EFFECTS OF CONFINEMENT ON ATTAINMENT OF PUBERTY IN GILTS

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EFFECTS OF CONFINEMENT ON ATTAINMENT OF PUBERTY IN GILTS

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Résumé

CONSÉQUENCES DE LA CLAUSTRATION SUR LA PRÉCOCITÉ SEXUELLE DE LA TRUIE. — Le présent travail est une revue des expériences réalisées pour déterminer l'effet des conditions d'élevage en claustration, pendant le jeune âge, sur l'apparition de la puberté chez la truie. Seuls quelques auteurs ont comparé l'âge des cochettes au premier œstrus ou à la première ovulation en fonction du type d'élevage : en bâtiments fermés, en plein air ou en semi plein air. Dans tous les cas, les résultats sont défavorables à l'élevage en claustration (de façon significative ou non), les retards de puberté vont de 5 à 17 jours selon les auteurs. L'existence d'interactions avec d'autres facteurs, notamment le génotype, la saison de naissance, l'âge de l'animal au moment de la mise en expérience, explique la divergence des résultats. L'étude des facteurs associés à la claustration, tels que l'intensité et la durée de l'éclairement, la température ambiante et l'environnement social, aboutit également à des résultats contradictoires. Toutefois, des températures élevées et l'élevage en loges individuelles ou à l'attache provoquent un retard de l'âge des cochettes au premier œstrus de 4 à 10 jours. Bien que le rôle fondamental des régulations hormonales dans le développement sexuel soit maintenant connu, les travaux portant sur l'influence des facteurs d'élevage de la jeune truie sur les sécretions hormonales sont récents, incomplets et peu nombreux. L'étude de l'activité de la glande pinéale, des niveaux plasmatiques de prolactine, de LH ou des œstrogènes n'a pas encore permis de mettre en évidence de variations significatives avec la claustration ou la durée et l'intensité d'éclairement. Le logement individuel provoque une altération du rythme de secrétion des corticostéroïdes chez les cochettes. La claustration ne modifie pas leur réponse à la stimulation de l'œstrus par les hormones gonadotropes mais altère l'effet des œstrogènes. Des études systématiques, tenant compte de l'existence d'intéractions entre le génotype, les conditions d'éclairement et de température, la saison de naissance, l'environnement social, doivent donc être entreprises afin de déterminer précisément les modifications hormonales de la truie avant sa puberté associées aux différents types d'environnement et leurs conséquences sur le développement sexuel ultérieur.

Specialization and concentration of pig production, as well as planning requirements, have promoted maintenance of the animals in confined buildings during their whole life. But this kind of housing is often supposed to have detrimental effects on the reproductive capacity of animals. For instance, sexual maturation and estrus behaviour of gilts, which are of great technical and economical importance, may be affected by confinement. The aim of this paper is to review the

experiments which concern the effects of kind of housing on puberty in gilts. Moreover the effects of the environmental factors which could be implied in sexual development will also be considered.

Effects of confinement on age at puberty in gilts

There are relatively few results concerning this problem. Comparing gilts in a slotted-floor building with females in outdoor dirt lots, Jensen *et al.* (1970) did not find any significant effect on age at puberty (respectively 226 and 221 days). But the treatments were only imposed after 160 days of age. When experiment begins at an earlier age, puberty of confined gilts is generally significantly delayed: the difference reaches 15,1 days according to Meacham and Masincupp (1970) or 14 to 17 days according to Salmon-Legagneur (1970) when treatments are applied from weaning until first estrus. Another experiment was initiated in order to explain differences in age at puberty between two Large white herds native from two different regions of France (Bolet *et al.*, 1977). Half of the gilts from each herd were moved from one location to the other when animals were 95 days old. All conditions were similar, excepted the kind of housing: confined heated building, or open-front piggery. The differences in age at puberty between the two herds were partly due to the genotype of the animals (7 days difference between females born in the two locations), and mainly to the type of housing (first estrus occurred 16 days earlier in females raised in open-front buildings) (fig. 1). Christenson (1981) found a higher percentage of females exhibiting estrus before 9 months of age when they were raised in dirt lots than when they were confined after 2,5 months of age (85.2 *vs* 71.3 %) but the percentage of gilts ovulating without demonstrating estrus behaviour was higher in the confined group of gilts. Similar effects were observed by Rampacek *et al.* (1981) with confined gilts which were moved outside to dirt lots after 100-120 days of age compared to females put in partially slatted, concrete floor in confinement. But differences were only significant with animals born in January through March (75.4 *vs* 37.4 % mature at 250 days for outside vs confined gilts born in January through March, or 62.6 *vs* 50.9 % mature at 270 days for gilts born in June or July). Moreover, the difference observed corresponded to delay in age at the first ovulation and not to behavioural anestrus.

Recent experiments have tried to determine which physiological parameters are implied in the delay of puberty due to confinement. High prolactin levels are known to be antagonistic to gonadotrophin release; but no difference in plasma prolactin levels could be detected between gilts maintained in confinement and gilts relocated to

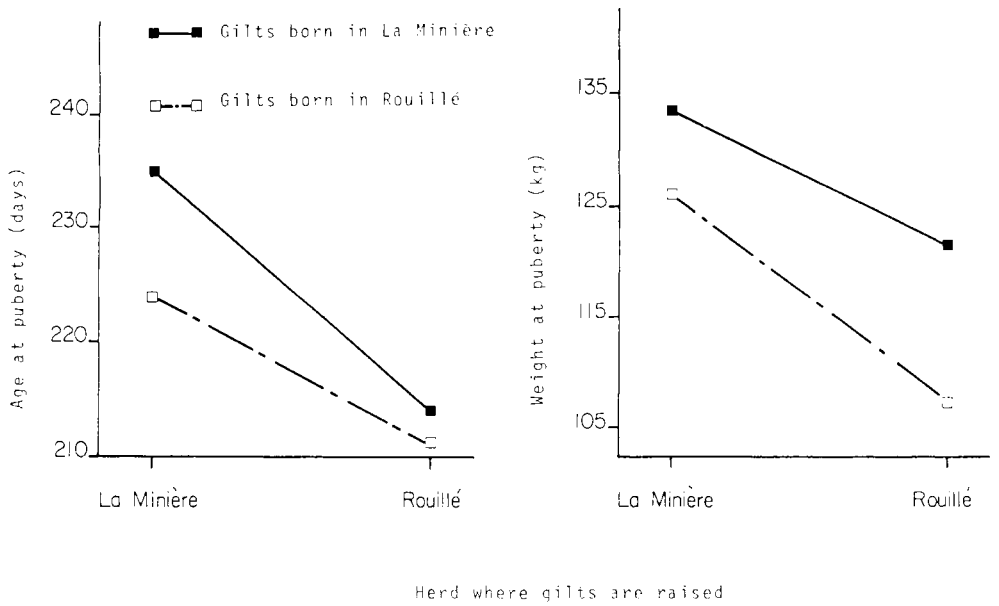

Fig. 1. — Influence of origin and herd conditions on puberty in gilts (Bolet *et al.*, 1977)

pasture lots (Esbenshade *et al.*, 1980). Esbenshade and Day (1981) showed also that the estrus response to human chorionic gonadotropin, luteinizing hormone or adrenocorticotropic hormone does not differ in gilts reared in confinement or relocated outside. But ovarian response of confined animals to low levels of estrogen is reduced (Esbenshade and Day, 1980).

Confinement modifies many environmental conditions and seasonal climatic variations are reduced. Heating of piggeries decreases the range of variation of temperature. Artificial lighting provokes modification of duration and intensity in comparison with the natural photoperiod. Social environment of the animals may also be affected through the size of the group of gilts and the density of animals in the piggeries. The effects of these parameters on sexual maturation of gilts are interesting to consider as they could at least partly explain the delay of puberty in gilts maintained in confinement.

Seasonal effects on puberty of gilts

Seasonal influence on age at puberty has often been reported, but conclusions appear conflicting. Christenson (1981) observed that the percentage of gilts cyclic at 9 months of age tends to be higher during the winter (October to April) than during the summer (April to October) season (81.3 *vs* 75.2 %). Puberty of gilts born in spring is delayed compared to those born in the fall season according to Robertson *et al.* (1951) and Mavrogenis and Robison (1976), with more than one month of difference in the second work (237 *vs* 202 days). The same tendancy was reported by Salmon-Legagneur (1970), but only with 8 days of difference. On the opposite, Carrez *et al.* (1977) showed that gilts born in the hot season (May through October) attain puberty earlier.

Contrarily to preceding experiments, Gossett and Sørensen (1959) and Sørensen *et al.* (1961) found no effect of the season of birth of gilts on their age at puberty.

Wiggins *et al.* (1957) have observed genital tracts of 2 967 gilts slaughtered at an unknown age. They showed that the percentage of prepubertal females is maximal in October and minimal in April. But the proportion of non mature gilts whose age was known is lower when they are born in spring. These results were confirmed by Scanlon and Krishnamurthy (1977) who reported that the percentage of mature gilts at 90 kg is minimal in September (6.95 %) and maximal in February (34.74 %). Gilts born in spring seem then sexually less-developped than others. But differences in climatic conditions between experiment locations may partly explain the discrepancies in the preceding conclusions. Moreover, season does certainly not act alone, but in relation with other factors. For instance, Mavrogenis and Robison (1976) reported that puberty is delayed in spring born gilts only when they are not presented to the boar. Earlier puberty is obtained in spring born gilts with Chester White breed, and in fall born gilts with Poland China breed (Zimmermann *et al.*, 1960). Rampacek *et al.* (1981) found that more January to March born gilts are mature if they are outside, but kind of housing has no effect when they are born in June-July. Finally, the season during which females approach the first estrus may be more important than their time of birth, as the animals receptivity to environmental influences should be greater at that period. It may thus be concluded with Christenson and Ford (1979) that when puberty normally arises in summer, females are submitted to detrimental conditions (light, excessive temperature conditions, less care of animals?) which lead to delay their sexual maturation.

Effects of temperature on puberty in gilts

Results on effects of temperature conditions on puberty are scarce. Jensen *et al.* (1970) compared gilts maintained at 16-27 °C or at 33.5 - 35.5 °C during 114 days after they reached 6 months of age. First estrus could not be detected in 8 out of 10 gilts in the second group. However, all females could be mated 14 days after temperature was decreased to the same values as in the first group. Sanwal *et al.* (1973) showed that uterus is lighter in gilts submitted to temperatures varying between 25.5 and 44 °C than in gilts kept at 18.5 °C. Although interesting, these results are obtained with few animals and do not allow to conclude for less excessive temperature conditions.

Effects of lighting conditions on puberty in gilts

Many experiments concern the effects of lighting conditions on puberty in gilts but as for the other parameters considered, results are conflicting. According to Dufour and Bernard (1968), gilts raised in complete darkness reach puberty earlier than those in natural lighting conditions (table 1). On the opposite, Hacker *et al.* (1974, 1976, 1979) and Ntunde *et al.* show that puberty in gilts maintained from weaning in darkness or with less than 6 h lighting per day occurs later than in those lighted during 12 or 18 h per day, or in natural lighting conditions. Surmuhin *et al.* (1970 a, b) found that genital tract and ovaries of 9 month-old gilts are lighter and developed follicles are less numerous on the ovaries when females are lightened during 8 h instead of 12 or 14 h daily.

Excessive lighting duration seems to delay sexual maturation of gilts according to Schnurrbusch *et*

Table 1. — Effects of lightening conditions from weaning on puberty in gilts

Age at puberty according to authors	Lightening duration (H/24 h)				Natural conditions
	0	6	12	18	
Dufour and Bernard, 1968	199,5a	...	...	...	209,2b
Hacker *et al.*, 1974	...	232a	...	190b	...
Hacker *et al.*, 1976	222a	...	183b	...	...
Hacker *et al.*, 1979	200,5	...	...	164,8B	175,3b
Ntunde *et al.*, 1979	193a	...	...	176b	177b

a, b: values on the same line with different letters differ significantly ($P < 0.05$)

al. (1982). Gilts continuously lightened between 4 and 6.5 months of age had less 2 to 5 mm follicles on the ovaries, and lower activity in the uterine epithelial layer (judged by cell height, number and size of glands, and alcaline phosphatase activity) than gilts with 2 x 2 h light daily.

Color of light seems also to be important: when compared to cool white, daylight or ultraviolet light produced by fluorescent bulbs during 16 h daily, red light increases age at puberty of gilts (192 *vs* 179 days for the mean of the three other colors) according to Wheelhouse and Hacker (1982). It was concluded that red light should appear as darkness to the pigs.

Continuous utilization of infrared lamps from birth until weaning induces earlier puberty than natural lighting conditions according to Martinat *et al.* (1970). Salmon-Legagneur (1970) did not find any difference in sexual maturation of gilts which were maintained in darkness or under red lamps during the nursing period. These results and those of Wheelhouse and Hacker (1982), lead to conclude that natural lighting conditions during early growth delay puberty in comparison with darkness.

Effects of light on pineal gland, which is receptive to environmental signals, have also been investigated. But the results now available are not conclusive. Gilts maintained under red lightening have heavier pineal glands (Wheelhouse and Hacker, 1982).But Ntunde *et al.* (1979) did not find a similar effect in females in complete darkness. Schnurrbusch *et al.* (1982) found that pineal gland cells of gilts in continuous lightening, whose sexual maturation seemed to be delayed, were less active than those fromigilts with 2 x 2 h lightening daily. Pineal weight or activity, however, is not necessarily an indication of pineal secretions.

Other experiments were initiated in order to relate differences in light regimen with modifications in hormonal patterns in gilts. But none of them showed that fluctuations of plasma total estrogens (Hacker *et al.*, 1979) or of circulating luteinizing hormone (Ntunde *et al.*, 1979) were associated to modifications of the photoperiod.

In conclusion artificial lightening does not affect sexual maturation when it is applied with the same duration than natural photoperiod. Darkness and light alternance seem to be necessary for normal sexual maturation.

Effects of group size on age at puberty in gilts

According to Jensen *et al.* (1970), tethered gilts have only a slight puberty delay (4 days) when compared with confined group-penned females, but expression of estrus is less discernible and the number of tethered gilts with infantile genital tract at 10 to 12 months of age is significantly greater. Hemsworth *et al.* (1982) observed that three out of ten gilts reared individually ovulated without behavioural estrus. Mavrogenis and Robison (1976) concluded also that individual rearing of gilts is detrimental for their sexual maturation since first estrus arises earlier in females in pens of 30 animals, but this effect is significant only in spring born gilts (table 2). The deleterious effect of individual penning may be associated with a chronic stress response, as indicated by a continuously high plasma corticosteroid concentration and a disruption of the corticosteroid rhythm in the study of Barnett *et al.* (1981).

Experiments in which the optimal group size was investigated are not conclusive. When groups of 8 gilts are compared to groups of 12 gilts,

Table 2. — Influence of groups size and of season of birth on age at puberty in gilts (days) Mavrogenis and Robison (1976)

Season of birth	One gilt/ pen	30 gilts/ pen
Spring	218,5a	208,8b
Fall	206,0b	198,8b

a, b : values on the same line with different letters differ significantly ($P < 0.05$)

opposite results are obtained with crossbred and with purebreed females (Christenson and Ford, 1979), but the comparison of the two genotypes was not realized in the same season. In fact, sexual maturation of gilts may be influenced by group size and/or by animal concentration. No difference in age at puberty was shown by Ford and Teague (1978) between control gilts (with 0.37 m^2/pig at 23 kg to 0.93 m^2/pig after 102 kg) and female pigs with 25 or 50 % less floor space.

It may then be concluded that raising gilts individually, which mainly induces lower estrus expression, must be avoided, but optimal group size and floor space for normal sexual maturation are not yet defined.

In conclusion, confinement generally delays puberty in gilt, but factors involved in that phenomenon are not yet known. Results on effects of season, temperature and lightening duration are scarce and conflicting. Interactions between these factors are generally significant, so that it is difficult to compare experiments in which non-controlled conditions differ. It is necessary to undertake experiments in which all conditions will be controlled in order to precise the main effects of the environmental factors and their interrelations.

Finally, age at puberty of gilts raised under the same environmental conditions varies greatly so that it may be assumed that age at puberty depends mainly on individual factors as far as external factors remain in a «normal» range.

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Summary

The present work is a review of experiments realized in order to determine the effects of confinement conditions on attainment of puberty in gilts. Few authors have compared age at first estrus or first ovulation of gilts bred in total confinement, in open front buildings and in outdoor dirt lots. Results are not always significant but lead to conclude to a detrimental effect of confinement on attainement of puberty (5 to 17 day delay). Interactions with other factors such as genotype, season of birth, age at treatment explain the differences between results. Large variations are also observed in the response of confined gilts housed in different conditions of intensity and duration of light, temperature and social environment. However, high temperature and individual penning induce a delay in age at puberty (4 to 10 days). Although the sexual development is known to depend on hormonal control, studies regarding the influence of environmental conditions on hormonal secretions are recent, rather scarce and incomplete. Significant variations in the pineal gland activity, the plasma levels of prolactin, LH and estrogens have not yet been associated with confinement, intensity and duration of light. A disruption of the corticosteroid rythm has been observed in individual compared to group penned animals. Estrus response to gonadotropin hormones is not modified but ovarian response to estrogen is reduced by confinement. Further experiments taking into account the existence of interactions between genotype, light and temperature conditions, season of birth and social relations are required in order to investigate more precisely the influence of the different types of environment on the hormonal secretions and consequently the sexual development of gilts.

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