



Effect of norgestomet on induction of oestrus in cattle: an overview

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ABSTRACT

Late attainment of puberty, silent oestrus and anoestrus are among the major constraints of reproduction in the breeding programme of farm animals that have direct impact on farmers' economy. Application of exogenous hormones that are available in the market constitutes powerful potential to address such reproductive problems of animals confronted by the farmers while rearing them for gainful purpose. The use of norgestomet along with compounds like oestradiol valerate and PMSG effectively enhanced puberty, induction and synchronization of oestrus entailing fertility in several breeds of cattle. Reproductive parameters associated with evaluation of efficacy appertaining to norgestomet applications and factors influencing their functions were discussed in this brief overview.

Key words: Cows, Heifers, Norgestomet, Puberty induction, Reproduction, Synchronization

Anoestricity associated with late onset of puberty lowers the reproductive rate of heifers because it delays their entry in herd as potential breedable animals (Britt 1987). Late attainment of puberty in zebu (*Bos indicus*) cattle is a major constraint in maximizing their reproduction and production efficiency (Rao *et al.* 1986).

The onset of puberty in heifers is primarily determined by the attainment of body weight at specified age, which differs in different breeds (Arije and Wiltbank 1971, Short and Bellows 1971, Gonzalez-Padilla *et al.* 1975b). Onset of puberty in beef heifers can be controlled to a certain extent by genetic (Wiltbank *et al.* 1966, Wiltbank *et al.* 1969, Laster *et al.* 1972) or environmental (Wiltbank *et al.* 1969, Short and Bellows 1971) variables. However, in many herds changing the levels of nutrition or the heifers' genotype may not be economically and practically feasible (Peter 1979). Puberty could be induced in heifers by the application of hormonal regimens such as progesterone and oestradiol-17 β (Gonzalez-Padilla *et al.* 1975a), oestrogens and progesterones (Short *et al.* 1976, Peter 1979), gonadotropins (Glencross 1980) and GnRH (McLeod *et al.* 1984). Precocious puberty could be induced in heifers by norgestomet along with oestradiol and PMSG treatment (Sarmah *et al.* 2003a, Sarmah *et al.* 2003b, Kakati *et al.* 2007 and Sarmah *et al.* 2008). Deka *et al.* (2009) reported that norgestomet could induce synchronized oestrus in nondescript cows. Bo *et al.* (1995) stated that in the heifers

treated with estradiol (E) - 17 β plus progesterone ear implants the dominant follicle ceased to grow 1 d after E-17 β treatment and subsequently regressed, resulting in an early emergence (day 5.2 ± 0.2) of the next follicular wave. Conversely, E-17 β administration to heifers without progesterone implant did not effectively suppress the dominant follicle and emergence of the next wave was delayed (day 9.8 ± 1.1). The progestin norgestomet (17-acetoxy-11 β -methyl-19-norpreg n-4-ene-3, 20-dione) inhibits oestrus and ovulation effectively in heifers when administered by a subcutaneous polymer implant in combination with an intramuscular injection of norgestomet and oestradiol valerate (Wishart and Young 1974, Wishart 1975). A 9- day implant treatment resulted in a precise oestrus and ovulatory response after the implant withdrawal, the mean interval between implant removal and ovulation being 68.5 ± 9.7 h (Wishart and Young 1974, Wishart 1975). This precision permitted the heifers to be inseminated at a fixed time which eliminated oestrus detection and provided the synchronously ovulating animals the opportunity of becoming pregnant. Progesterone caused suppression of LH release, and its withdrawal resulted in a gradual rise in plasma concentration of LH culminating in a preovulatory LH surge and ovulation (Peters and Lamming 1984). However, preovulatory LH surge could induce ovulation only if a follicle at the appropriate stage of development was already present. LH may not be sufficient by itself to promote growth of preovulatory follicles in the absence of development of early follicle at prepubertal age. Treatment with synchromate-B (SMB: a progesterone implant) implant plus a small dosage of PMSG at the implant removal was effective in inducing fertile oestrus in prepubertal

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heifers of several breeds (Lokhande *et al.* 1983, Rao *et al.* 1986). PMSG is known to act primarily by stimulating follicular development and increased LH release induced by endogenous oestrogen production. Tibary *et al.* (1992) also stated that low dosage of PMSG was beneficial in promoting follicular development and ovulation in acyclic heifers. Oestrus synchronization was shown to be a good technique for advancing and/or shortening the breeding season in beef cattle (Wiltbank and Spitzer 1978). Oestrus synchronization could be achieved in cyclic animals with prostaglandin (PGF_{2α} or its analogues) or progesterone implants such as norgestomet/ SMB (Wiltbank and Spitzer 1978, Seguin *et al.* 1989). In the present brief overview the efficacy of norgestomet and allied treatment in inducing puberty, synchronization or induction of oestrus in cattle are discussed with regard to parameters on reproduction and associated factors.

Retention of ear implant and tissue reaction

In most of the animals ear implants of norgestomet were retained (Sarmah 2001, Singh *et al.* 2001, Sarmah *et al.* 2004) throughout the duration of treatment with the exception of a few animals which could be due to improper restraining and inadequate handling facilities. Drew *et al.* (1979) reported that only 16 out of 3,050 cows lost implant during treatment. They were also of the opinion that there was no evidence of tissue reaction at the sites of implantation. Rao *et al.* (1986) stated that 3 out of 35 prepubertal heifers lost implant during the study undertaken by them. Hill *et al.* (1992) found that 95% of norgestomet implants were retained in beef heifers for an extended period of time. Cetin *et al.* (2007) reported that norgestomet silicone ear implant that was placed subdermally was not lost in any of the 29 heifers.

Oestrus response

Norgestomet and estradiol valerate were effectively utilized to synchronize oestrus and to control ovulation in cattle (Kazmer *et al.* 1981 and Spitzer *et al.* 1981). Holtz *et al.* (1979) reported that 70.60% heifers responded to the treatment of norgestomet plus 500 IU PMSG upon implant removal. However, when the suckler cows sooner than 50 days after parturition were treated, only 4 out of 24 cases (16.67%) responded to treatment. Gonzalez Stagnaro *et al.* (1981) observed induced oestrus in postpartum cows within 48 h after the end of treatment which included norgestomet implant for 7–9 days plus PMSG at the time of implant withdrawal. Rao *et al.* (1986) reported that following treatment with norgestomet and PMSG all the treated prepubertal zebu heifers were detected in oestrus between 48 h and 72 h post treatment. The onset of oestrus interval was shorter in 28 postpartum anoestrous cattle when treated with norgestomet plus PMSG (52.8 h) than with norgestomet (62.4 h) alone (Agarwal *et al.* 2001). Joshi *et al.* (1992) recorded that when 11 heifers were treated by norgestomet implantation followed by PGF_{2α} analogue injection 7 days later and 400 IU PMSG injection 9 days

later at implant removal, all of them showed oestrus within 48 h of PMSG injection. Almost all heifers (97%) and cows (81%) were induced to oestrus, the majority of them within 120 h of implant removal, when 51 pubertal Harijana and Sahiwal anoestrous heifers and 55 postpartum cows were treated with 10-day norgestomet (3 mg) subcutaneous ear implants with an initial intramuscular injection of 3 mg norgestomet plus 5 mg oestradiol valerate, followed by 500 IU eCG at implant withdrawal (Singh *et al.* 1998). Corbet *et al.* (1999) recorded that application of 3 mg of norgestomet subcutaneously for 14 days followed by PGF_{2α} on day 16 resulted in high incidence (88%) of induced oestrus in zebu beef heifers. Sarmah *et al.* (2003b) reported that the mean duration of oestrus in norgestomet - treated prepubertal heifers was 32.25±0.90 h when mated at induced oestrus; however, it was 70.00±1.51 h when the heifers were not allowed to mate at induced oestrus. Nath *et al.* (2004a) found that 9 out of 10 postpartum indigenous anoestrous cows evinced behavioural oestrus for 19.11±0.34 h (range: 18 to 21 h) at a mean interval of 30.81±1.43 h (range: 22 to 37.5 h) after completion of treatment with crestar (norgestomet) ear implant for 9 days accompanied by crestar injection at the time of implantation and administration of 300 IU PMSG injection at implant removal. Deka *et al.* (2010) reported that 4 out of 5 Asom local cows exhibited oestrus after 29.80±0.01 h of implant removal when they were subjected to 3 mg norgestomet ear implant for 9 days during follicular phase followed by 5 mg oestradiol valerate intramuscularly. Tjondronegoro *et al.* (1987) detected behavioural oestrus in postpartum anoestrous cows within 24 to 36 h after completion of progesterone (PRID) treatment. Ozyurtlu *et al.* (2009) found that the rate of induced oestrus was 80% following application of norgestomet ear implant and PRID in acyclic Holstein heifers. Abdoon *et al.* (1994) found that all the 6 prepubertal buffalo heifers exhibited oestrus 72.00±40.16 h after removal of norgestomet ear implant and the duration of oestrus averaged 20.0±14.5 h. Bernardo *et al.* (1996) stated that 10 of the 12 cows treated with progesterone showed oestrus signs within 100 h of implant removal; 9 of the 10 cows that exhibited oestrus had mean interval of 78.1±1.9 h between removal of the implant and expression of oestrus. The duration of oestrous period of the treated cows (13.6±2.7 h) was significantly higher as compared to that in control cows (7.2±2.5 h). They concluded that the response of synchronization of oestrus in cows using progesterone implant was comprehensive with normal sexual activities of the females during oestrus. Nath *et al.* (2004a) also noted that 9 out of 10 postpartum indigenous anoestrous cows that were induced to oestrus following treatment with crestar and PMSG revealed palpable follicle, tonic uterus, relaxed cervix and oedematous vulva. Cervical mucus was also discernible in the treated cows induced to oestrus and the percentage of conception was higher in cows that showed clear and stringy cervical mucus than in that showing clear and thin cervical mucus discharge at induced oestrus. The conception rate was higher in oestrus-induced

cows having stringy or thin cervical mucus with typical fern pattern than with atypical fern pattern. The mean serum progesterone concentration at induced oestrus was significantly lower than that had typical fern pattern (0.22 ± 0.03 ng/ml) of cervical mucus as compared to atypical (0.37 ± 0.04 ng/ml) one. Animals with no fern pattern of cervical mucus at induced oestrus that did not conceive subsequently showed significantly elevated mean serum progesterone (0.68 ± 0.02 ng/ml) concentration at induced oestrus (Nath *et al.* 2004d). Pinheiro *et al.* (1998) reported that treatment with norgestomet and oestradiol valerate induced high sexual receptivity in cows with 66% ovulation. The mean duration of behavioural oestrus exhibited was 10.90 ± 1.40 h and ovulation occurred 26.60 ± 0.44 h after the onset of oestrus. Petit *et al.* (1978) observed cent per cent ovulation in postpartum cows treated with progesterone, oestradiol benzoate and PMSG. The concentration of mean serum progesterone was the lowest and that of serum oestradiol- 17β the highest at induced oestrus following treatment with norgestomet in indigenous postpartum anoestrous cows when compared with the level before or during treatment which was congruous with low progesterone and high oestradiol- 17β concentrations during oestrus in untreated controls (Nath *et al.* 2003b). Further, the mean serum progesterone concentration reached higher level in treated animals on day 12 post onset of oestrus that conceived subsequently as compared to animals that did not conceive (Nath *et al.* 2003a). Nath *et al.* (2004c) also recorded significant rise in serum calcium and inorganic phosphorus concentration at induced oestrus that was concomitant with elevated oestrogen level in indigenous postpartum cows treated with norgestomet, oestradiol valerate and PMSG. The serum cholesterol was also recorded to be at significantly elevated level at induced oestrus as compared to pretreatment measure (Nath *et al.* 2004e). Veselinovic *et al.* (1996) conducted an experiment for induction and synchronization of oestrus in dairy and beef cattle breeds by use of crestar preparation (norgestomet implant + norgestomet injection + oestradiol valerate injection). They reported that out of 115 dairy cows, 110 cows (95.60%) and of 370 beef cows 350 cows (94.60%) were induced to oestrus following its use, and opined that the results of induction and synchronization of oestrus were similar in dairy and beef cows, both showing well - defined clinical signs of oestrus following use of crestar ear implant. Deka *et al.* (2009) obtained much less prominent behavioural signs in crestar- implanted indigenous cows compared to that of the control cows at oestrus. Singh *et al.* (2001) also reported that only 4 of 10 treated heifers exhibited behavioural oestrus and remaining were diagnosed to be in silent oestrus following crestar implant and injection. Kastelic *et al.* (1999) found that injecting eCG at implant removal did not significantly improve oestrus response in cows given norgestomet and oestradiol. Cetin *et al.* (2007) reported that the rate of induced oestrus was 86.2% in 29 norgestomet ear implant -treated post-pubertal Holstein heifers with inactive ovaries which

exhibited oestrus after a mean period of 47.2 ± 9.7 h of implant removal. Ozyurtlu *et al.* (2009) found that 80% of 25 non-cyclic Holstein heifers were induced to oestrus with the application of 6 mg norgestomet ear implant followed by intramuscular injection of 3 mg norgestomet plus 5 mg oestradiol valerate after 11 days of implant removal. Peter (1979) reported that 47% of young age (age: 334 days, body weight: 239 kg) group and 81% of light weight (age: 406 days, body weight: 243 kg) group heifers exhibited oestrus following SMB treatment, when the implants were removed after 9 days. During the first 5 days of the breeding season, significantly more heifers came into oestrus in the young age and light weight groups than in the control group. In crossbred Santa Gertrudis 88% heifers with body weight ranging from 250 to 271 kg exhibited oestrus when treated with SMB, while only 54% of the heifers weighing 204 to 226 kg responded to the treatment (Smith *et al.* 1979). Seguin *et al.* (1989) reported that the proportion of animals with high serum progesterone concentration 14 days following SMB treatment was 64% in acyclic heifers, while it was 85% in cyclic heifers. Tibary *et al.* (1992) reported that the oestrus response in SMB-treated cyclic and acyclic heifers was 89 and 60% respectively, while it was 75% in acyclic heifers when treated with SMB plus PMSG.

Presence of corpus luteum

Administration of progesterone was consistently effective in controlling ovulation, and the effectiveness of treatment increased with PMSG injection given at the time of implant removal (Mulvehill and Sreenan 1977). Holtz *et al.* (1979) reported that all the heifers, which responded to progesterone treatment had single ovulations. Peter (1979) reported that all the heifers that were induced to oestrus following treatment revealed presence of corpus luteum on rectal palpation 9–16 days post-oestrus. Rao *et al.* (1986) observed that 75% of the treated prepubertal heifers had a single corpus luteum palpable on either of the ovaries 8 to 10 days after treatment. Joshi *et al.* (1992) reported that 10 of the 11 heifers that were brought to oestrus by administration of norgestomet, $\text{PGF}_{2\alpha}$ analogue and PMSG had palpable corpora lutea 8–10 days after oestrus. All 9 postpartum indigenous anoestrous cows that were induced to oestrus ovulated as revealed by the presence of corpus luteum on day 9 post onset of oestrus (Nath *et al.* 2004a). Abdoon *et al.* (1994) found that all the 6 prepubertal buffalo heifers that were induced to oestrus following norgestomet, oestradiol and PMSG treatment had a corpus luteum 6–8 days after manifestation of oestrus. Progesterone profile following onset of oestrus after withdrawal of norgestomet implant increased significantly in all the treated 28 postpartum true anoestrous cows (2.16 to 2.62 ng/ml) as compared to prior to implant insertion (0.496 to 0.630 ng/ml) indicating development of corpus luteum and efficacy of norgestomet implant in inducing ovulatory oestrus (Agarwal *et al.* 2001). Pratt *et al.* (2006) reported that 67, 50 and 92%, and 42, 75 and 77% of 74 suckled beef cows had functional corpora lutea at implant removal for 5 mg

and 6 mg of oestradiol valerate, respectively, administered intramuscularly on day 1, 3 or 5 following 6 mg norgestomet ear implant for 9 days and an initial intramuscular injection of 3 mg norgestomet. Sarmah *et al.* (2003b) reported that the ovulatory response was 77.78 and 66.67% in mated and non-mated heifers respectively at their induced pubertal oestrus treated with norgestomet plus PMSG.

Conception rate

Norgestomet treatment was effective in advancing the age of first conception in prepubertal heifers when compared with untreated controls (26 vs 30 months). Pregnancy rate of the heifers induced to oestrus was 7 and 63% for young age and light weight group heifers respectively (Rao *et al.* 1986). Veselinovic *et al.* (1996) reported that the average conception rate was similar in dairy (62.7%) and beef (58.6%) cows following insemination when induced to oestrus using crestar ear implant. They found significantly higher conception rate in both types of cows when the feed was supplemented with mineral during application of the ear implant. Singh *et al.* (1998) found that the overall pregnancy rate was significantly higher in heifers (71.8%) than in cows (51.2%) when assessed for post treatment fertility following induction of 51 Hariana and Sahiwal anoestrous heifers and 55 postpartum cows into oestrus by treating with norgestomet, oestradiol valerate and eCG. However, Singh *et al.* (2001) found that following treatment with norgestomet the conception rate in heifers was much lower than in cows and only 1/5th of the treated heifers conceived at first insemination. Dosage and duration of norgestomet treatment could have influenced the fertility rate. Kesler and Favero (1996) opined that dose of norgestomet used in the implant could be sublethal and inadequate in providing progesterone priming that depressed fertility in postpartum cows subsequently. Nath *et al.* (2004b) found that 5 out of 9 postpartum anoestrous cows that ovulated on oestrus induction by the application of crestar and PMSG conceived, the percentage of conception being 55.56. The conception and calving rates were 51 and 46% respectively in zebu beef heifers when inseminated at the induced oestrus caused by applying 3mg of norgestomet subcutaneously for 14 days followed by PGF_{2α} on day 16 (Corbet *et al.* 1999). Ozyurtlu *et al.* (2009) reported that the pregnancy rate was 44% in acyclic Holstein heifers when impregnated during oestrus following treatment with norgestomet ear implant and PRID. They found that 9 out of 20 non-cyclic Holstein heifers conceived at 48 h-fixed timed insemination when they were induced to oestrus by the application of 6 mg norgestomet silicone ear implant followed after 11 days by intramuscular injection of 3 mg norgestomet plus 5 mg oestradiol valerate. Chaudhari *et al.* (2012) reported 33.33% pregnancy rate at induced oestrus in delayed pubertal heifers following crestar ear implant for 9 days plus 500 IU of PMSG on the day of implant removal. However, the heifers that received only crestar or crestar with PGF_{2α} conceived after third service. Sarmah *et al.* (2003b) reported that none

of the indigenous heifers conceived at induced pubertal oestrus following norgestomet treatment but the heifers continued cyclic activity and 55.56% heifers conceived at their second natural oestrus. In suckler cows 52% calved after breeding during the non-calving season when the supply of essential feed components was low on treating them with norgestomet plus PMS later than 50 days post partum (Holtz *et al.* 1979). Wishart (1975) reported 48.2% pregnancies on treating suckler beef cows with norgestomet under field conditions. Favero *et al.* (1993) noted that calving rate could be significantly ($P<0.05$) increased in beef heifers that were synchronized to oestrus with SMB implant and inseminated artificially 47h after implant removal, when they were further treated with two silicone implants containing 10mg of norgestomet each for 20 days after the initial AI. Agarwal *et al.* (2001) found that fertility at induced oestrus was higher when 28 postpartum anoestrous cows were treated for induction of oestrus with norgestomet plus PMSG (60%) than with norgestomet alone (40%) and norgestomet plus PGF_{2α} and PMSG (50%). Cetin *et al.* (2007) observed that the pregnancy rate was 48.2% in post-pubertal Holstein heifers with inactive ovaries following insemination 48 and 72 h after the removal of norgestomet ear implants and injection of 50µg of GnRH analogue after the first insemination. Peter (1979) reported that the first service pregnancy rate following SMB treatment was 3 and 35% for young age group (age: 334 days, body weight: 239 kg) and light weight group (age: 406 days, body weight: 243 kg) heifers, respectively, which differed significantly. Tibary *et al.* (1992) observed that pregnancy rate after 90 days of breeding did not differ significantly in cyclic heifers between control (53%) and SMB - treated (57%) animals, while it was significantly higher in acyclic heifers treated with SMB + PMSG (86%) as compared to control (46%) and SMB- treated heifers (47%).

Service per conception

Holtz *et al.* (1979) indicated that only one insemination on day 3 or on days 2 and 3 following induction of oestrus by norgestomet treatment yielded 100 and 60% conception, respectively, and suggested to employ set time insemination on either or both of the days. Aguer *et al.* (1984) reported that 1 or 2 fixed-time artificial inseminations during induced oestrus at 48 to 72 h after implant removal resulted in calving rates of 56 and 52% respectively. The services per conception did not differ significantly between treated (1.25) and control (2.25) heifers (Rao *et al.* 1986). Tibary *et al.* (1992) reported that single appointment insemination at 48±2 h resulted in higher pregnancy rates in SMB-treated cyclic and SMB+PMSG- treated acyclic heifers (43%) than in acyclic heifers treated with only SMB (20%).

Resumption of cyclicity

Rao *et al.* (1986) recorded that 25% of the heifers that were induced to oestrus by norgestomet treatment exhibited cyclic oestrus after induced oestrus at an interval of 41 to

76 days and conceived. Glencross (1980) observed failure of ovulation in prepubertal heifers after regression of corpus luteum following induction of oestrus using PMSG and HCG. However, display of irregular cyclic patterns was also noticed in control heifers in such trials (Rao *et al.* 1986). Sarmah *et al.* (2003b) reported that 77.78% prepubertal heifers that were mated at oestrus induced with the application of norgestomet ear implant + norgestomet injection + PMSG exhibited natural oestrus within 31 days of induced oestrus. However, all (100%) the heifers that did not allow to mate at induced oestrus resumed cyclic activity during this period. Peter (1979) reported that very few heifers belonging to young age group resumed cyclicity of oestrus following treatment with SMB, whereas, the heifers in the light weight group once induced to oestrus with the treatment evinced oestrus in successive cycles till they conceived. He observed that the manifestation of postpartum oestrus was significantly shortened by 24 days in the treated light weight group of heifers (age: 406 days, body weight: 243 kg) as compared to the control light weight heifers (age: 407 days, body weight: 266 kg).

Influence of age and body weight

The effectiveness of the treatment with norgestomet for induction of puberty was reported to be influenced by age (Arije and Wiltbank 1971, Gonzalez-Padilla *et al.* 1975b) and body weight (Arije and Wiltbank 1971, Gonzalez-Padilla *et al.* 1975b, Short *et al.* 1976) of heifers at puberty. The age and body weight of the heifers that conceived were significantly higher than the heifers which did not become pregnant at the induced oestrus following norgestomet treatment (Rao *et al.* 1986). Ovarian inactivity in prepubertal heifers was associated with a low frequency of LH episodes due to hypothalamic inhibition of GnRH release (McLeod *et al.* 1984). The episodic frequency of LH increases with age (Schems *et al.* 1981), which is an essential prerequisite for the onset of puberty. It was demonstrated that 2 months before the onset of puberty in heifers, there was no cyclic pattern of LH release. The pattern appears gradually and is apparently mediated by gonadal steroids through frequency modulation of the LH pulse generator (Gonzalez-Padilla *et al.* 1975c). Peter (1979) reported that lower percentage of heifers belonging to young age group (age: 334 days, body weight: 239 kg) were induced to oestrus following treatment as compared to the heifers of light weight group (age: 406 days, body weight: 243 kg), which was attributed to lower age in young age group despite comparable body weight in both the groups. Staigmiller *et al.* (1979) reported that when beef heifers were treated with oestradiol-17 β , 66.67% of 5-months-old heifers responded to treatment but none of the heifers of 3-months-old responded. They opined that the hypothalamo-hypophyseal mechanism responsible for oestradiol-stimulated LH release becomes functional between 3 and 5 months of age in calves that do not ovulate until 12 to 16 months of age in beef heifers. Hall *et al.* (1997) reported that pubertal oestrus was induced within 5 days after implant removal at 12.5 months but not at 9.5 or

11 months of age in crossbred heifers treated with norgestomet (6 mg) implantation for 10 days. They found that norgestomet significantly increased LH pulse frequency at all age groups investigated but mean LH concentration was increased only at 12.5 months. It was noted that rapid (0.82 kg/day) or slow-then-rapid (0.41 kg/day for 90 days then 0.82 kg/day) body weight gain of the heifers due to feeding after weaning could not influence induction of puberty by norgestomet in all age groups. Drew *et al.* (1979) recorded that body weight of Hereford-Friesian cross suckler cows had a significant effect on the proportion of cows conceiving to fixed time insemination following induction of oestrus using norgestomet and oestradiol valerate. Smith *et al.* (1979) stated that fertile oestrus could be induced in beef heifers weighing over 250 kg following use of SMB, however, it could not be ascertained whether body weight was the only factor determining a heifer's response to SMB. It was possible that age, body weight and breed function interplay together in determining the onset of puberty in heifers (Arije and Wiltbank 1971, Short and Bellows 1971, Gonzalez-Padilla *et al.* 1975b).

Effect of nutrition

An increased level of nutrition during the pre-breeding period was important for success of synchronization treatment (Lokhande *et al.* 1983). Drew *et al.* (1979) recorded that significantly higher percentage (59.7) of Hereford-Friesian cross suckler cows that were provided with a supplementary ration became pregnant as compared to control group (37.9%) on fixed time insemination after they were induced to oestrus by application of norgestomet implant and oestradiol valerate. Cetin *et al.* (2007) reported that the post-pubertal Holstein heifers with inactive ovaries that became pregnant on insemination at induced oestrus following use of norgestomet ear implant and GnRH analogue had higher average body condition score (BCS) of 4.5 ± 0.9 as compared to 3.9 ± 0.8 obtained in non-pregnant ones suggesting that efficacy of treatment culminating in pregnancy was associated with nutritional status of the animal since BCS that reflected the body reserves available for basic metabolism, growth, lactation and activity (Montiel and Ahuja 2005) revealed nutritional attainment of animals. Mc Dougall *et al.* (2005) found that the duration of oestrus and oestrus expression rates declined in heifers with low BCS following treatment of anoestrous animals with progesterone and oestradiol benzoate. Stevenson *et al.* (2000) recorded that oestrus synchronization and pregnancy rates following treatment combining norgestomet, GnRH and prostaglandin F $_{2\alpha}$ decreased in beef cows with BCS scores lower than 5, and found that even a single unit increase of BCS score could increase pregnancy rate by 27%.

Effect of season

The response to norgestomet treatment and fertility at induced oestrus was higher in the cooler month (February) than in the hotter month (May), although the difference was

not significant (Rao *et al.* 1986). Heat stress affected behavioural oestrus, ovulation, oestrous cycle and conception rates (Gangwar *et al.* 1965, Fuquay 1981). There was a decreased secretion of basal as well as pre ovulatory surges of LH at elevated environmental temperature (Madan and Johnson 1973), which could explain lower response to treatment during summer.

Norgestomet application was found to be a useful tool in improving reproductive efficiency for augmenting production under field conditions in cattle with a long postpartum resting period and a satisfactory level of nutrition (Holtz *et al.* 1979). Although SMB + PMSG treatment offered some advantages in promoting follicular development and ovulation in acyclic heifers using low dosage of PMSG (Tibary *et al.* 1992), there were risks of twinning even at doses as low as 400 IU (Lokhande *et al.* 1983). Norgestomet ear implant could be utilized to induce estrus in prepubertal heifers, dairy and beef cows with variable success on impregnation (Rao *et al.* 1986, Veselinovic *et al.* 1996) and in delayed pubertal heifers, lower conception rate at induced oestrus notwithstanding (Chaudhari *et al.* 2012). Beneficial effect of norgestomet and PMSG treatment was conspicuous since the age of conception could be advanced by 3 to 4 months in the treated prepubertal zebu heifers (Rao *et al.* 1986) when compared with the herd average. Fertile estrus could be stimulated in acyclic heifers following treatment with norgestomet ear implant and PRID (Ozyurtlu *et al.* 2009) with acceptable pregnancy rate. Although frequent use of hormones is undesirable for initiation of puberty in animals, which has a hereditary predisposition, resorting to administration of exogenous hormones like norgestomet/SMB and PMSG could provide an effective alternative in augmenting reproductive activity in cattle with inherent trait of delayed maturity.

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