Abstract

Puberty in gilts is the occurrence of first oestrus and the onset of reproductive capability (usually at between 200 and 220 days of age). It is the combined effect of genetic factors and management factors (including nutrition, boar exposure and season) that contribute to the age at puberty. Consumer demands for leaner pork have lead to genetic selection for increased lean tissue growth rate and reduced body fat. This has resulted in a delay in the age at puberty and a decrease in energy stores for subsequent growth, pregnancy and lactation. Restriction of dietary protein during the prepubertal period is a way to enhance body-fat reserves; however, this has detrimental effects on the age at puberty and ovulation rates, but can be overcome by restoring dietary protein in the weeks before the induction of puberty. Luteinizing hormone (LH) is a key hormone in regulating ovarian follicular growth and, hence, the age at which puberty occurs. Concentrations of LH in the blood fluctuate during the prepubertal period in association with ovarian development. The nutritional modulation of hormone secretion is not clear. Future management strategies to enhance both reproductive performance and to satisfy consumer demands need to consider hypothalamo-pituitary maturation in association with body weight and body-composition parameters. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

Reducing the number of non-productive sow days is an important component of productivity in current pig-production enterprises. It has been estimated that between 15 and 25% of litters produced in pig units are from gilts (Gordon, 1997). Since gilts have smaller litters and longer weaning-to-service intervals than sows, the percentage of gilts in a herd has a marked effect on overall productivity.

The first management decision to be made about animals entering the breeding herd is the timing of first breeding. Breeding at a younger age is associated with fewer non-productive days and, consequently, with lower initial costs. However, when deciding whether or not to breed gilts early, two consequences must be considered: firstly, the effect on subsequent reproductive performance and, secondly, the effect on longevity of these gilts in the herd. It has been shown that, as the age at first
farrowing increases, there is an increase in the average number of piglets born alive and weaned per litter, but that there is also a decrease in the average number of litters at culling (Le Cozler et al., 1998). In practical terms, this effect is only significant for gilts that are successfully mated at greater than 270 days of age (Le Cozler et al., 1998). Extreme leanness increases the age at puberty and has detrimental effects on lifetime reproductive performance (Gaughan et al., 1995).

Puberty in gilts is the occurrence of first oestrus and the onset of reproductive capability. Once puberty has been reached, gilts will normally exhibit regular oestrous cycles of around 21 days duration. Age at puberty is regulated by internal (breed, live weight, backfat depth) and management factors (nutrition, boar exposure, environmental factors), both of which are mediated via the endocrine reproductive axis. There is increasing awareness of the possible conflict between that of increasingly leaner pigs and of maintaining or increasing reproductive performance. The aim of this paper is to review the hormonal changes that precede puberty in gilts and the management options available to producers with particular reference to modern, leaner, highly growth-efficient gilts.

2. Endocrine changes

2.1. Hormone profiles and ovarian development before puberty

In gilts, luteinizing hormone (LH) is the key hormone that appears to control ovarian development and, hence, the age at puberty in gilts (Fig. 1). In European breeds, concentrations of LH in blood decrease from birth to about 40 days of age (Colenbrander et al., 1977; Pelletier et al., 1981; Camous et al., 1985). Between 80 and 120 days of age, there is a transient rise in LH concentrations, which then decline to a nadir by about 180 days of age (Pelletier et al., 1981; Diekman et al., 1983; Camous et al., 1985). From this nadir until first ovulation (puberty), LH concentrations increase (Pelletier et al., 1981; Prunier et al., 1993a), as is typical in most species. This increase in LH secretion is characterised by an increase in mean LH concentrations and LH pulse frequency (Pelletier et al., 1981; Lutz et al., 1984; Prunier et al., 1993a). This final increase is associated with final maturation of ovarian follicles (Beltanena et al., 1993) and culminates in a preovulatory surge that successfully stimulates ovulation. Follicle-stimulating hormone (FSH) concentrations are high early in life and decrease after 70 to 125 days of age, and it is clear that mean FSH concentrations do not increase as puberty draws closer (Diekman et al., 1983; Diekman and Trout, 1984; Camous et al., 1985; Grieger et al., 1986; Prunier et al., 1993a).

Christenson et al. (1985) reviewed the maturation of ovarian follicles in prepubertal gilts. Primordial follicles account for most of the follicles in the ovaries between birth and about 100 days of age (Oxender et al., 1979). Antral follicles are rarely seen in gilts before 60 days of age; however, they are prevalent after about 100 days of age (Fig. 1; Casida, 1935; Oxender et al., 1979; Dyck and Swierstra, 1983; Grieger et al., 1986). Based on temporal relationships, we suggest that the early transient increase in LH secretion, between about 80 and 120 days of age, stimulates this initial increase in follicle development (Camous et al., 1985; Prunier et al., 1993a).
1993b), as has been suggested for cattle (Evans et al., 1994; Day and Anderson, 1998). In Meishan gilts, ovarian development is more rapid than in commercial breeds, with antral follicles first appearing between 30 and 60 days of age (Miyano et al., 1990).

Oestradiol concentrations (Fig. 1) are low throughout the majority of the prepubertal period but increase prior to puberty (Esbenshade et al., 1982; Lutz et al., 1984; Camous et al., 1985). Progesterone concentrations only increase after puberty with the formation of the first corpora lutea (Esbenshade et al., 1982; Prunier et al., 1993a). Puberty usually occurs between 200 and 220 days of age, although considerable variation exists according to internal (including genetic) and management factors.

2.2. Regulation of gonadotrophin secretion

Puberty occurs only when gilts reach a certain stage of physiological maturation (i.e., when physiological development is adequate to support successful reproduction). While this involves physical growth attributes, it is reliant on the culmination of a series of maturational events in the endocrine system that regulate hormone secretion, resulting in behavioural oestrus and ovulation.

The regulation of gonadotrophin secretion occurs via changes in inhibitory (negative feedback) and/or stimulatory actions at the hypothalamus and pituitary. The exact importance of these two contrasting actions is unclear during sexual maturation in gilts. During the early prepubertal period, it is likely that the central mechanisms (i.e., above the pituitary) that regulate reproduction are immature. During this time, the pituitary is responsive to exogenous gonadotrophin releasing hormone (GnRH) stimulation (Chakraborty et al., 1973; Foxcroft et al., 1975; Pressing et al., 1992), indicating that the pituitary is functional at a young age. Negative feedback by ovarian steroids is weak, as shown by a lack of increase in LH following ovariectomy (Elsaesser et al., 1978). The early transient increase in LH concentrations may occur due to maturation of the central control of gonadotrophin secretion causing an increase in GnRH production by the hypothalamus, which stimulates an increase in pituitary LH and FSH secretion. The decrease from the transient rise in LH concentrations may occur because of the establishment of oestradiol negative feedback, which is first seen at about 100 days of age (see Christenson et al., 1985). FSH also appears to be regulated by negative feedback from at least 84 days of age (Prunier and Louveau, 1997).

In some species (rats and primates in particular), the final maturational events leading to the increase in LH concentrations and puberty appear to occur as a result of positive stimulation to the hypothalamus via activation of a central drive component to GnRH neurons (Ojeda, 1991). Endogenous opioid peptides regulate LH secretion in some farm animals (Haynes et al., 1989); however, opioidergic systems do not appear to regulate tonic LH secretion during the peripubertal period in gilts (Barb et al., 1988; Kuneke et al., 1993). None-the-less, opioidergic systems may play a role in the preovulatory LH surge in pubertal gilts (Asanovich et al., 1998). The excitatory amino acids, glutamate and aspartate, are important neurotransmitters in the central control of gonadotrophin secretion in many species (Brann, 1995). However, like opioidergic systems, it is unlikely that excitatory amino-acid stimulation of the hypothalamus is the cause of increased gonadotrophin secretion before puberty in gilts (Barb et al., 1992; Chang et al., 1993; Estienne et al., 1995; Popwell et al., 1996). During the weeks preceding puberty, the prevailing theory is that the sensitivity to steroid negative feedback diminishes (gonadostat hypothesis; see Day and Anderson, 1998). This allows LH secretion to increase (Pelletier et al., 1981; Prunier et al., 1993a) in the face of low or increasing oestradiol concentrations (Esbenshade et al., 1982; Lutz et al., 1984; Camous et al., 1985). While there is evidence to support this theory (Berardinelli et al., 1984; Lutz et al., 1984), others have been unable to demonstrate a reduction in oestradiol negative feedback prior to first ovulation (Elsaesser et al., 1991). It has also been suggested that increases (Pearce et al., 1988) or decreases (Prunier et al., 1993a) in corticosteroid concentrations may increase LH secretion at about the time of puberty.

Oestradiol has primarily negative feedback effects, but positive feedback develops as sexual maturation advances. Positive feedback of oestradiol stimulates the surge release of LH that is necessary for ovula-
tion; this is absent at 6 days of age, weak at 60 days of age (Kuneke et al., 1993) and evident at 160 days of age (Elsaesser and Foxcroft, 1978; Foxcroft et al., 1984).

In summary, fluctuations in LH concentrations are closely related to maturation of the reproductive tract and first ovulation in gilts. The control of LH secretion is complex. The initial increase in LH concentrations may be due to maturation of hypothalamic activity and/or factors regulating the hypothalamus, and the increase in the immediate peripubertal period appears to be due to a resetting of the sensitivity to oestradiol negative feedback.

3. Influence of genetic factors on age at puberty

3.1. Age and weight

Some authors suggested that age is the most important factor determining puberty attainment (Prunier et al., 1987; Newton and Mahan, 1992). However, it is widely recognised that unstimulated gilts may reach puberty from as early as 170 days to as late as 260 days of age (Dyck, 1988; Eliasson et al., 1991). Part of the variability of age at puberty appears to be related to the genetic background of the gilts and to other aspects of the environment in which they are kept. Consequently, age is not considered to be an accurate predictor of puberty in gilts (Rozeboom et al., 1995).

Gilts must reach a minimum weight of about 75 kg before puberty can be attained (Hughes and Cole, 1975; Young et al., 1990); however, like age, great variability exists. Recently, it was suggested that live weight on its own does not account for the induction of puberty, but contributes as one of the factors leading to puberty (Gaughan et al., 1997). Body weight is a measure of the combined components of the different elements of body composition, and consideration needs to be given to the fatness and leanness of gilts (see Section 3.3).

3.2. Breed

Large differences between breeds in the age at puberty have been reported, with the average age being greatest in Duroc gilts and lowest in Meishan gilts (Table 1). Crossbred gilts reach puberty earlier and have fewer non-productive days compared with purebred animals (Bidanel et al., 1996). Besides these differences between breeds, considerable vari-

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<th>Breed</th>
<th>Overall mean age</th>
<th>Mean±S.D.</th>
<th>Reference</th>
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<tr>
<td>Duroc</td>
<td>235</td>
<td>195±17</td>
<td>Haines et al., 1959</td>
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<td></td>
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<td>224±20</td>
<td>Christenson and Ford, 1979</td>
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<td>259±25</td>
<td>Bryan and Hagen, 1991</td>
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<td>263</td>
<td>Good et al., 1965</td>
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<tr>
<td>Hampshire</td>
<td>207</td>
<td>207±28</td>
<td>Christenson and Ford, 1979</td>
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<td>Large White</td>
<td>205</td>
<td>173±13</td>
<td>Gaughan et al., 1997</td>
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<td>200±20</td>
<td>Allrich et al., 1985</td>
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<td>Sterling et al., 1998</td>
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<td>Rydhmer et al., 1994</td>
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<td>Christenson and Ford, 1979</td>
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<td>Eliasson et al., 1991</td>
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<td>215±49</td>
<td>Bidanel et al., 1996</td>
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<td>215</td>
<td>Kerr and Cameron, 1997</td>
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<td>Landrace</td>
<td>185</td>
<td>173±25</td>
<td>Christenson and Ford, 1979</td>
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<td>198±35</td>
<td>Bidanel et al., 1996</td>
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<tr>
<td>Meishan</td>
<td>97</td>
<td>81±9</td>
<td>Legault and Carietz, 1983</td>
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<td>94±15</td>
<td>Pickard and Ashworth, 1995</td>
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<td>115±20</td>
<td>Hunter et al., 1993</td>
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ation exists within breeds, as demonstrated by the variability within studies (one standard deviation about the mean age at puberty is about 20 days) and between studies for a given breed (Table 1). These differences may be explained by variations in genotypes within breeds and in management regimens. Therefore, breed influences age at puberty, but, among commercial breeds, management factors can have a greater effect than breed on the onset of reproductive capability.

3.3. Modern genotypes and body composition

The 1970s were a period of rapid change in the pig industry, with consumers in many countries demanding less fat and leaner meat. The industry responded by selecting its breeding animals for low backfat and the genotype of the animals changed. Animals that are selected for lower backfat grow bigger and, compared with animals of small mature size, are leaner at the same body weight because they have a lower proportion of their mature body size and are physiologically younger (Gaughan et al., 1997). As well as reduced backfat, voluntary food intake of the selected animals has been reduced (Webb, 1989). Based on measures of live weight, backfat thickness and average daily gain, it has been proposed that puberty occurs only after the attainment of a minimum level of leanness (Cunningham et al., 1974), fatness (den Hartog and van Kempen, 1980) or the ratio of fat to lean (Kirkwood and Aherne, 1985).

Genetic changes in body composition and appetites are associated with reduced reproductive performance in contemporary comparisons of lines of pigs selected for different components of efficient lean growth (Kerr and Cameron, 1995). Animals selected for low daily food intake and/or a high lean-to-food-conversion ratio show a delay in the age at puberty (Kerr and Cameron, 1995). There is a strong positive genetic correlation between leanness at 90 kg body weight and subsequent age at puberty (Eliasson et al., 1991; Rydhmer et al., 1994), indicating that leaner gilts reach puberty later than fatter gilts. In another study, offspring of sows selected for early puberty cycled at an earlier age, with more fat, than offspring of sows selected for late puberty (Hixon et al., 1987). In addition, leaner gilts show a shorter oestrus and decreased reddening and swelling of the vulva compared with fatter gilts (Rydhmer et al., 1994). It has been suggested that puberty is delayed in extremely fast-growing gilts because the increase in growth rate is primarily due to a more rapid accumulation of lean rather than fat tissue (Beltranena et al., 1991). It has been determined that a minimum fatness threshold of about 6 mm in backfat thickness needs to be achieved for the attainment of puberty (Beltranena et al., 1993). However, it is considered that gilts need at least 13 mm of backfat before first mating (Yang et al., 1989). Hence, body fat and muscle content are associated with age at puberty, and there appears to be genotype-specific minimum levels of body fat and muscle required for the onset of puberty to occur (Kerr and Cameron, 1997). More recently, the rate of fat and/or protein deposition has been linked to physiological maturity and reproductive performance of gilts (Edwards, 1998), and this rate is suggested to be a more important determinant for puberty than age, weight or boar exposure (Gaughan et al., 1997).

In conclusion, to most efficiently meet customer demands, selection for future genotypes of pigs needs to concentrate on daily food intake, high lean growth rate and consideration needs to be given to a minimum level of fatness in order to avoid pubertal retardation.

4. Influence of management factors on age at puberty

4.1. Nutrition

Nutrition of gilts during rearing has effects on subsequent reproduction, both in the short-term and in the long-term (see Aherne and Kirkwood, 1985). Anderson and Melampy (1972) reviewed the literature on the effects of energy intake on age and weight at puberty in pigs. They noted that restricting energy intake delayed puberty by an average of 16 days in nine experiments, but hastened puberty by an average of 11 days in five other experiments. In later studies, a reduction of feed intake during rearing resulted in an increase in age and a decrease in body weight at puberty (den Hartog and van Kempen, 1980; den Hartog and Noordewier, 1984; Le Cozler
et al., 1999a). Modern pig genotypes are extremely sensitive to modest reductions in feed intake, which can delay puberty by more than 3 weeks (van Lunen and Aherne, 1987). The plane of nutrition used in rearing gilts influences the age at which first oestrus is shown (Dzuik, 1991; Prunier, 1991).

The improved genotype of modern sows codes for increased lean growth and decreased body-fat content. This decrease in fat has partly resulted in gilts that are less able to deal with the simultaneous demands of growth, pregnancy and subsequent lactation. There are two possible approaches to overcome this problem: firstly, increase the plane of nutrition of gilts prior to puberty as a way of increasing fat reserves or, secondly, use dietary protein restriction to limit lean tissue growth and increase body-fat reserves (Edwards, 1998). The first strategy is undesirable as it leads to an increase in mature body size (O’Dowd et al., 1997), which increases management problems associated with oversized animals and leads to higher feed maintenance costs and a reduced feed intake in the first lactation (Le Cozler et al., 1999b). A 50% restriction of dietary lysine to growing gilts is an effective way of restricting lean tissue growth and increasing body lipid content (den Hartog and Verstegen, 1990; Gill, 1997; Cia et al., 1998; Fig. 2). However, this method reduces growth rate, delays age at puberty and decreases ovulation rate (Fig. 2). This negative effect of protein restriction on ovulation rate in gilts can be overcome by protein flushing in the weeks prior to the induction of puberty (Fig. 2). Such short-term changes in food intake can modify reproductive function in the absence of changes in body weight or body composition (Booth et al., 1994).

Decreasing the amount of food made available to animals will reduce feed costs. While severe restrictions during the prepubertal period will have detrimental effects on reproductive performance (van Lunen and Aherne, 1987; Dzuik, 1991; Prunier, 1991), moderate restrictions (75 to 90% of ad libitum intakes) during rearing have recently been shown not to affect reproductive performance (Klindt et al., 1999; Le Cozler et al., 1999b). However, restricted animals had a higher voluntary food intake in first lactation and a higher culling rate than non-restricted animals, suggesting that the economic gains of feed restriction during rearing may be lost after the first two parities (Le Cozler et al., 1999b).

The complicated link between nutrition and reproductive hormones has previously been reviewed (Booth, 1990; Cox, 1997; Cosgrove, 1998). The most likely hormonal links between nutrition and the reproductive axis are insulin and insulin-like growth factor I (IGF-I), which may act at either the hypothalamic–pituitary level or directly at the ovarian level.

In conclusion, gilts of modern genotype are leaner and this is associated with a delay in the age at puberty compared with gilts of older genotypes. Body fat can be increased by dietary protein restriction, but flushing with protein prior to puberty is necessary to avoid the detrimental effects of protein restriction on age at puberty and ovulation rate.
4.2. Boar effect

The timing of puberty in gilts is markedly influenced by the age at which they first come in contact with a boar (reviewed by Hughes et al., 1990). For maximum boar stimulation, it is essential that gilts are reared out of sight and sound of boars until they are about 165 days of age. At this time, they are transported to a new location and are regularly exposed to a sexually active boar. This has the effect of bringing them into heat within 7 to 20 days (Hughes et al., 1990). For most effective boar exposure, gilts and boars should to be in physical contact for at least 30 min each day (Caton et al., 1986; Hughes et al., 1990). Introducing and removing the boar is more effective than maintaining the boar and gilts in constant fence-line exposure (Caton et al., 1986). The pubertal response is further enhanced if boar contact occurs more than once a day (Hughes et al., 1997; Hughes and Thorogood, 1999). For best results, mature boars with high libido should be used (Hughes, 1994; Fig. 3).

While tactile, auditory and visual cues from the boar may be involved in the pubertal response, pheromonal stimulation has an important role in stimulating puberty in gilts (Signoret, 1970; Hughes et al., 1990; Pearce and Paterson, 1992). When the olfactory bulbs were removed from gilts, they were unresponsive to boar stimulation (Kirkwood et al., 1981). In addition, transportation of gilts increases the response to boar stimulation, but transport alone (not followed by boar stimulation) is insufficient to stimulate early oestrous behaviour (Hughes et al., 1997).

The procedures of transportation, relocation and regular boar exposure are stressful to gilts, and stress is likely to be an integral component of the boar effect. Success of the boar effect relies on increasing LH concentrations (Fig. 3) and it has been suggested that cortisol mediates this stress effect (Pearce and Hughes, 1987). In most gilts, boar exposure increases circulating concentrations of cortisol (Kingsbury and Rawlings, 1993; Turner et al., 1998; Fig. 3) and cortisol infusion can increase LH concentrations in prepubertal gilts (Pearce et al., 1988). However, administering cortisol to concentrations seen in the presence of a boar are ineffective in stimulating puberty (Pearce and Paterson, 1992), and treating gilts with adrenal corticoids did not advance the age at puberty (Esbenshade and Day, 1980). In addition, some gilts also do not respond to boar exposure but do show an increase in cortisol secretion (Kingsbury and Rawlings, 1993). Hence, a pivotal role for cortisol is in doubt and the exact endocrine mechanism(s) linking boar exposure with an increase in LH secretion remains to be established. The increase in LH concentrations in the immediate peripubertal period may be due to a resetting of the sensitivity to oestradiol negative feedback (Pelletier et al., 1981; Berardinelli et al., 1984; Lutz et al., 1984). Based on the above observations, we suggest that the mechanism of the boar effect may involve an as yet unidentified central pathway(s) that impinges on the
system(s) regulating the sensitivity of LH to oestradiol negative feedback.

In summary, for optimal effect, gilts need to be exposed to a mature boar with high libido for one or more 30 min periods per day after 165 days of age. Boar exposure increases LH concentrations but the role of cortisol and the mechanism by which this occurs is unclear.

4.3. Confinement

Overcrowding may decrease the percentage of gilts showing oestrus (Cronin et al., 1983; Christensen, 1986). Gilts maintained with a space allowance of 1 m² per pig had significantly elevated free corticosteroid concentrations and a lower proportion displayed oestrus and were successfully mated compared with those pigs allowed 2 or 3 m² of space (Hemsworth et al., 1986). This may be explained by a delay in growth that has been observed in gilts submitted to space restriction (Pearce and Paterson, 1993). However, others have crowded gilts together to the extent that growth rate and feed efficiency were reduced but without affecting the average age at first oestrus (Ford and Teague, 1978). While crowding may be a factor in controlling the age at puberty, group size appears to be an additional variable. Gilts housed in small groups (three or less) reached puberty later than gilts housed in larger groups (nine or more) at the same density (Christensen, 1986).

4.4. Season

The attainment of sexual maturation in gilts is subject to seasonal variation (Paterson et al., 1989; Hughes et al., 1990), as puberty is delayed in summer compared with winter (Paterson et al., 1991). Heat stress may contribute to the delay of puberty during summer (Flowers et al., 1989; Flowers and Day, 1990), but the long light duration probably plays a more important role, since seasonal variations can be reproduced under constant temperature by altering light patterns to mimic natural photoperiods (Paterson and Pearce, 1990). In many species (especially seasonal breeders), melatonin secretion is elevated during periods of darkness; however, melatonin secretion in response to light:dark cycles is less clear in pigs. Some studies have shown a nocturnal rise in melatonin secretion (McConnell and Ellendorff, 1987; Paterson et al., 1992a), whereas others have not (Minton et al., 1989; Diekman et al., 1992). More recently, it has been concluded that pigs have no clear circadian rhythm of melatonin in peripheral blood (Bubenik et al., 2000) but that there is a weak nocturnal rise in serum melatonin concentrations (Green et al., 1996). In addition, differences in melatonin secretion between light and dark periods may vary according to light intensity and age (Green et al., 1999). Lengthening the duration of the period of high circulating melatonin concentrations by oral administration of melatonin in the afternoon to gilts kept under long-days will overcome the seasonal inhibition of attainment of puberty (Paterson et al., 1992b). Seasonal depression of the attainment of puberty in gilts can also be partially or wholly overcome by providing olfactory stimulation from boars (Hughes et al., 1990; Paterson et al., 1991).

As in other species, links between long days, high melatonin and increasing LH secretion are complex in pigs (see Love et al., 1993). Since the inhibitory influence of long-day regimes on gilt puberty attainment can be altered by the use of boar contact (Paterson and Pearce, 1990; Paterson et al., 1991), we speculate that photoperiodic regulation of the attainment of puberty may be by a similar mechanism(s) as the boar effect (i.e., by altering the sensitivity to oestradiol negative feedback by as yet unidentified pathways).

4.5. Manure gases

Poor air quality delays the onset of puberty in gilts. When gilts were exposed to aerial ammonia concentrations of either < 5 or 20 ppm from 10 to 40 weeks of age, a greater proportion of the gilts reared in the cleaner environment attained puberty by 26 weeks of age (Malayer et al., 1987). In that study, average daily gain and feed efficiency were similar, and LH and FSH secretory patterns were not different between groups. In another study, gilts reared in an environment of 20 ppm ammonia attained puberty later than gilts reared in an environment of < 10 ppm ammonia (Zimmerman et al., 1988). The mech-
anism whereby poor air quality delays the onset of puberty in gilts is unknown, but it appears that odorous gases, such as ammonia, may diminish the ability of the gilts to perceive olfactory cues from boars (Curtis, 1972).

5. Conclusion

Modern pig genotypes have been selected for rapid, efficient, lean-tissue growth, in combination with low body-fat content. This has been associated with detrimental effects on pubertal development. Using nutritional strategies, it is possible to alter body composition and increase body-fat reserves to improve the rate of sexual maturation. To fully understand the importance of nutritional programmes on reproduction, such strategies need to consider that the onset of puberty in gilts is a function of hypothalamic-pituitary maturation rather than attainment of specific body weight or composition parameters. We suggest that there may be an as yet undescribed link between a decrease in oestradiol negative feedback, that allows LH concentrations to increase in the peripubertal period, and management regimens used to stimulate puberty in gilts. Future research on factors that regulate puberty in gilts needs to integrate understandings of the effects of dietary manipulations and management procedures on circulating hormone concentrations.

References


