to shorten the time from parturition to ovulation in comparison with that in mares foaling under normal stable conditions. In light-treated mares foaling in April–May, the interval was 12 days. In untreated mares, the corresponding figure was 13 days in Spring and 9 days in Summer (*Koskinen* 1991).

It is apparent that the critical factor in our study was artificial light treatment, and not the increasing natural length of day because, in February, the length of day in Southern-Finland is still only about 10 h, which is non-stimulant (*Palmer et al.* 1982).

Cycling started 8–14 (mean 11.1) weeks after the onset of light treatment. This is similar to the findings of *Oxender et al.* (1977) and *Allen* (1985). However, although *Oxender* detected normal oestrous cycles within 2 months from the beginning of the light treatment period, we found these within 3 months of light treatment in Finnhorse mares in Finland. The difference could be attributable to a difference in breed, or more profound anoestrus in our mares. The results in this study favour a difference between breeds, because our Finnhorse mares started to cycle 2 weeks later than our warm blooded mares ($p < 0.02$).

The finding that 3 years old Finnhorse mares cycled significantly earlier than older Finnhorse mares probably reflects a shallower anoestrus in the three year olds.

Although the difference was not statistically significant, lactation seems to delay the start of cycling. This has previously been demonstrated by *Palmer & Driancourt* (1983).

Conception by 12 out of 14 mares (86 %) in the 2nd oestrus of the year during light therapy and their succesful foaling the following winter corresponds to the findings of *Cooper & Wert* (1975). It shows that breeding after the onset of cycling is not in itself "unphysiological", even if breeding takes place early in year.

No mares in this study became anoestrous after the 1st post-partum ovulation. Although there was considerable variation in the time from foaling to the first post-partum ovulation (9–32 days in the treated mares), regular cycling continued after first ovulation.

At least 10 weeks of light treatment was needed pre partum to shorten significantly the interval from parturition to first post partum ovulation. The recommendation of *Palmer & Driancourt* (1983) to start long-day treatment 2 months before foaling in winter may need to be altered to a commencement a few weeks earlier in mares in Finland, to overcome the seasonal effect.

In conclusion, the responses of non-foaling and pregnant mares to light treatment in the 2 experiments reported suggest that light treatment provides an effective method of starting the breeding season in Finland at the beginning of February.

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Sammanfattning

Igångsättning av lutealfasen hos fölston och anöstrala ston behandlade med artificiellt ljus.

Sextiofyra ston (huvudsakligen finnhästar) av vilka 27 var fölston och 37 subfertila eller virginella ston, utsattes dagligen för 14,5 timmars artificiellt ljus åtföljt av 9,5 timmars mörker – behandlingen inleddes i början av december. Initieringen av brunstcykeln hos de icke-fölande stona fastställdes med hjälp av progesteronhalten i blodprover tagna en gång per vecka. I mitten av mars var alla icke-fölande ston igång med sin brunstcykel; igångsättningen skedde i genomsnitt i mitten av februari, dvs. 11.1 veckor efter det att studien påbörjades. Följande signifikanta skillnader påvisades: 1) ras: finnhästarna visade brunst 2 veckor senare än varmblodiga ston ($p < 0.02$); 2 ålder: ston som fölat (genomsnittsålder 10 år) inledde ovulationscykeln 10 dygn senare än treåriga ston ($p < 0.03$). Ingen signifikans påvisades däremot i relation till tidigare laktation, utom hos ston som hade lakterat under föregående höst. Dessa ston inledde brunstcykeln 7 dygn senare än de övriga stona ($p < 0.15$).

Artificiell insemination av 14 ston under deras andra brunst för året (i mars) resulterade i 12 fölningar (86 %) under det följande året.

Följande vinter utsattes dräktiga ston (N = 27) för samma ljusbehandling med början 1 december. Det första stoet fölade i slutet av januari. Intervallet mellan fölning och den första ovulationen var signifikant längre (17.0 dygn) hos de ston som fölat inom 10 veckor efter påbörjad ljusbehandling jämfört med ston som fölat senare än 10 veckor efter inledd ljusbehandling (17.0 vs. 12.1 dygn, $p < 0.01$).

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