BEHAVIOUR AND WELFARE OF VEAL CALVES
IN RELATION TO HUSBANDRY SYSTEMS

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J.G. de Wilt

BEHAVIOUR AND WELFARE OF VEAL CALVES IN RELATION TO HUSBANDRY SYSTEMS

Proefschrift

ter verkrijging van de graad van
doctor in de landbouwwetenschappen,
op gezag van de rector magnificus,
dr. C.C. Oosterlee,
in het openbaar te verdedigen
op vrijdag 6 december 1985
des namiddags te vier uur in de aula
van de Landbouwhogeschool te Wageningen

Aan mijn ouders

STELLINGEN

1. De huisvesting van vleeskalveren in kleine groepen in plaats van in individuele boxen is een belangrijke stap in de richting van een verbetering van hun welzijn.
   Dit proefschrift

2. Kwantitatieve veranderingen in paradoxale slaap bij kalveren kunnen worden geschat op basis van gedragskenmerken.
   Dit proefschrift

3. De mogelijke invloed van de voedermethode tijdens de eerste levensdagen op het optreden van preputiaalzuigen bij vleeskalveren is zowel biologisch als praktisch van grote betekenis en dient daarom nader te worden onderzocht.
   Dit proefschrift

4. Voerverwerking door middel van herkauwen vormt een langdurige tijdpassering, die herkauwers ten opzichte van niet-herkauwers een belangrijk voordeel verschaft bij de aanpassing aan een prikkelarme omgeving.

5. Zowel de vorm als de frekwentie van stereotypieën bij kalveren kunnen door onderlinge imitatie worden beïnvloed.

6. Een stressor kan de humorale immuunrespons stimuleren of reduceren, afhankelijk van het tijdsinterval tussen zijn toediening en die van het antigeen.
   Metz, J.H.M. en C.C. Oosterlee, 1980. KTBL-Schrift 264: 39-50.
   Meerson, F.Z., 1984. In: Adaptation, Stress and Prophylaxis. Springer, Berlijn.

7. Het bestaan van lebmaagzweren bij vleeskalveren is mede te wijten aan het optreden van cognitieve conflicten.
   Wiepkema, P.R. en G.M. Cronin, 1985. Vakbl. Biol. 65: 359-363.

8. De maatgeving van hokken voor vleeskalveren dient niet te worden gerelateerd aan het lichaamsgewicht, maar aan de lichaamsmaten van de dieren.
   Putten, G. van, en W.J. Elshof, 1982. In: Welfare and Husbandry of Veal Calves: 83-97. Nijhoff, Boston.

9. Voorlichting en subsidiëring, als middelen ter bevordering van diervriendelijke produktiesystemen, verdienen de voorkeur boven wettelijke voorschriften.
   N.N., 1985. Een Wet voor het Welzijn van Dieren. Uitgave: Dierenbescherming.

10. Wegens de overschakeling van het transport van melk in melkbussen naar een rijdende melkontvangst verdient het aanbeveling de hoeveelheid melk in volume- in plaats van in gewichtseenheden aan te duiden.

11. Het taalkundig onjuiste gebruik van een punt (.) achter samentrekkingen zoals drs, dr en ir ontleent zijn rechtvaardiging mede aan de toenemende werkloosheid en de geringe arbeidsmobiliteit onder academici.

J.G. de Wilt
Behaviour and welfare of veal calves in relation to husbandry systems
Wageningen, 6 december 1985

Voorwoord

Het onderzoek beschreven in dit proefschrift is uitgevoerd bij de Vakgroep Veehouderij, *sectie Ethologie van de Landbouwhogeschool te Wageningen en bij het Instituut voor* Mechanisatie, Arbeid en Gebouwen, eveneens te Wageningen. Een groot deel van het onderzoek is gefinancierd uit het Fonds Welzijn Landbouwhuisdieren. Het verschijnen van dit proefschrift biedt mij een welkome gelegenheid om allen die hieraan hebben meegewerkt hartelijk te bedanken.

Mijn dank gaat in de eerste plaats uit naar mijn promotor, prof. dr. P.R. Wiepkema voor de vele leerzame discussies, waardevolle adviezen en stimulerende opmerkingen tijdens alle fasen van dit onderzoek. Onze samenwerking heb ik altijd als zeer plezierig ervaren.

Mijn co-promotor dr. G. van Putten dank ik voor zijn deskundig commentaar op het manuscript. Ook de opmerkingen van vele anderen hebben bijgedragen aan de inhoud van het proefschrift. Ik denk hierbij o.a. aan ir. H.J. Blokhuis, prof. dr. H.J. Breukink, drs. K.K. van Hellemond, prof. dr. A. Hoogerbrugge, prof. ir. A.A. Jongebreur, dr. ir. J.H.M. Metz en de leden van de Werkgroep "Vleeskalverenonderzoek".

Ing. A.C. Smits, één van de initiatiefnemers van het project waarvan dit onderzoek deel uitmaakt, heeft mij steeds met raad en daad terzijde gestaan. Ik ben hem hiervoor zeer erkentelijk.

Denkavit Nederland B.V. stelde enkele proefstallen beschikbaar en bood gelegenheid tot het gebruik van de administratie, de werkplaats en de kantine. Ik dank alle medewerkers van deze firma voor de geboden informatie, assistentie en verpozing. Enkele van hen wil ik met name noemen. Drs N. Steenkamer heeft mij gestimuleerd door zijn grote kennis van de vleeskalverhouderij en zijn warme belangstelling voor het onderzoek. G. Schuit verzorgde de kalveren op vakkundige wijze. Ik wil hem en de bedrijfsleider ing. J. Meindertsma bedanken voor hun bereidwillige medewerking aan de experimenten, die soms een ingrijpende verandering van de bedrijfsvoering vergden.

Ook de bedrijfsleiders en medewerkers van de proefbedrijven "De Ossekampen", "De Haar", de "A.P. Minderhoudhoeve" (LH), de "C.R. Waiboerhoeve" (PR) en de proefaccommodatie van het IVVO ben ik dankbaar voor hun coöperatieve opstelling.

S.F. van Heulen heeft door het ontwikkelen en onderhouden van het videosysteem een belangrijke bijdrage geleverd aan de uitvoerbaarheid van het onderzoek. Ook de hulp van doctoraalstudenten en stagiaires (17 in totaal) bij de waarnemingen was onontbeerlijk. Hun inbreng en inzet heb ik bijzonder gewaardeerd.

De steun van ir. J. Jansen, dr. ir. M.A.J. van Montfoort en ir. P. van Ewijk bij de statistische analyse van de gegevens werd door mij zeer op prijs gesteld.

De typistes van de interdepartementale typekamer te Winschoten hebben het vele typewerk snel en correct uitgevoerd. De Engelse tekst werd gecorrigeerd door L. Hammell, M. Sc. en G. Bateman. C. van Maanen tekende op soepele wijze de figuren. De tekening op de omslag is van de vaardige hand van B.J. Elfrink en de foto's werden gemaakt door J.C. Vierbergen. H. van Dillen en E.F.M. Hoogstede-Veens adviseerden bij de vormgeving van het proefschrift. Het geheel werd gecoördineerd door ing. H.J. Manting. Ook naar hen gaat mijn waardering uit.

Tenslotte wil ik iedereen bedanken die aan dit proefschrift heeft bijgedragen maar niet met name is genoemd.

Contents

I General introduction

Veal production was already practised in ancient agriculture when surplus milk from the house cow was used to fatten a calf. The calf did not compete with its mother for available forage and cereals, since it was killed at a young age. Furthermore, the meat of the fattened calf would have been white, since cow's milk is deficient in iron (Webster and Saville, 1982). In the early 19th century, Le Francq van Berkhey (1811) reported on two housing systems for veal calves: group housing in batches of two or three calves and individual housing, both on straw. The calves were muzzled to prevent the intake of straw and the floor area per calf was limited in order to reduce activity. Later, veal calves were mostly housed in individual pens with solid walls on all sides, which created a hot, humid and dark environment. It was assumed that restriction of movement promoted fast growth, as did a humid and warm environment, while the rearing in darkness was associated with the white colour of the meat (Anon., 1960). It was not until the 1960's, that science rejected these ideas and housing became gradually more open to provide fresh air and light. The whiteness of the meat, which resulted from an iron deficiency, was maintained as a mark of quality. At that time, the economic importance of veal production was increasing, because a milk replacer on the basis of skimmed milk powder was introduced as a relatively cheap and easily distributable substitute for cow's milk and forms of cooperation between feed stuff producers and veal calf farmers were established. This stimulated the concentration of veal calves in large units on specialised farms, such as those which presently exist.

In the Netherlands, about 1,1 million calves per year are raised for veal on a total of about 2 500 veal calf farms; 35% of these farms have a capacity of more than 400 calves per year. In 1982, the total production of veal amounted to about 157 000 tonnes, which is about 19% of the total production in the European Community. About 135 000 tonnes (± 80%) is exported, mainly to Italy, France and Western Germany (Postema, 1985). Therefore, veal calf farming has become an economically important way of validating products of dairy farming such as male calves and skimmed milk.

The calves are usually bought on markets or special collection centres at the age of about one week. Until slaughter at 20-24 weeks, they are housed in crates[1], consisting of two sidewalls (about 1 m high and 0,60-0,65 m apart), a front constructed of slats, a barred rear section and a slatted floor. This type of housing ensures individual care and early recognition of ill health and restricts the spread of infection, which are important requirements to promote the characteristic fast growth of veal calves. Due to the rising prices of newborn calves and the relative cheapness of the milk replacer, slaughter weights have increased from 144 to 220 kg in the last twenty years (Zwetsloot, 1973; Anon., 1983). In contrast, crate width has increased only by a little : from 0,50-0,55 m to 0,60-0,65 m.

The spatial problems of the calves in these crates were recognized and legislation was introduced to guarantee a certain freedom of movement which was thought to be essential for the calves. The "Mestkalverenbesluit" concerning veal calves of 1961, the first law on animal husbandry in Europe, decreed among other things that the size of the crate should be such as to allow the animals to lie on either side unimpeded. However, since no strict measures were laid down, this law had no real effect. Later, to establish exact standards for minimum crate width, the lying behaviour of calves was repeatedly studied since lying was clearly hindered in crates of 0,60-0,65 m in width (Breuer, 1967). On the basis of different starting points which will be discussed later, at least two authoritative studies (Scheurmann, 1971; Van Putten and Elshof 1982a) arrived at very divergent conclusions

[1] This terminology is in agreement with Webster (1982).

concerning minimum crate width, which signifies the need for further research on this point. Therefore, the sleeping behaviour of the calves will be investigated in relation to lying postures which are impaired in crates of traditional width (chapter VIII).

Any increase in crate width will result in a decrease in the number of animals per unit area and thus higher building costs per animal (Jongebreur and Zwakenberg, 1976). This and a public opinion which is opposed to the keeping of calves in crates (Anon., 1982) stimulated the interest in alternative housing systems, such as group housing. Apart from the more efficient use of available space, which is important for the economic viability of a system, several welfare advantages were anticipated, such as social contacts and freedom of the calves to move around, to explore the environment and to stretch their legs while lying. In the past, a housing system for veal calves in groups of 10-15 animals with teat dispensers was not competitive with the individual housing in crates with regards to health and growth. Apart from technical defects, this was mainly due to the lack of control over individual feed intake and the late recognition of illness (Anon., 1975; Van Putten, 1982). To avoid these complications, the calves in the present study were housed in small groups of five and bucket fed, which is essential for individual care.

Earlier experiments with this combination of housing and feeding have not been satisfactory, mainly because of the occurrence of preputial sucking and the intake of urine, which may cause local inflammations and reduce growth (Pesch, 1968; Van Putten, 1982). These problems are effectively avoided in this study by tethering the calves to the feeding gate during the first 6-8 weeks after arrival and separating them by wooden partitions. The influence of different tethering systems on lying behaviour will be evaluated in chapter VII. In order to create possibilities for group housing of veal calves in the first 6-8 weeks, it is essential to investigate the causation of preputial sucking and urine drinking. This study will present a detailed description of the development of preputial sucking and urine drinking (chapter V) and some experiments concerning the prevention of these activities (chapter VI).

The provision of roughage to veal calves have been deliberately avoided in the past on the assumption that this would have a negative effect on milk intake, feed conversion and meat colour. Bogner et al. (1973) and Elshof and Van Putten (1978) challenged this and showed that small quantities of straw contributed to the animals' well-being by promoting rumination and reducing the development of hairballs, parakeratosis of the ruminal epithelium and stereotypies. An undesirable effect of the provision of straw is that it may stimulate the genesis of abomasal lesions (Bogner et al., 1981). This point will be discussed briefly in chapter III.

Because of its mainly favourable influence on health and well-being, roughage is provided in both the individual and group housing systems investigated in this study. In the crates, a maximum of 100 gram of straw is provided daily to each calf, while in the group pens, straw is available ad libitum in baskets. In addition, the floor of the group pens is covered with straw as a non-slippery, comfortable bedding (Graf et al., 1976).

The provision and removal of the straw bedding, however, is labour intensive and seen as a major disadvantage of this system of group housing. For this reason, other group pens are equipped with slatted floors without straw bedding. To prevent the obstruction of the manure channel by straw spilled from the racks in this latter system, cobs of chopped straw and starch are supplied instead.

Data on production, health and labour aspects of group housing with and without straw bedding in comparison to individual housing will be discussed in chapter III. A major objective of the present investigation, however, is to assess the advantages and disadvantages of these housing systems with regards to the behaviour and well-being of the calves (chapter IV).

This study is part of a larger project, aimed at the development of an economically acceptable alternative to the traditional housing of veal calves in crates, which should provide a significant improvement in calf welfare. The housing of calves in groups of five may be a possible alternative and this system is evaluated concerning husbandry, health and ethological aspects. The husbandry aspects of individual and group housing on practical farms are compared by the Institute of Agricultural Engineering in Wageningen, whereas the health status of the calves in both housing systems is studied mainly by the Institute of Animal Production "Schoonoord" in Zeist.

The ethological research which is presented in the following was performed in consultation with the Ethology Section (Department of Animal Husbandry) of the Agricultural University and the Building Division of the Institute of Agricultural Engineering, both in Wageningen. Most of the observational work was executed at the experimental farm of Denkavit Nederland B.V. in Voorthuizen (a manufacturer of feeding- stuffs); some work was also carried out at the experimental farm "De Ossekampen" of the Agricultural University in Wageningen. The work was mainly financed by the "Fonds Welzijn Landbouwhuisdieren" and the Ministry of Agriculture of the Netherlands.

II General materials and methods

Details of the equipment, animals and procedures used throughout the investigations are presented in this chapter.

CALF-HOUSE

All experiments, except those reported in chapter VIII, were executed in two rooms, referred to as units, at the experimental farm of Denkavit Nederland B.V. (fig. 2.1). These units were situated in a wooden building with insulated walls and roof. Air volume was about 272 m^3 in unit I and about 269 m^3 in unit II, which makes about 7 m^3/calf in unit I (39 calves) and about 6 m^3/calf in unit II (47 calves).

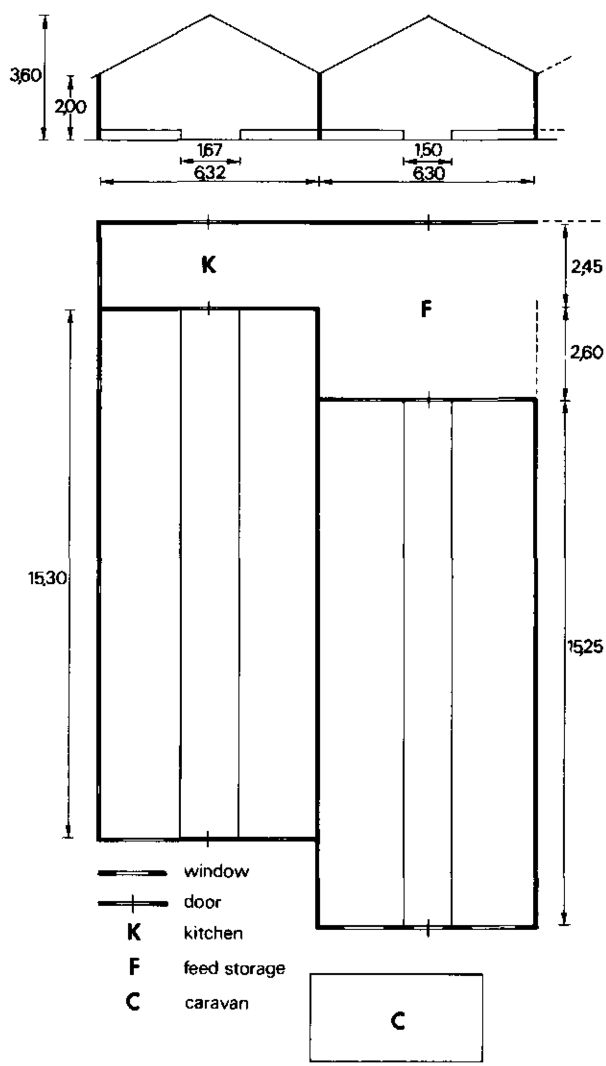

Fig. 2.1 Cross-section and overview of experimental unit I (left) and II (right). Dimensions in metres.

The air was introduced through openings in the doors on both sides of the feeding passage and exhausted by a fan in the ridge of the roof. During the first two weeks after arrival of the calves, the ambient temperature was maintained at a minimum of 13-15°C by the use of three gas heaters placed above the feeding passage. Daylight which entered the units from windows and sky-light plates was supplemented by nine artificial fluorescent lights per unit.

VIDEO EQUIPMENT

In unit I, three infrared sensitive video-cameras were suspended on a pen and tilt unit that could be rotated automatically around a vertical and horizontal axis and shifted by hand along a rail in the ridge of the roof. An infrared light was paired with each camera. The recording equipment consisted also of a switch panel, two monitors, one time-lapse recorder (Sony-U-matic) and two video-recorders (Betamax SL-C7E) provided with cassette changers. This equipment was located in a caravan just outside the experimental building (fig. 2.1).

ANIMALS

Nearly all calves were male and Dutch-Friesian; however, in three experiments presented in chapters III and IV, they were of the Maas-Rijn-IJssel breed. As most of them were interbred with Holstein-Friesians, they will be referred to as black and white or red and white respectively, according to the colour of their markings.

During the first days of life, before transfer to the fattening house the calves remained at the various dairy farms where they had been born. In all experiments, except those described in chapter VI and VIII, no individual information about this period was available. It can be assumed however, as this is the common practice, that most calves were separated from their mother at birth, kept individually and fed from open buckets; others would have been suckled by the mother or fed by teat buckets for the first day or longer, possibly followed by feeding from open buckets. Few would have been kept in groups. For about three days after birth, the calves would have received colostrum from the mother cow and later whole milk or a milk replacer.

At about one week of age they were transported to markets or collection centers, from where they were trucked over 80 to 150 km to the experimental units. On arrival, these calves had usually not been fed for about 24 hours. They were penned and left alone for a few hours, after which they were given a solution of electrolytes to drink. The fact that these calves were tired was apparent from their reluctance to stand up for this first meal and their tendency to lie with the limbs stretched out during the first days after arrival (Kersten, 1983). The activity of the calves during this period was low and hesitant.

FEEDING

The calves were fed twice daily from open buckets with a milk replacer at 40°C, distributed from a mixer on wheels. In the first 7 weeks after arrival, the milk replacer powder provided to the calves contained 24% protein, 17% fat and 57 ppm soluble iron. After 7 weeks, the powder used contained 20% protein, 21,5% fat and 8 ppm soluble iron. The instructions for powder concentration and amount of liquid fed on each day of the fattening period are summarized in appendix 1. Generally, in the first 2 weeks after arrival, additional water (1,5 l/calf/day, 30°C) was provided in the empty buckets after the morning feeding. Deviations from this scheme were usually very small. The amount of the milk replacer provided (equal for all calves) and the residue was noted by the herdsman, in most cases per individual calf.

WEIGHING, BLOOD SAMPLING AND CLIPPING

Routinely, the calves were individually weighed at 0, 2, 6, 10, 14, 18 and 20 weeks after arrival and on the day before slaughter. Blood for haemoglobin (hb) measurements was taken from the jugular vein immediately after arrival and 20 weeks later. Calves with extremely low hb levels were injected with an iron preparation. The calves' haircoat was clipped once between 8 and 16 weeks, dependent on the climate in the unit.

HEALTH CONTROL AND MEDICAL TREATMENT

The herdsman inspected the calves twice daily at feeding times. Attention was paid to the general health of the calves as indicated by their alertness, appetite, posture and external appearance (coat condition) and to specific symptoms of disease such as abnormal consistency and colour of the faeces (gastro-intestinal disorders), coughing, watery eyes, laboured breathing and nasal mucus (respiratory diseases), swollen and hot navel (omphalitis). In case of apathy without specific symptoms, the colour of the gums was inspected for the possibility of excessive anaemia. The occurrence of lice infestations, mange and other ailments such as otitis, arthritis and tympany were also noted.

At the first sign of these symptoms, treatment was initiated and continued until these phenomena disappeared. In the case of sluggishness and anaemia, treatment with an iron and vitamine B12 preparation was continued for a fixed number of days, regardless of the reaction of the calves. Occasionally, when more than 10% of the calves were slow or showed other signs of disease, antibiotics, vitamines, electrolytes or iron solutions were mixed with the milk replacer and supplied to all calves for 5-10 consecutive days. Furthermore, all calves received antibiotics mixed with the milk replacer for 7-12 days after arrival as a preventive cure against gastro-intestinal disorders. Calves that died were dissected only when the cause of death was not obvious.

OBSERVATIONS

Behaviour was recorded either directly by an observer present in the unit or by means of videotapes that were viewed in the caravan. Observations were continuous or periodic. The exact procedure followed during each of the experiments is described in the relevant chapters. The ethogram used is presented below. The definitions of most ethological terms are given by Heymer (1977). In order to measure possible obstructions of lying behaviour in the crates (chapter IV) and in the tethering stalls (chapter VII), numerous lying postures were discriminated. The postures of the trunk and legs, the position of the head and the performance of different activities were recorded separately.

Postures of the trunk and legs

Standing
Standing on three or four straightened legs, without locomotion.

Lying postures of the trunk and legs

— Lying on brisket, with legs bent (fig. 2.2A)
Lying on the brisket, the forelegs bent under the body, the hindlegs to one side and at least one of them bent. This posture is common just after lying down, just before getting up or when disturbed. The stretching of one hindleg when the other is bent, is rare.

— Lying on brisket, with foreleg(s) stretched and hindleg(s) bent (fig. 2.2B)
Lying on the brisket, usually one or sometimes both forelegs stretched and at least one hindleg bent.

— Lying on brisket, with forelegs bent and hindlegs stretched (fig. 2.2C)
Lying on the brisket, both forelegs bent, thigh flat on the floor and both hindlegs stretched.

— Lying on brisket, with foreleg(s) stretched and hindlegs stretched (fig. 2.2D)
Lying on the brisket, usually one but sometimes both forelegs stretched, thigh flat on the floor and both hindlegs stretched.

— Lying on side (fig. 2.2E)
Lying with the forequarters resting on the shoulders, the hindquarters on the thigh and the legs stretched.

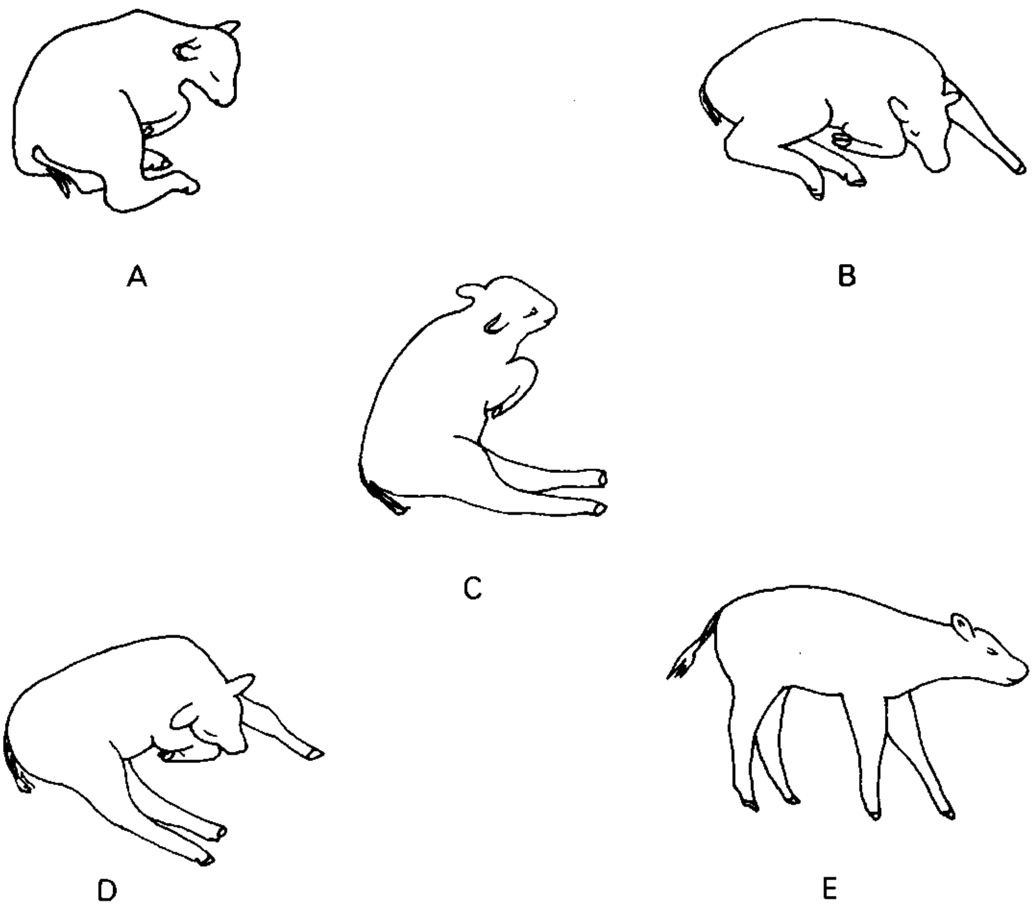

Fig. 2.2 Lying on brisket with legs bent (A), with foreleg(s) stretched and hindleg(s) bent (B), with forelegs bent and hindlegs stretched (C), with foreleg(s) stretched and hindlegs stretched (D) and lying on the side (E). Adapted from Scheurmann (1971).

Postures of the head

Head postures during standing
All head postures performed while standing.

Lying postures of the head

— Lying with head turned backwards (fig. 2.3A)
Lying with the head supported on the shoulder, belly, hindleg or floor. The muzzle is placed behind or level with the shoulder.

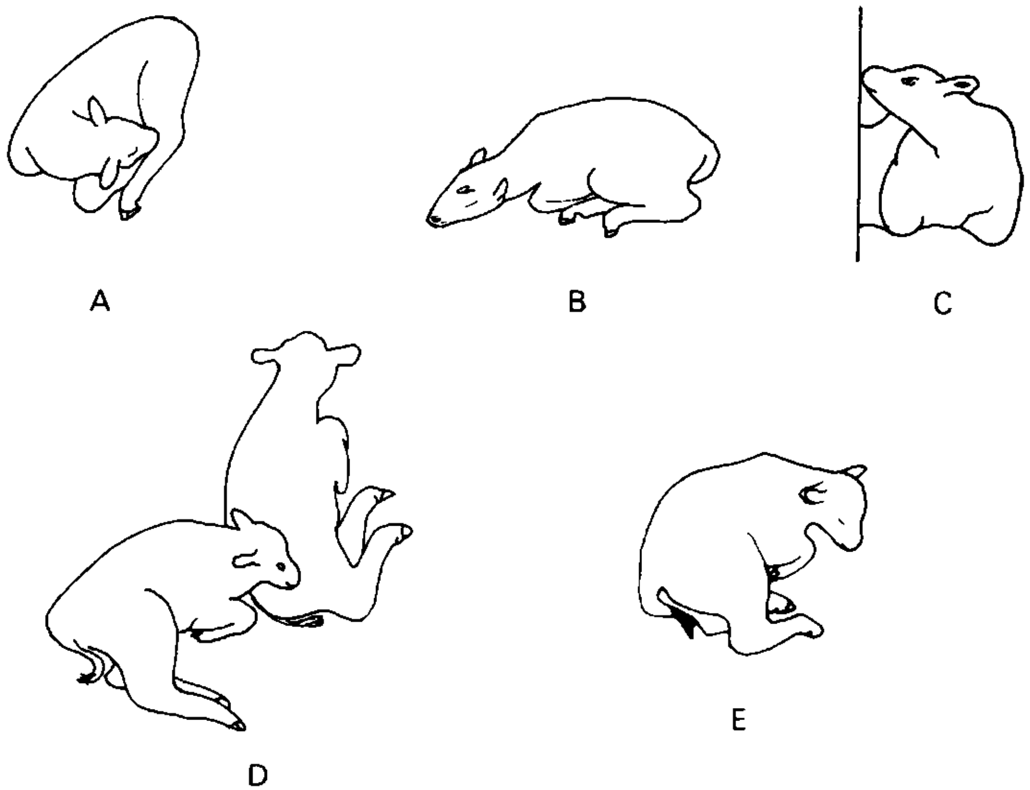

Fig. 2.3 Lying with the head turned backwards (A), forwards (B), on/against object (C), on congener (D) and upright (E). Adapted from Scheurmann (1971).

— Lying with head forwards (fig. 2.3B)
Lying with the head supported on the floor or foreleg(s) and the muzzle before the shoulder. The head may be close to the trunk with the muzzle on the floor or it may be extended forwards with its side or the lower jaw on the floor.

— Lying with head on/against object (fig. 2.3C)
Lying with the head supported on a bar or on the neck chain, or leaned against a sidewall or partition.

— Lying with head on congener (fig. 2.3D)
Lying with the head supported on the back, neck, shoulder, thigh or belly of another lying calf.

During these postures with the head supported, there is no oral activity apart from some sporadic chewing movements. Sometimes, sudden twitches of eyes, ears, muzzle, mouth or body occur. The eyes are open during most of the time.

— Lying with head upright (fig. 2.3E)
Lying with the head not supported.

Activities

Eating and (sham) ruminating

— Eating straw
When eating straw from a rack, the tongue is protruded upwards through the grid and withdrawn with some pieces of straw, which are chewed or nibbled while partly sticking out of the mouth and then swallowed. When eating straw from the floor, the tongue is slung sideways around a handful of straw that is chewed or nibbled and then swallowed.

— Eating straw cobs
When eating straw cobs from a full trough, the tongue is hardly used, since the cobs are directly accessible. When the trough is almost empty, the tongue is used to gather dispersed cobs. They are chewed and then swallowed.

— Ruminating
After eructation, visible from the stretching of the head forwards and the widening of the throat, the bolus is chewed in a relatively slow and regular fashion and then swallowed. This behaviour is almost exclusively performed while lying.

— Sham ruminating
After eructation of loose hairs and ruminal fluids, chewing movements are performed in a relatively fast, irregular fashion and with only a limited range. The behaviour occurs in the absence of roughage.

Smelling, licking or scraping object and tongue playing

— Smelling object
After the head is extended forwards or lowered towards the object, the nostrils are widened while the calf is breathing in. This lasts only a few seconds and may be repeated without change in posture; sometimes the muzzle is moved along the surface of the object. Smelling may be directed at any structure in the pen, including the floor and straw bedding. When smelling straw on the floor, the muzzle is occasionally used to push the straw away.

— Licking object
After extending the tongue, the upper side is shifted along the surface of the object while retracting it into the mouth and at the same time moving the head upwards. This sequence is usually repeated, sometimes protracted over several minutes. Licking is directed towards bars, feeding trough, wall, windows and floor. The object, for example a (horizontal or vertical) bar, is sometimes kept in the mouth with the tongue extended. The mouth may be shifted back and forth, while the tongue is swaying and curling. This may last several minutes.

— Scraping object
The incisor teeth in the lower jaw are moved over the surface of the object by raising and lowering the lower jaw, supported by vertical head movements. Sometimes single scraping movements are alternated with single licking movements (scrape-licking) and protracted over several minutes. This activity is directed at the same objects that are licked.

— Tongue playing
Extending the tongue and swaying it sideways, turning and partly rolling and unrolling it.

The tongue may also be repeatedly rolled and unrolled inside the open mouth. The complexity and speed of these movements may vary greatly between calves; some calves hold the tongue extended almost motionless. The head is usually in a more or less upward position and occasionally the eyeballs are rolling.

Comfort behaviour and stretching

Behaviour patterns and movements that serve to enhance an animal's comfort and body care (Heymer, 1977).

— Self licking
Licking as described under "licking objects", directed at all parts of the calf's own body within reach of the tongue, such as the hindquarters, forequarters and forelegs (fig. 2.4). This excludes the head, the neck and the area between both hindlegs. The licking movements can be alternated with rubbing activities of the incisor teeth in the lower jaw and they are performed both in a lying and standing position. When licking the region between loin and tail-base while standing, only three legs are used for support; the inside hindleg is held relaxed. A three leg balance is also practised when licking a hindleg while standing.

— Rubbing
Moving the head, neck, shoulder or side up and down the surface of objects and sometimes along the hindquarters or legs of congeners in a rhythmical way. This behaviour is sometimes performed while lying.

— Scratching
After bending the head and neck sideways, the claw of the hindleg on the same side is rubbed over the head, neck or shoulder repeatedly while balancing on three legs for sometimes more than 10 seconds. Scratching may also occur during lying.

— Nose licking
Moving the tongue over the muzzle, inserting the tip of the tongue alternately in both nostrils and back into the mouth again. This can be repeated several times.

— Stretching
Bending the back upwards and then downwards (back stretch) with the tail slightly lifted or bent sideways to the seat bones (tail stretch), the hindlegs placed backwards and

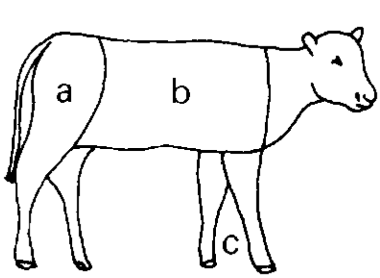

Fig. 2.4 Self licking sites: hindquarters (a), forequarters (b), and forelegs (c).

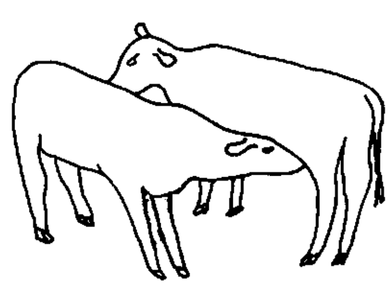

Fig. 2.5 Preputial sucking.

sometimes lifted separately (leg stretch). The neck may be lifted while the muzzle is moved downwards (neck stretch). These stretches may occur simultaneously, but sometimes only a back stretch is performed. Stretching is most common after standing up, but it also occurs during lying; the legs may then be stretched sideways.

Smelling and licking congener

— Smelling congener
Smelling as described above, now directed towards the haircoat of a congener.
Smelling at the prepuce or urine jet is sometimes followed by "flehmen" (Heymer, 1977), in which the head is extended forwards and the upper lip raised.

— Licking congener
Licking as described under "licking objects", concentrated at head, neck and shoulders of a congener; these are spots which the calf itself cannot easily reach with its tongue. Sometimes licking is interspersed by scraping at the haircoat with the incisor teeth in the lower jaw. A calf may perform this behaviour spontaneously or after "invitation" by a congener which keeps its head in a low horizontal position close to the muzzle of the first, occasionally butting with the head extended.

Preputial sucking and urine drinking

— Preputial sucking (fig. 2.5)
Sucking at the prepuce of a congener which tolerates this in most cases and eventually starts urinating. The sucking calf usually holds on to the prepuce and sucks the urine without spilling much. This behaviour is generally accompanied by vigorous muzzle butting and it is often very persistent, in spite of the occasional kicking and walking away of the sucked calf.

— Urine drinking
Licking of the urine jet of a calf which is urinating either spóntaneously or induced by sucking and licking in the ano-genital region. Sometimes a calf licks its own urine while urinating.

Other sucking

A body part or physical object is enclosed by the mouth and the extended tongue is aligned to its surface. The neck is lowered and the head is in a more or less horizontal position, the forelegs are slightly spread and placed forwards. Sometimes the lower jaw is moving up and down, making smacking sounds. It is now and then accompanied by muzzle butting. Sucking is concentrated after the drinking of the milk and may be very vigorous, especially in younger calves.

— Sucking object
Sucking at a rim of a bucket, a bar, a chain, a collar of a congener, etcetera.

— Mouth sucking
Sucking at the lower or upper jaw of a congener. This is often mutual, interrupted by the licking of milk remaining around each others mouths.

— Ear sucking
Sucking at the ear of a congener which tries to avoid this by walking and turning its head away, sometimes after standing up.

— Leg sucking
Sucking at a tuft of hair at the back of a foreleg of a congener, while both calves are standing in a parallel position. This is usually tolerated.

— Scrotum sucking
Sucking at the scrotum between the hindlegs of a congener, mostly from behind but also from the side. Once the testes have descended into the scrotum, they are pushed upwards during sucking, which is then tolerated. Muzzle butting however, is often followed by walking away and kicking.

— Remaining sucking
Sucking at other parts of the body, such as dewlap, groin, tail, neck and jawbone.

Head butting, mounting, jumping and running

— Head butting
After lowering the head with the muzzle pointing downwards, the forehead is pushed against the front of the head, neck or shoulder of a congener and twisted or moved up and down. The forelegs are spread a little and placed forwards. This behaviour may also be directed at the hindquarters of a congener or at objects or lying penmates. The butted calf may engage in the same behaviour, but it does not always react. Sometimes three calves head butt each other simultaneously.

— Mounting
Laying the head on the loins, back or withers of a congener, jumping upwards with both forelegs, putting them on either side of the head which is simultaneously raised. This sequence is often broken off by an avoidance reaction of the mounted calf, when the head is placed on the loins, back or withers. Congeners which are lying may also be mounted after initial licking and rubbing of the muzzle on the back; the forelegs are then placed on either side of the lying calf. This usually results in this calf standing up.

— Jumping
Pushing the forequarters upwards with a sudden movement of the forelegs and head, often followed by the kicking of both hindlegs backwards. The tail may be lifted and the ears set close against the neck. Sometimes short sounds are uttered. Elements of this behaviour also appear separately, such as the swaying of the head upwards or the kicking of both hindlegs.

— Running
The left foreleg and right hindleg are placed forward simultaneously, followed by the right foreleg and left hindleg and so forth. This is performed with great vigour and velocity (trotting). Sometimes both fore- and hindlegs are placed forward alternately (galloping). Intermediate forms of trotting and galloping consist of placing both fore- and hindlegs forwards not simultaneously, but immediately after one another.

Other activities

Not performing one of the activities described above.

A selection of these behaviours is registered in the following chapters.

III Individual housing vs group housing: husbandry aspects

INTRODUCTION

The application of ethology to production animals involves the study of the behaviour of animals kept for the production of meat, milk, eggs or fur in some husbandry system. Such a system has to meet the high demands of production efficiency to assert its existence. It is therefore necessary to evaluate production and management aspects of new housing systems before studying the behaviour of the calves in these systems becomes relevant.

In the present study, important parameters for production are growth rate and feed conversion and the percentage of calves delivered at slaughter. Because health inspection may be more difficult in group housing than in individual housing and since the spread of infections is probably promoted by close physical contact (Wood, 1980; Webster, 1984), health may be impaired in the group pens. This is even more likely when preputial sucking becomes habitual (Pesch, 1968). The latter behaviour was therefore either prevented by muzzling or by tethering. In addition to production characteristics, health treatments and the muzzling and tethering of the calves are registered.

Relevant to the management of a housing system is the amount of work connected to its operation. Labour requirements may be excessive in the group pens provided with straw bedding, due to the supply and removal of large quantities of straw by hand. The labour connected to these activities is also measured in the present investigation. Furthermore, some orientating screenings are performed on the occurrence of abomasal lesions, which is a subject of current interest (Van Putten, 1982; Dämmrich, 1983; Wiepkema, 1985).

In this chapter, a first impression is provided on production, health and labour aspects of group housing with and without straw bedding as compared to individual housing.
This study involves two groups of experiments:
- five experiments concerning individual crates with limited straw supply and group pens with straw bedding and ad libitum supply of straw;
- four experiments concerning individual crates with limited supply of straw cobs and group pens with slatted floors and a similar provision of straw cobs.

The experiments within each group constitute mutual replicates. Differences between replicates, e.g. with respect to the breed of the calves (black and white or red and white) or the frequency of straw provision in the group pens (2 or 3 times a week) are disregarded.

Individual crates vs group pens with straw bedding

MATERIALS AND METHODS

Animals, housing and management

In each of five consecutive experiments, 19 calves were housed in individual crates, while 20 calves were housed in group pens in four groups of five, constituting a total of 95 individually housed calves and 100 group housed calves. All animals were male (except two) and about one week of age at arrival. The calves were housed according to weight; the average weight in group pens and crates was similar: 39,2 kg and 39,0 kg respectively. Just after arrival the haemoglobin (hb) content in the blood of the calves was 11,5 g/100 ml and 11,6 g/100 ml in the crates and the group pens respectively. The breed was black and white in three experiments and red and white in the other two experiments.

The 19 crates and four group pens were installed in unit I (fig. 3.1). The crates (1,65 m long, 0,65 m wide) consisted of two sidewalls (1,10 m high), a partly rippled front, a back

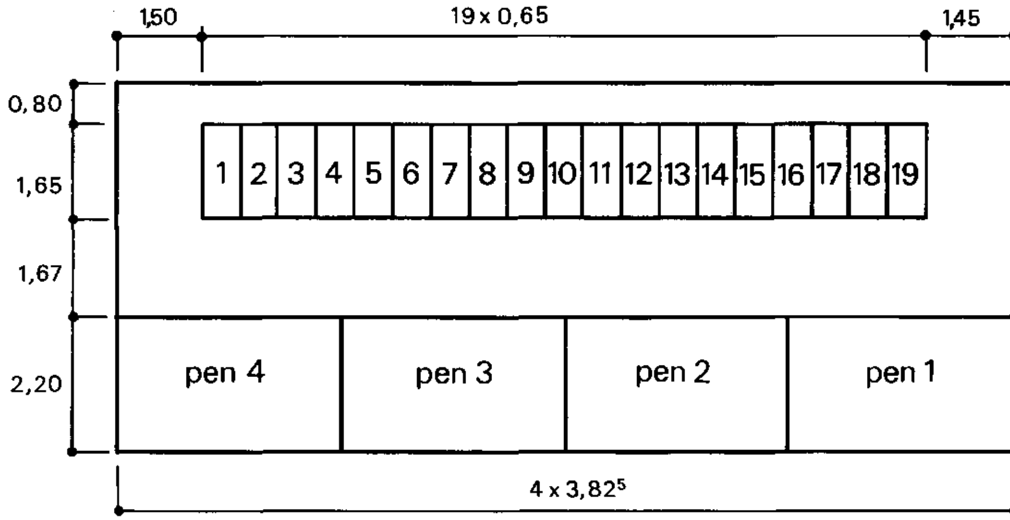

Fig. 3.1 General view of unit I. Dimensions in metres.

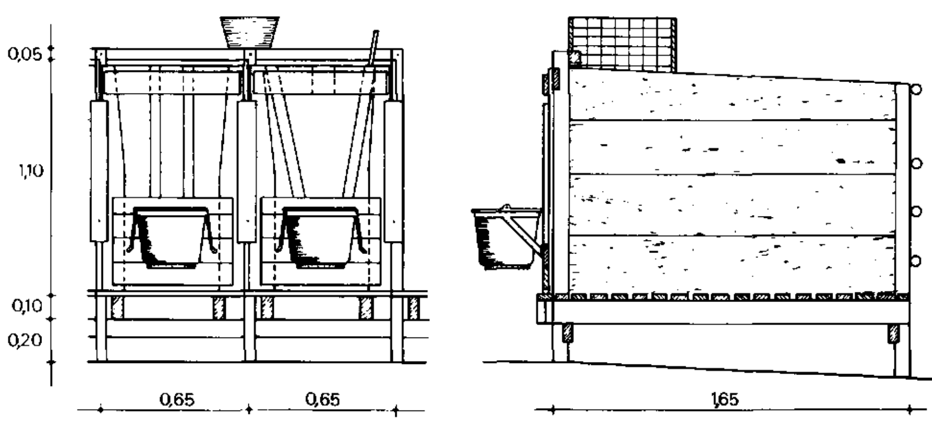

Fig. 3.2 Front and side view of two individual crates with limited straw supply (unit I). A rack for straw supply is placed on top of the sidewall. Dimensions in metres.

section barred by horizontal galvanized pipes and a slatted floor (slat 70 mm, slot 30 mm), as illustrated in fig. 3.2 and photo 3.1. Behind the crates, which were situated about 0,30 m above floor level, there was a 0,80 m wide passage (fig. 3.1). The calves were tied to the front of the crates by neck chains (length 0,50 m) until 12-14 weeks after arrival to prevent them from turning around. Barley straw for feeding was available to a maximum of 100 g/calf/day; initially in racks attached to the sidewall about 0,70 m above floor level, later in racks placed on top of the sidewall (fig. 3.2).

The group pens (2,20 m deep, 3,825 m wide) were surrounded by galvanized railings, a feeding gate, which was 1 m in height, and the wall of the unit (fig. 3.3, photo 3.2). The concrete slatted floor (slat 110 mm, slot 5-8 mm) was covered with barley straw that was replaced two or three times a week. In addition, barley straw was continuously available in a basket in a back corner of each pen. The straw contained about 80 ppm of iron on average.

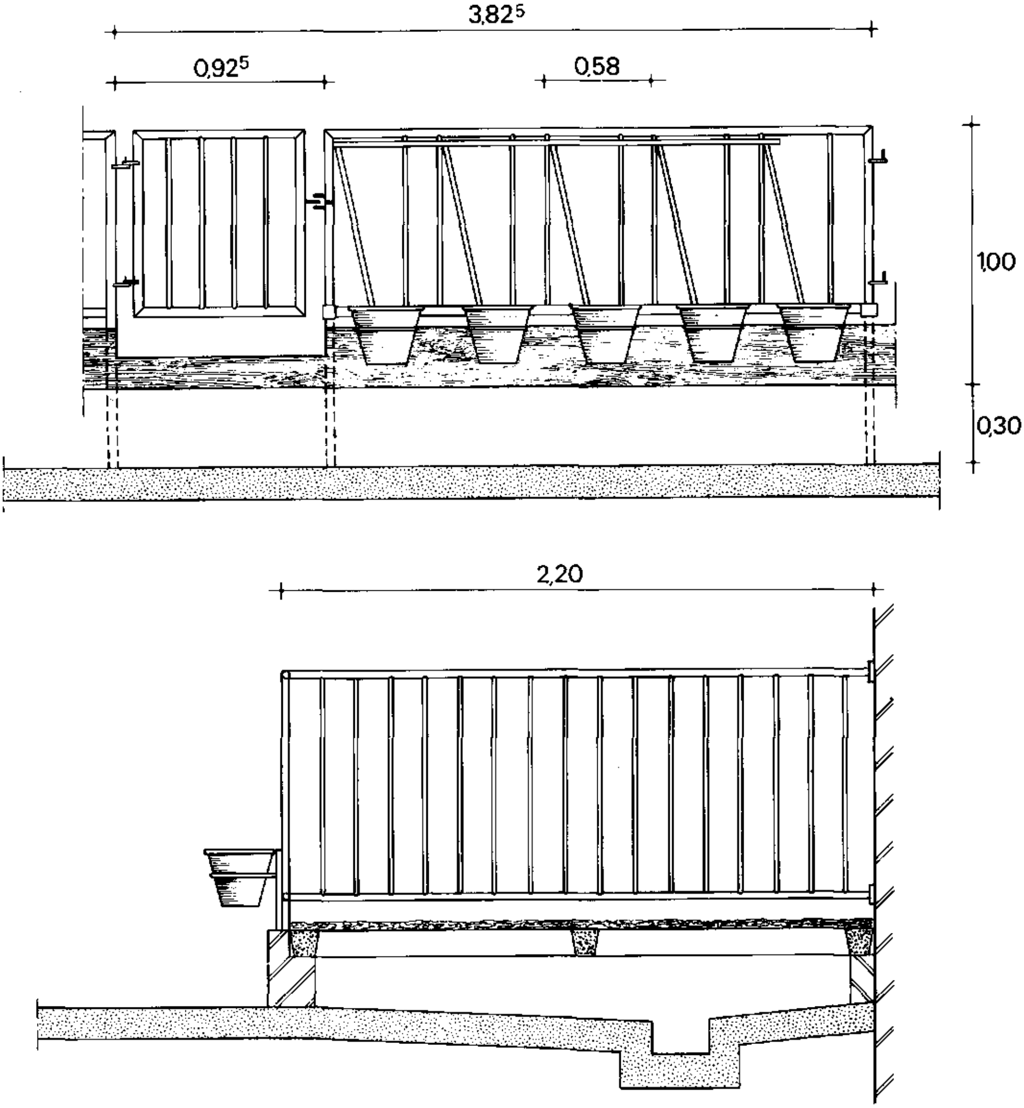

Fig. 3.3 Front and side view of a group pen with straw bedding, equipped for five calves (unit I). The feeding gate is open. Dimensions in metres.

All calves were fed a milk replacer twice daily, around 8.00 and 16.00 h. During the first 2 weeks 1,5 l water (20-30 °C) was provided to each calf after the morning feeding (appendix 1). Straw was supplied as stated above. The calves in group pens were loose housed immediately after arrival. As a routine, the herdsman inspected the calves twice daily around feeding time. Any calf that was observed sucking the prepuce of a congener, was muzzled for 1-2 weeks to prevent this behaviour. If this behaviour reoccurred, the procedure was repeated, except in experiments 3 and 5, with large numbers of preputial suckers (table 3.4). In group pens, severely diseased calves, which were drinking slowly and which were often pushed away by penmates, were transferred to another calf-house for treatment. They were considered to be "culled" (see below). Weighing, blood sampling,

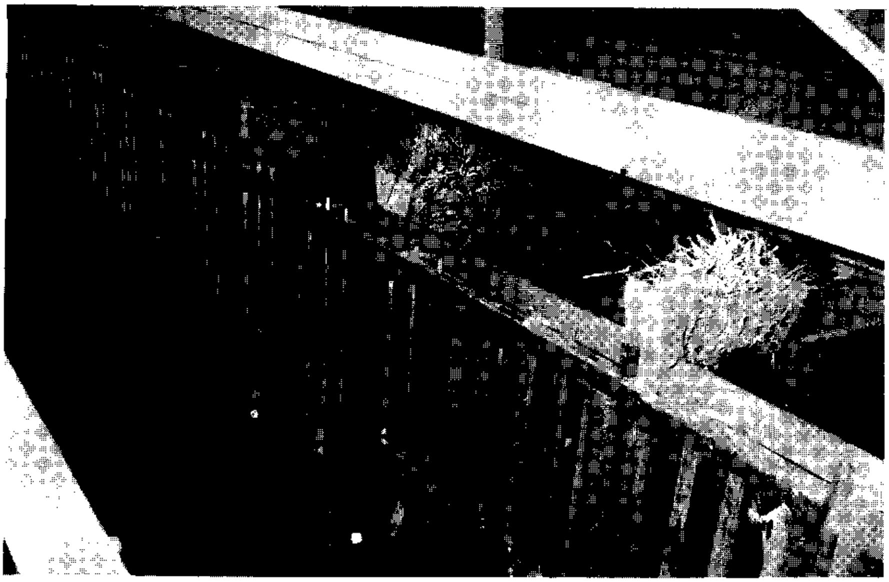

Photo 3.1 Individual crates with limited supply of straw (100 g/calf/day) in racks.

Photo 3.2 Group pens with straw bedding and ad libitum supply of straw in baskets.

health check and treatment of illnesses was performed as mentioned in chapter II. Immediately after slaughter, carcass weight was assessed. Ambient temperature in the unit was not recorded during the first three experiments. In experiments 4 and 5, the temperature was incidentally checked; it varied between 4°C and 26°C throughout the year (appendix 2A).

Registrations

The number of deaths (calves that died during the fattening period), culls (calves that were transferred from the unit during the fattening period either to be slaughtered or to be housed elsewhere for medical treatment) and eliminations (calves that were slaughtered at a normal age together with the others, but with extremely poor growth or with prolonged poor appetite) was registered, as well as the cause of death, culling and elimination. These calves were excluded from the calculations (!).

The feed conversion (powder consumption (kg)/weight gain (kg)) was computed from the total weight gain and the total milk replacer consumption of the individual calves from arrival to 20 weeks. The amount of the milk replacer provided (which was equal for all calves) and the quantity left over by some of them was noted down by the herdsman. The average killing out percentage was calculated from the carcass weight and the liveweight of the calves. Moreover, the colour and cover of meat and fat on the carcass was evaluated by an expert, who rated these traits from 1 (very bad) to 10 (excellent).

In cases of disease, the days of treatment were noted. The duration of a disease case included the first and the last day of the treatment and the days in between. An interruption of treatment for one day only was disregarded. Furthermore, the number of days on which calves were muzzled was registered. The quantities of straw used were calculated from the amount of straw in storage before and after the experiments. In one experiment, the time required for several activities concerning the provision of straw and the removal of the dung was recorded. The incidence of erosions, ulcers and scars on the abomasal mucosa was scored by a veterinarian immediately after slaughtering in one experiment.

RESULTS

The percentage of deaths, culls and eliminations was higher in the group pens than in the individual crates (table 3.1). In the crates, deaths and culls were attributed to cases of bronchopneumonia (three), while in the group pens, three calves died of gastro-intestinal disorders and four were culled due to prolonged poor appetite. In addition, some calves in both housing systems were eliminated as a result of poor growth. Growth rate and feed conversion of the calves slaughtered at a normal weight were comparable in both housing

Table 3.1 Number of calves removed and production results in individual crates and group pens with straw bedding.

	Ind.	Group
Total number of calves*	94	99
Days in unit	149	149
Deaths	2	3
Culls	1	4
Eliminations	1	3
Growth rate (0-20 w) in g/day	1192	1218
Feed conversion (0-20 w)	1,53	1,50
Killing out percentage	63,39	62,53
Hb content at 20 weeks (g/100 ml)	8,1	9,0

*: two female calves excluded

systems. In the crates, the killing out percentage was slightly higher and the haemoglobin (hb) content was somewhat lower than in the group pens.

Table 3.2 Slaughter quality, rated from 1 (bad) to 10 (excellent), in individual crates and group pens with straw bedding.

	Ind. (N = 90)	Group (N = 89)
Meat colour	7,1	7,0
Meat cover	7,2	7,2
Fat colour	7,9	7,9
Fat cover	5,8	6,0

Slaughter quality traits (table 3.2) were comparable in both housing systems. All traits were quite satisfactory, except fat cover which was rather excessive. The total amount of milk replacer left over by the calves slaughtered at a normal weight during the fattening period was only 1,6 kg powder/calf in the crates and 1,9 kg powder/calf in the group pens.

Concerning the health status of the calves, omphalitis and apathy were the most frequent ailments in both housing systems during the first two weeks after arrival (table 3.3). After two weeks, the illnesses most often treated were respiratory diseases. These occurred mainly during the period of 4 to 8 weeks after arrival and were more frequent in the crates than in the group pens. In general, the duration of treatment was slightly longer in the crates than in the group pens (table 3.3). When more than 10% of the calves in a unit showed symptoms of respiratory diseases or enteric disorders, the feed was medicated for 5-10 days (chapter II), which happened on average 5,0 times per experiment.

Table 3.3 Medical treatments during the first two weeks of the fattening period (above) and thereafter (below) in individual crates and group pens with straw bedding.

	Ind. (N = 90)		Group (N = 89)	
	Cases per 100 calves	Days/case	Cases per 100 calves	Days/case
Gastro-intestinal disorders	7,8	3,4	2,2	1,0
Respiratory diseases	0,0	0,0	1,1	3,0
Apathy	11,1	.	14,6	.
Omphalitis	16,7	1,9	7,9	1,0
Miscellaneous	0,0	0,0	2,2	1,0
Gastro-intestinal disorders	0,0	0,0	9,0	2,5
Respiratory diseases	55,6	3,3	29,2	3,2
Apathy	21,1	.	11,2	.
Omphalitis	0,0	0,0	2,2	1,0
Miscellaneous	2,2	1,0	1,1	3,0

. : not relevant

The average amount of straw supplied in the group pens during the entire fattening period amounted to 23,3 kg/calf for feeding and 106,3 kg/calf for bedding. In the crates, 7,1 kg straw/calf/fattening period was provided for feeding. The provision of the straw and the removal of the dung in the group pens took 138,7 min in total per calf during the fattening period, whereas the supplying of straw and the removal of spilled straw in the crates took only 32,6 min/calf in total during the fattening period.

The percentage of group housed calves muzzled during the first 6 weeks of the fattening period to prevent preputial sucking and the average number of days this treatment was imposed varied greatly between experiments (table 3.4). In experiment 3, the recurrence of preputial sucking among most calves after removal of the muzzles was tolerated until this activity ceased at about 8 weeks. The muzzling of large numbers of calves was considered impractical. In experiment 5, when again most calves engaged in preputial sucking, all animals were tethered after initial muzzling. Tethering at the feeding gate between partitions obstructed the sucking at each other's prepuce and after release, the occurrence of preputial sucking was negligible. The reasons for the large number of incidents of preputial sucking in these two experiments are not clear.

Table 3.4 Percentage of calves muzzled in group pens with straw bedding and the average duration of muzzling in different experiments.

Experiment	Calves muzzled (%)	Days muzzled
1	25	14
2	16	31
3	88	7[a]
4	5	21
5	65[b]	8[c]

a) after removal of the muzzle preputial sucking continued until 8 weeks after arrival
b) three calves muzzled again after 6 weeks
c) after removal of the muzzle all calves were tethered from weeks 3 to 6

Inspection of the abomasum in one experiment revealed the occurrence of erosions, ulcers and scars in fairly similar frequencies in both housing systems (table 3.5). These lesions were located in the pyloric region.

Table 3.5 Percentage of abomasums affected with erosions, ulcers or scars in individual crates and in group pens with straw bedding. An abomasum could be affected by a variety of lesions.

	Ind.	Group
Number of abomasums	18	17
Erosions (%)	55	47
Ulcers (%)	28	18
Scars (%)	6	0
Total affected (%)	83	65

Individual crates vs group pens with slatted floors

MATERIALS AND METHODS

Animals, housing and management

In each of four consecutive experiments, 12 calves were in individual crates and 35 calves were in seven groups of five, constituting a total of 48 individually housed calves and 140 group housed calves. All animals were male (except two) and about one week old at arrival. The calves were housed according to weight; the average weight in crates and group pens was similar: 41,4 kg and 41,5 kg respectively. The starting haemoglobin (hb) content in the blood of the calves was 11,6 g/100 ml and 11,4 g/100 ml in crates and group pens respectively. The breed was black and white in three experiments and red and white in one experiment.

In unit II, 12 crates and 7 group pens were installed (fig. 3.4). The crates (1,70 m long, 0,70 m wide) were comparable to those in unit I. The method of tethering the calves was also similar, whereas the control passage was 0,70 m wide instead of 0,80 m. A metal tray was attached to the sidewall of the crate about 0,50 m above floor level and used for the provision of straw cobs (fig. 3.5, photo 3.3).

The group pens (2,40 m deep, 3,05 m wide) were surrounded by galvanized partitioning fences, a mainly wooden feeding gate (1,10 m high) and a wall in the backside (fig. 3.6, photo 3.4). The floor consisted of wooden slats (slat 70 mm, slot 30 mm) with wooden or aluminium laths in the transverse direction, about 0,70 m apart (photo 3.4). This was the same for pens 1, 3, 4 and 5. The same slats were present in pen 2, 6 and 7, but here the back half of the pen consisted of concrete slats (slat 80 mm, slot 20 mm). In contrast to the group housed calves in unit I, those in unit II were tethered to the feeding gate by neck chains (length 0,35 m) during the first 6 weeks after arrival. They were separated by wooden partitions (0,60 m long, 0,80 m high), which were removed after this 6 week period. Serving the provision of straw cobs, a trough was positioned in the door of each group pen. (fig. 3.6, photo 3.4).

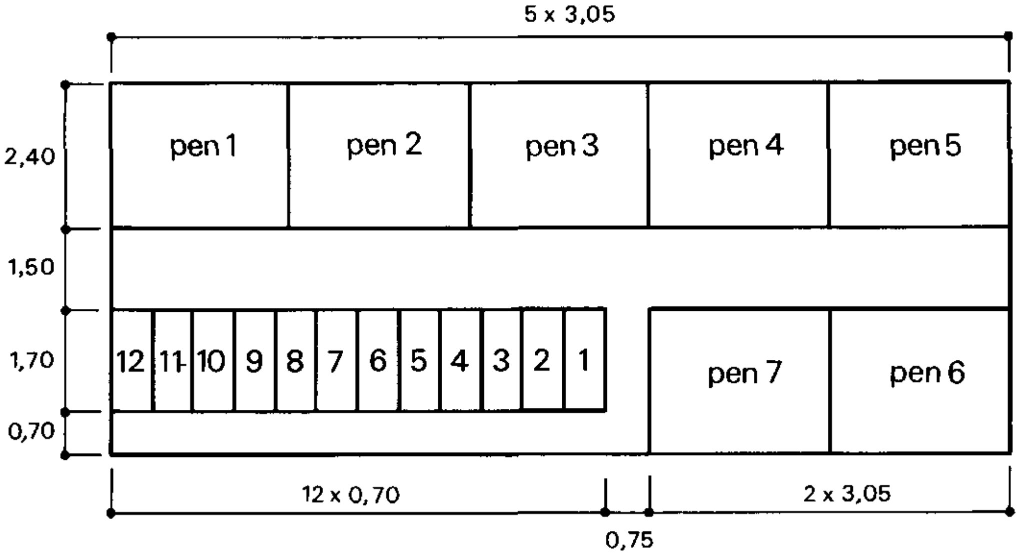

Fig. 3.4 General view of unit II. Dimensions in metres.

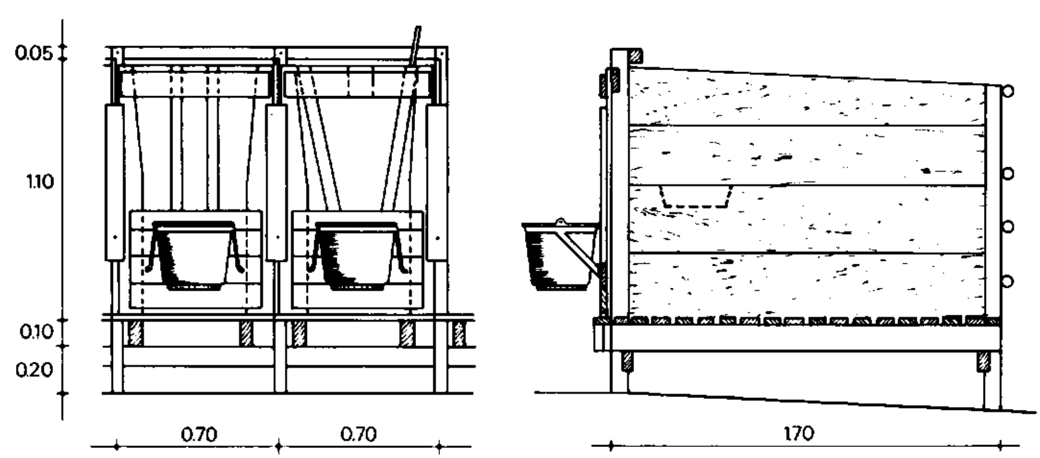

Fig. 3.5 Front and side view of two individual crates with limited supply of straw cobs (unit II). A tray is attached to the sidewall of each crate. Dimensions in metres.

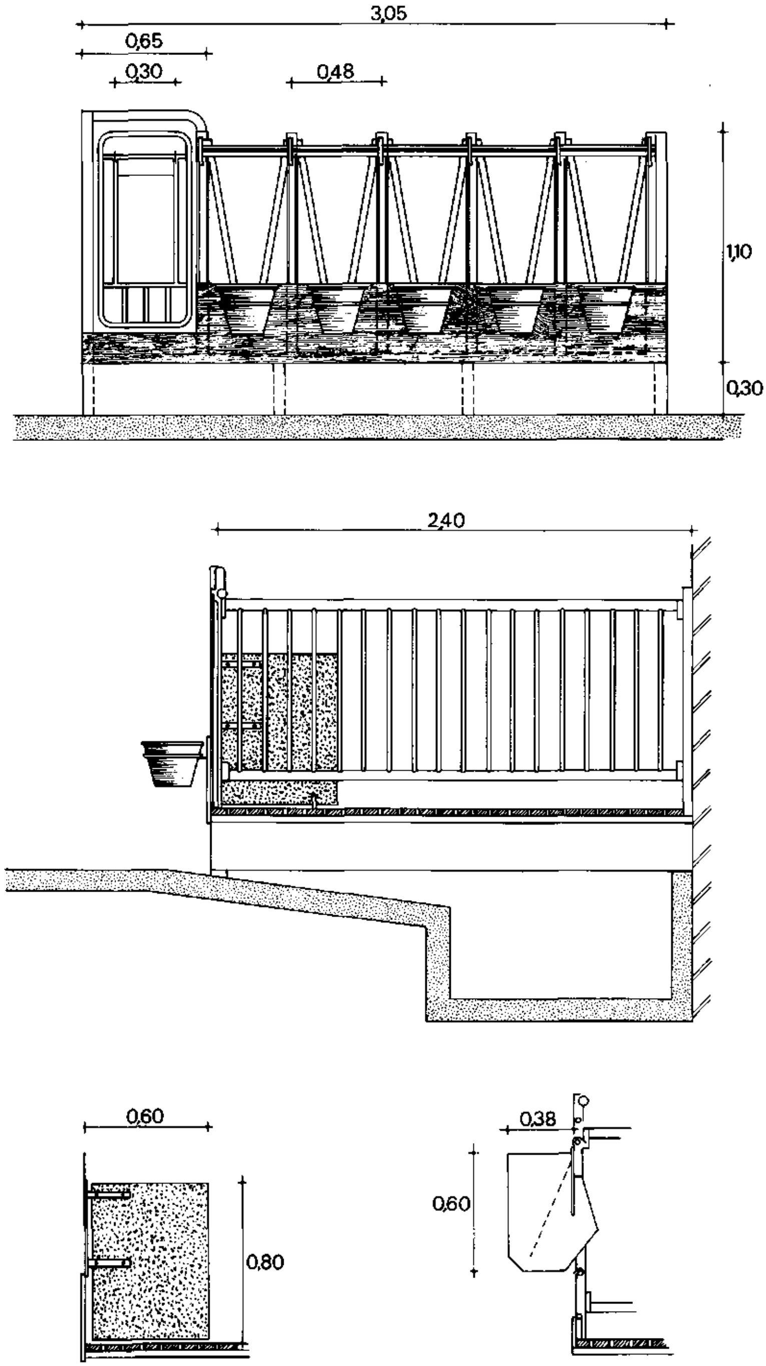

Fig. 3.6 Front and side view of a group pen with a slatted floor and a limited supply of straw cobs, equipped for five calves (unit II). The partitions (4 in one group pen) are only present during tethering. The feeding trough is positioned in the door of the pen. The feeding gate is open. Dimensions in metres.

Photo 3.3 Individual crate with limited supply of straw cobs (200 g/calf/day) in a tray. The front part of this crate has been removed for clarity of presentation; it is still present in the two adjacent crates.

The provision of a milk replacer (and water), weighing, blood sampling, health check and treatment of illnesses was carried out as in the previous series of experiments. Cobs (diameter 16 mm, length 15-20 mm) of chopped straw (fibre length 6-8 mm) with an average iron content of about 120-130 ppm were supplied each day at about half an hour after the morning feeding. In the first two experiments this was done from week 9 onwards, in the last two experiments from week 7 onwards. These supplies of straw cobs amounted to 200 g/calf/day in the individual crates and 1 kg/five calves/day in the group pens.

In the group pens, diseased calves with a low drinking rate were sometimes tethered to the feeding gate for several days, instead of being transferred to another calf-house. Usually, they were eliminated from the calculations afterwards. Liveweight before slaughtering was not determined since weighing was no longer practised at the slaughterhouse. Besides, there was no reason to suspect a difference between both housing systems concerning the killing out percentage (calculated from the liveweight and the carcass weight), because roughage supply, being a major determinant of the killing out percentage, was equal in crates and group pens. In all experiments, the temperature was registered incidentally; it fluctuated between $-1\,^{\circ}C$ and $+27\,^{\circ}C$ (appendix 2A).

Photo 3.4 Group pens with wooden slatted floors provided with laths transversely to the slats. The calves are tethered by neck chains and separated individually by partitions during the first 6 weeks; after the untethering of the calves, the partitions are removed and 1 kg of straw cobs is supplied daily in the trough which is situated in the door of the pen. This photograph shows the self-yoking feeding gate which was used in the experiments described in chapter VII.

Observations

The same characteristics of production, health and labour were recorded as in the previous series of experiments. As an exception, the killing out percentage could not be calculated for reasons mentioned above. Furthermore, because all the calves were tethered during the first 6 weeks, no observations were performed on preputial sucking in this period.

RESULTS

Deaths and culls occurred only in the group pens (table 3.6), due to omphalitis (three), bronchopneumonia (two) and tympany (one). In the crates, only one calf was eliminated for poor growth, whereas in the group pens seven calves were eliminated as a result of poor appetite (six) and poor growth (one). After exclusion of these calves, the differences in growth rate and feed conversion between group pens and individual crates were very small (table 3.6). The haemoglobin (hb) content of the blood of the calves was generally rather high.

Table 3.6 Number of calves removed and production results in individual crates and group pens with slatted floors.

	Ind.	Group
Total number of calves*	47	139
Days in unit	150	152
Deaths	0	3
Culls	0	3
Eliminations	1	7
Growth rate (0-20 w) in g/day	1230	1194
Feed conversion (0-20 w)	1,46	1,51
Hb content at 20 weeks (g/100 ml)	9,9	9,3

*: two female calves excluded

Slaughter quality traits were satisfactory (table 3.7), with only minor differences between the two housing systems. The total amount of milk replacer powder left over (by the calves slaughtered at a normal weight) during the fattening period was only 0,6 kg/calf in the crates and 1,9 kg/calf in the group pens.

Table 3.7 Slaughter quality, rated from 1 (bad) to 10 (excellent), in individual crates and group pens with slatted floors.

	Ind. (N = 90)	Group (N = 89)
Meat colour	7,0	7,3
Meat cover	7,4	7,1
Fat colour	6,7	7,0
Fat cover	6,1	6,4

With respect to the health of the calves, apathy and omphalitis were more frequent in the crates than in the group pens during the first two weeks after arrival (table 3.8). After two weeks, the incidence of respiratory diseases was relatively high in the group pens, in relation to both the frequency of other diseases in the same housing system and the frequency of illnesses in the crates (table 3.8). This tendency appeared in all four experiments. The total number of various other ailments such as tympany, arthritis, otitis,

Table 3.8 Medical treatments during the first two weeks of the fattening period (above) and thereafter (below) in individual crates and group pens with slatted floors.

	Ind. (N = 46)		Group (N = 126)	
	Cases per 100 calves	Days/case	Cases per 100 calves	Days/case
Gastro-intestinal disorders	13,0	2,8	10,3	2,2
Respiratory diseases	0,0	0,0	4,0	2,4
Apathy	45,7	.	31,0	.
Omphalitis	19,6	1,9	11,9	1,6
Miscellaneous	0,0	0,0	0,0	0,0
Gastro-intestinal disorders	2,2	2,0	0,8	1,0
Respiratory diseases	19,6	3,2	42,9	3,7
Apathy	15,2	.	64,3	.
Omphalitis	0,0	0,0	0,0	0,0
Miscellaneous	19,6	3,0	24,6	1,7

. : not relevant

lice infestations and mange was substantial in both housing systems. A few cases of tail nibbling, causing wounds and inflammation, were observed in the group pens in one experiment. Generally, the duration of the treatments was longer in the crates as compared to the group pens. The feed was medicated for all calves over several days, on average 5,5 times per experiment.

The total quantity of straw cobs provided during the fattening period was 13,2 kg/calf in the crates and 14,4 kg/calf in the group pens. Supplying these cobs from week 9 onwards took 15,2 min/calf/fattening period in the crates and 17,1 min/calf/fattening period in the group pens. The incidence of various lesions of the abomasal mucosa as recorded in one experiment was comparable in both housing systems (table 3.9).

Table 3.9 Percentage of abomasums affected with erosions, ulcers or scars in individual crates and group pens with slatted floors. An abomasum was sometimes affected by a variety of lesions.

	Ind.	Group
Number of abomasums	11	30
Erosions (%)	45	50
Ulcers (%)	27	30
Scars (%)	27	36
Total affected (%)	63	86

DISCUSSION

The results of the experiments on group housing with straw bedding will be fused with those of the research on group housing with slatted floors. Essential differences in the outcome of both parts of this study will be regarded explicitly. Obviously, the limited data presented in this chapter do not allow firm conclusions; nevertheless, they provide a valuable first impression on various husbandry aspects of group housing in comparison to individual housing.

Growth rate and feed conversion of calves slaughtered at a normal weight in group housing with and without straw bedding on the one hand and in individual housing on the other were comparable (tables 3.1 and 3.6). These results are somewhat more favourable than those obtained on practical farms with calves in crates (Van Horne, 1985. Personal communication). This shows that group housing is not inconsistent with fast growth and favourable feed conversion. Preliminary results of Smits (1984), who recorded growth and feed conversion in individual crates and in group pens with slatted floors on practical farms, support this conclusion. Slaughter quality was satisfactory and comparable in group pens with and without straw and in individual crates (tables 3.2 and 3.7). However, a relatively large number of group housed calves died or were culled or eliminated (tables 3.1 and 3.6). The reasons for these losses are related to the health of the calves.

Both on straw bedding and on slatted floors the culls and eliminations in the group pens were in fact due to a general characteristic of diseased calves: a hesitating approach to the bucket and a low drinking rate. In the group pens, these calves were usually pushed aside by penmates, before they were able to ingest their feed. This thwarted the treatment of illness by medicination of the milk replacer. The detection of diseased calves in group pens was not impaired in this study, but this may be more cumbersome on practical farms with more groups and less qualified herdsmen.

In general, the health status of the remaining calves, assessed by the frequency and duration of the treatments imposed, was no worse in the group pens than in the crates. Most diseases occurred during the first 8 weeks of the fattening period, when the calves in group pens with slatted floors were mainly tethered in relative isolation. In the group pens with straw bedding, in which calves were loose housed from arrival, the higher chances of mutual contamination may have been counterbalanced by possibly increased resistence against disease. Namely, immunological reactions may be enhanced when behavioural restrictions are diminished, as found in chickens (Siegel, 1980) and in pigs (Metz and Oosterlee, 1981).

An exception was the incidence of respiratory diseases, which was higher in the group pens on slatted floors than in the crates in the same unit. For this reason, apathy was greatly enhanced in these group pens. Since in group pens with straw bedding, the frequency of respiratory diseases was lower than in the crates, the occurrence of these ailments might have been reduced by the presence of straw on the floor, which increases thermal comfort of the calves (Webster, 1984). It is not unlikely that calves in group pens are more vulnerable to respiratory diseases than crated calves as a result of possibly increased exposure to draughts or physical contacts with congeners, which facilitates mutual contamination (Wood, 1980). The variation in the occurrence of respiratory diseases found in this study is in agreement with data presented by Postema (1985) on calves in crates. The influence of group housing on the occurrence of respiratory diseases and the relevance of straw bedding in this respect, requires further investigation.

The calves on straw bedding had a lower killing out percentage and a higher haemoglobin content than their crated congeners (table 3.1). This is a result of the high intake of straw in the group pens which stimulates filling and development of the prestomachs and increases haemoglobin levels of the blood, due to small quantities of soluble iron which straw contains (Unshelm et al., 1979). When straw cobs were provided, haemoglobin levels were also rather high (table 3.6); meat colour however, was considered adequate in both cases of roughage supply (tables 3.2 and 3.7).

In the group pens with straw bedding, the provision of huge quantities of straw and the removal of the dung by hand was very labour intensive. The fact that such activities can only be partly mechanised implies that a bare slatted floor is preferred to the use of straw bedding in further research. The time required to supply straw cobs was about equal in group pens with slats and in crates. Total labour requirements, comprising all activities connected to the operation of the housing system, such as stalling, feeding, health control and medical treatment, tethering and untethering the calves and cleaning the pens are also similar in group pens with slatted floors and in individual crates (Giesen, 1984). The relevance of straw bedding for the well-being of the calves will be discussed briefly in the next chapter.

In the first weeks after arrival, preputial sucking was detected in various degrees in each experiment when the calves were loose housed on straw bedding (table 3.4). Muzzling of the calves to prevent this behaviour obstructed licking as a social, exploratory and grooming activity and it also prevented the intake of roughage and impaired olfactory exploration. For this reason and because of its limited effectiveness in preventing the ingestion of urine, muzzling is very unsatisfactory.

The etiology of abomasal lesions and their relationship to suffering is still largely unknown. The only relationship established is an increase of the number of calves with abomasal lesions when roughage is provided (Groth et al., 1979; Bogner et al., 1981; Van Putten, 1982), but this does not account for their appearance in the first place (Bogner and Matzke, 1982). According to Mercier (1975) an apparently more favourable environment, viz. group pens instead of individual crates, may not reduce the occurrence of these lesions. This finding is supported in the present study, as the group housing systems tested here did not diminish the frequency of this undesirable phenomenon (tables 3.5 and 3.9). The number of abomasums inspected in this investigation, however, was low.

CONCLUDING REMARKS

- Group housing with or without straw bedding seems not incompatible with fast growth and favourable feed conversion and slaughter quality, but the losses in these housing systems were high in comparison to those in the individual crates. This was mainly due to difficulties concerning the medical treatment of diseased calves. Detecting illness was no problem in this study, due to the intensive surveyance of the animals. The restraint of all calves at feeding, which may be accomplished by the use of self-yoking feeding gates (Zappavigna, 1983) or the isolation of severely affected calves by transfer to individual crates, facilitates treatment of diseased animals and may reduce losses. Moreover, self-yoking feeding gates are helpful in detecting diseased calves, which can be particularly valuable on practical farms, when health inspection is not as intensive as in the present study.

- The absence of straw as a bedding material in group pens is indeed labour saving, but its effect on the occurrence of respiratory diseases needs to be investigated.
- The tethering of the calves for the first 6 weeks after arrival appears effective in the prevention of preputial sucking and can be followed by loose housing. However, this method reduces the behavioural abilities of the calves without taking into account the causation of this behaviour. Therefore, the investigation and removal of the causes of preputial sucking in group housed calves has a high priority.

IV Individual housing vs group housing: behavioural aspects

INTRODUCTION

Animal welfare is a function of the adaptation of animals to their environment. As a guideline, welfare is defined as the existence in harmony with the environment from a physiological and ethological point of view (Lorz, 1973). Therefore, behavioural studies can be used to assess the well-being of veal calves in different housing systems. For this purpose, an extensive study was carried out on the behaviour of veal calves in individual crates and in both types of group pens described in chapter III. The present comparison covers the period from 8 to 20 weeks after arrival and does not refer to the first weeks of the fattening period when some calves were muzzled or tethered.

Available data on the behaviour of calves in individual crates and group pens are limited. This lack of information is surprising, since in the last decades several studies have been concerned with the minimum standards for crate width, dependent on the behaviour of the calves. Most of these investigations were on lying behaviour only, because this is most obviously restricted in crates of traditional width. Scheurmann (1971) recommended a minimum crate width that is equal to croup height at slaughter (more than 1 m), which allows the calf to lie completely stretched out on its side. Van Putten and Elshof (1982a) introduced the average lying breadth as a parameter for minimum crate width. They concluded that calves with a body weight of 220 kg require crates of at least 0,70 m in width. These studies did not consider calf responses to spatial restrictions, nor were they concerned with behaviours other than lying. This information however, is highly relevant for the assessment of welfare in both housing systems.

Cattle are highly social animals as apparent from their strong tendency to aggregate with congeners, forming large herds with a well-developed social organisation. This organisation relies upon mutual recognition of herd members, allowing affinitive bonds and forms of cooperation to develop, with distinct roles for individual animals (Schloeth, 1961; Leuthold, 1977; Reinhardt, 1980). Repeated fighting in competitive interactions is avoided since the animals usually acknowledge each others physical capabilities, which are exhibited during play activities (Steinel, 1977) and aggressive encounters (Syme and Syme, 1979). Group housing may promote various social interactions, such as licking, head butting and mounting, whereas individual housing obstructs most of them.

Furthermore, the familiarity of the calves with their total environment may be enhanced in the group pens as a result of the possibility to move around and explore the surroundings. In circumstances of restricted movement, sterile environment or in the absence of key stimuli, stereotypies may develop (Kiley-Worthington, 1977; Cronin, 1985). In calves, the repeated and prolonged performance of fairly similar sequences of licking or scraping objects and tongue playing without any clear purpose may constitute such stereotypies. A low level of occurrence of these activities in group pens as compared to crates may reflect a possible contribution of group housing to the welfare of the calves.

The presence of a straw bedding in some of the group pens may influence the behaviour of the calves as compared to a slatted floor of wood or concrete. The straw bedding may contribute to lying comfort and improve the grip on the floor while standing, which is of particular importance in group housing because the mobility of the calves is higher than in individual crates. Moreover, since the straw bedding represents an ad libitum provision of straw, it may stimulate the intake of roughage and rumination in comparison to the restricted supply of straw or straw cobs.

The present chapter provides comparative data on the behaviour of calves in individual crates and in group pens and shows necessary behavioural compromises; these are subsequently evaluated in terms of their biological significance.

- Apart from a quantitative assessment of different lying postures of the trunk and legs in crates and group pens, this study reports on the various postures of the head while lying. Some of these postures, such as the lying with the head sideways on the floor or on the shoulder, belly or hindlegs demand lateral space and therefore their performance may be hampered by the sidewalls of the crate.
- For the same reason, the grooming of the hindquarters may be thwarted and this is also investigated.
- Furthermore, the nature and frequency of social behaviour in individual crates and in group pens is compared.
- The behavioural consequences of restrictions to moving around and exploring the surroundings in the crates are discussed.
- It is also examined if group housing reduces the occurrence of stereotypies such as forms of licking or scraping of objects and tongue playing.
- Briefly, the influence of straw on lying behaviour, mobility, roughage intake and rumination of the group housed calves is mentioned.

The general question of this research is to what extent calves in individual crates are restricted in their behaviour in comparison to calves in group pens and how they deal with their situation.

MATERIALS AND METHODS

Animals, housing and management

The animals, housing systems and management were the same as described in chapter III. The observations were performed during experiment 4 and 5 in unit I, which comprised individual crates (100 g straw/calf/day for feeding) and group pens with straw bedding (and ad libitum straw in baskets) and during experiment 1, 2, 3 and 4 in unit II, which involved individual crates (200 g straw cobs/calf/day for feeding) and group pens with slatted floors without straw bedding (1000 g straw cobs/pen/day for feeding). The group pens each contained five calves. Minimum and maximum ambient temperatures, which may influence the performance of several lying postures (Van Putten and Elshof, 1982a), were recorded on observation days (appendix 2A).

Observations

The behaviour of the calves in both housing systems was registered over a 24 hour period in weeks 8, 12, 16 and 20 after arrival. For technical reasons, observations were interrupted for half an hour during each feeding period. By means of instantaneous sampling (Altmann, 1974) the proportion of the observation time which the calves spent in different postures and activities was estimated. The behaviour of each calf was recorded once every 10 minutes during one 24 hour period. This time interval permitted an accurate estimation of relatively long lasting behaviours such as lying postures and ruminating (Tyler, 1979). Short lasting behaviours, such as grooming or play activities, were estimated less accurately but the comparison between individual and group housing remains meaningful.

During observations, the observer walked cautiously up and down the feeding passage for six or eight consecutive hours, before being relieved. In this way, one period of 24 hours was covered by three or four observers. 1-2 seconds were required to observe each calf and to identify its behaviour, which was subsequently noted down in numeric codes on a registration form. The ethogram used is defined in chapter II; the postures of the trunk and legs, the position of the head and the performance of different activities were recorded separately. For clarity of presentation, the position of the hindlegs and forelegs is regarded separately; both types of lying on the brisket with the hindlegs stretched were summated (lying on brisket, hindlegs stretched), as were both types of lying on the brisket with the foreleg(s) stretched (lying on brisket, foreleg(s) stretched).

Statistics

During one period of 24 hours, 138 observations per calf were obtained. The frequencies per 24 hours of all categories of behaviour were computed from this, for each calf separately. The frequencies of the different lying postures were expressed as a percentage of the total frequency of lying. The incidence of all non-lying activities was expressed as a percentage of the total number of observations.

Since the behaviour of the different calves in one pen may be substantially correlated, each pen was considered as an experimental entity, in agreement with Hoekstra en Jansen (1985). In each experimental entity, the average (level) and linear trend (development) over weeks 8, 12, 16 and 20 were computed for several categories of behaviour. An analysis of variance (Cochran and Cox, 1957) was carried out on these quantities with the two experiments in unit I and the four in unit II as replicates (blocks). The differences between individual and group pens in the average and trend of several behaviours were analysed against variance within experiments. In this study, mainly differences in average will be discussed.

RESULTS

The data refer to the four experiments in group pens with wooden slatted floors and a limited supply of straw cobs and the corresponding individual crates (unit II) as shown in table 4.1. The behaviour of calves in group pens with straw bedding and in crates with a limited supply of straw (unit I) will only be presented when this is relevant in assessing the influence of straw bedding on calf behaviour. The calves in one group pen are treated as a statistical entity.

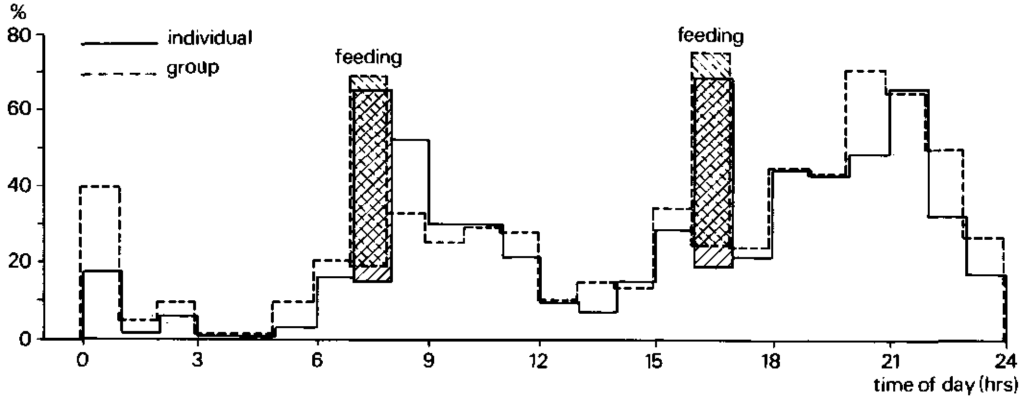

Fig. 4.1 Duration of standing for consecutive hours during one 24 hour period in individual crates and in group pens with slatted floors at 20 weeks after arrival. The values indicated are percentages of the total number of observations per hour. Sunrise at 6.00 h; sunset at 21.30 h. N_{ind} = 12; N_{group} = 7.

Activity

As illustrated in fig. 4.1, the general pattern of activity (standing) was similar in individual and group housing, with peaks during feeding and moderate activity during the day in between feedings. After feeding in the afternoon, considerable activity was observed until midnight. From midnight to sunrise, activity was very low. The activity of five calves within the same pen was fairly synchronized, which was especially clear at the beginning and ending of activity periods: in some pens all calves were lying, whereas in other pens, all calves were standing.

Table 4.1 Different lying postures and activities in individual crates and group pens with slatted floors. The calves in both housing systems were provided with about 200 g straw cobs/calf/day. The values shown are mean percentages and standard deviations (Kendall and Buckland, 1982) over weeks 8, 12, 16 and 20 of four experiments comprising a total of 552 observations per individual.

Behaviour	Ind. (N = 46)	Group (N = 28)	p
Total lying	73,97 (4,56)	68,14 (1,34)	**
Lying postures of the trunk and legs (a)			
Lying on side	0,77 (0,92)	2,24 (0,94)	**
Lying on brisket, hindlegs stretched	1,52 (0,98)	8,05 (2,21)	**
Lying on brisket, foreleg(s) stretched	26,30 (7,10)	13,30 (2,38)	**
Lying postures of the head (a)			
Lying, head backwards	14,84 (5,93)	22,21 (3,28)	**
Lying, head forwards	6,57 (3,12)	3,13 (1,03)	**
Lying, head on object	1,44 (1,21)	0,33 (0,21)	**
Lying, head on congener		5,22 (1,57)	
Lying, head upright	77,16 (5,67)	69,13 (2,99)	**
Comfort behaviour and stretching (b)			
Total self licking	2,66 (1,19)	3,84 (0,84)	**
Licking hindquarters (3)	0,73 (0,43)	1,07 (0,39)	**
Licking forequarters (3)	0,93 (0,57)	2,10 (0,68)	**
Licking forelegs (3)	1,04 (0,60)	0,73 (0,21)	*
Rubbing (3)	0,61 (0,44)	0,72 (0,38)	n.s.
Scratching	0,05 (0,11)	0,16 (0,11)	**
Nose licking	1,90 (0,81)	1,06 (0,30)	**
Stretching	0,14 (0,18)	0,25 (0,11)	**
Social activities (b)			
Smelling congener	0,03 (0,08)	0,51 (0,13)	**
Licking congener	0,10 (0,16)	2,53 (0,64)	**
Sucking congener	0,01 (0,06)	0,32 (0,22)	**
Preputial sucking		0,13 (0,11)	**
Urine drinking		0,17 (0,06)	**
Playing°	0,39 (0,43)	1,11 (0,25)	**
Exploration and stereotypies (b)			
Smelling object	0,99 (0,58)	1,05 (0,25)	n.s.
Licking object	4,17 (1,58)	5,09 (1,01)	**
Scraping object	2,16 (1,12)	3,19 (0,83)	**
Tongue playing	2,05 (1,66)	1,86 (1,06)	n.s.
Eating straw and ruminating (b)			
Eating (2)	1,23 (0,47)	1,45 (0,23)	n.s.
Ruminating (2)	8,28 (2,50)	9,55 (1,12)	n.s.

a : percentage of total lying / b : percentage of total observations
n.s.: not significant /*:0,01 < p ≤ 0,05 /**: p ≤ 0,01
(2) or (3): concerns only two or three experiments
°: see table 4.3

Postures of the trunk and legs

The incidence of lying was higher in the crates than in the group pens (table 4.1). Lying behaviour can be characterised by the position of the trunk, limbs and head. Subsequent to lying down, the group housed calves first lay with the forelegs tucked under the body and the hindlegs bent, slightly to one side. After a while they used to stretch and bend the fore- and hindlegs and to recline and raise the head in succession, assuming a large variety of lying postures. (Scheurmann (1971) described 40 of them.) This sequence was usually concluded by the bending of all legs, which after a while was followed by standing up. In the next lying period, each calf generally reclined with its hindlegs to the opposite side of the body.

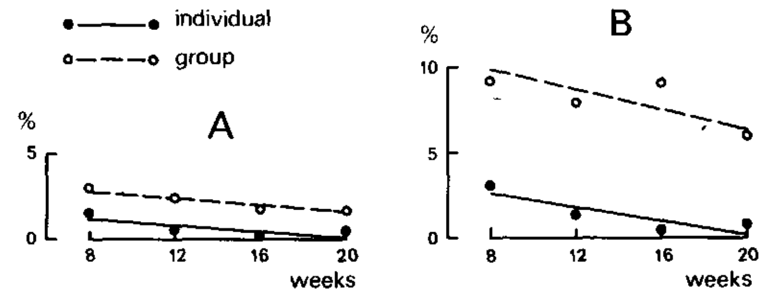

Fig. 4.2 Lying on the side (A) or on the brisket with both hindlegs stretched (B) in individual crates and group pens with slatted floors from week 8 to 20. The lines show the overall average and trend of these lying postures in both housing systems while the dots indicate the averages per week. The values indicated are percentages of total lying. $N_{ind} = 46$; $N_{group} = 28$.

By comparing the incidence of different positions of the trunk, limbs and head in group pens and individual crates, deviations in the lying behaviour of calves in crates can be detected. At 8 weeks, when croup height is about 0,90 m, calves in crates of only 0,65-0,70 m in width still manage to lie completely stretched out on the side every now and then (fig. 4.2A). They do so by stretching both fore- and hindlegs in a forward direction while lying on the side (fig. 4.3). This is a nuance of the contention by Scheurmann (1971) and Van Putten and Elshof (1982a) that crate width should equal croup height to permit lying on the side with all limbs stretched.

However, apparent from the lower incidence of this lying posture in the crates as compared to the group pens, this way of adapting to the restricted lying space was not successful. By week 16 after arrival, the lying on the side and the stretching of both hindlegs while lying on the brisket was seldom seen in the crates (fig. 4.2); the calves were then lying almost exclusively on the brisket with one hindleg more or less tucked in between

Fig. 4.3 Lying on the side, normal (left) and abnormal (right).

the sidewall and the trunk. However, it was still occasionally observed that the calves tried to assume lying postures with the hindlegs stretched or tried to lie with the shoulder on the floor of the crates, but they rarely succeeded in doing so. The stretching of one or both forelegs while lying was more frequent in the crates than in the group pens (table 4.1). The total frequency of stretching postures was similar in both housing systems and was related positively with ambient temperature (table 4.2).

Table 4.2 The relation between the total incidence of lying postures with hindlegs and/or foreleg(s) stretched in individual crates and group pens with slatted floors during each of four experiments and the average range of ambient temperatures during these experiments. Lying on the side is included twice in this calculation, since hindlegs and forelegs are stretched during the performance of this posture. The mean frequency of the separate lying postures as a percentage of total lying are shown in appendix 2B; the minimum and maximum temperatures per observation week are presented in appendix 2A. N_{ind} = 11/12; N_{group} = 7.

Experiment	Temperature (°C)		2 × lying on side + hindlegs stretched + foreleg(s) stretched (%)	
	Min.	Max.	Ind.	Group
1	3,8	10,0	21,6	17,0
2	17,5	23,0	35,4	34,0
3	7,5	13,0	20,2	18,6
4	13,8	20,3	34,5	32,6

Lying postures of the head

Lying with the head turned backwards occurred more in the group pens than in the individual crates, due to a more drastic decrease over time of this behaviour in the crates (fig. 4.4A). In contrast, the frequency of lying with the head forwards on the floor was higher in the crates than in the group pens since the incidence of this behaviour increased over time in the crates (fig. 4.4B). Supporting the head otherwise, e.g. on objects in the individual crates or on congeners (or objects) in the group pens was least common in the crates (fig. 4.4C). Lying with the head upright, which is complementary to lying with the head supported, was more frequent in the crates than in the group pens due to a rise over time in the frequency of this behaviour in the crates (fig. 4.4D).

Comfort behaviour and stretching

The self licking of the haircoat serves the grooming of hair and skin. Calves of species with extensive maternal grooming rarely lick themselves (Espmark, 1971). Furthermore, suckled calves spend less time licking themselves than calves kept in separation from their mothers (Webster and Saville, 1982). In one of the four experiments, the calves in group pens were infected with lice and engaged in excessively long periods of licking of the hind- and forequarters in weeks 12 and 16. The total duration of these activities amounted to 10% of 24 hours in week 12 and 6% in week 16. During this time, rubbing was increased to levels of 3%. Therefore, in the analysis of system related differences in behaviour, the frequency of licking the haircoat and rubbing was computed for the three remaining experiments only.
As shown in table 4.1, the licking of the hind- and forequarters was more frequent in the group pens than in the crates. In contrast, the forelegs were licked more often in the crates as compared to the group pens. The total frequency of the licking of the haircoat was higher in the group pens than in the crates.

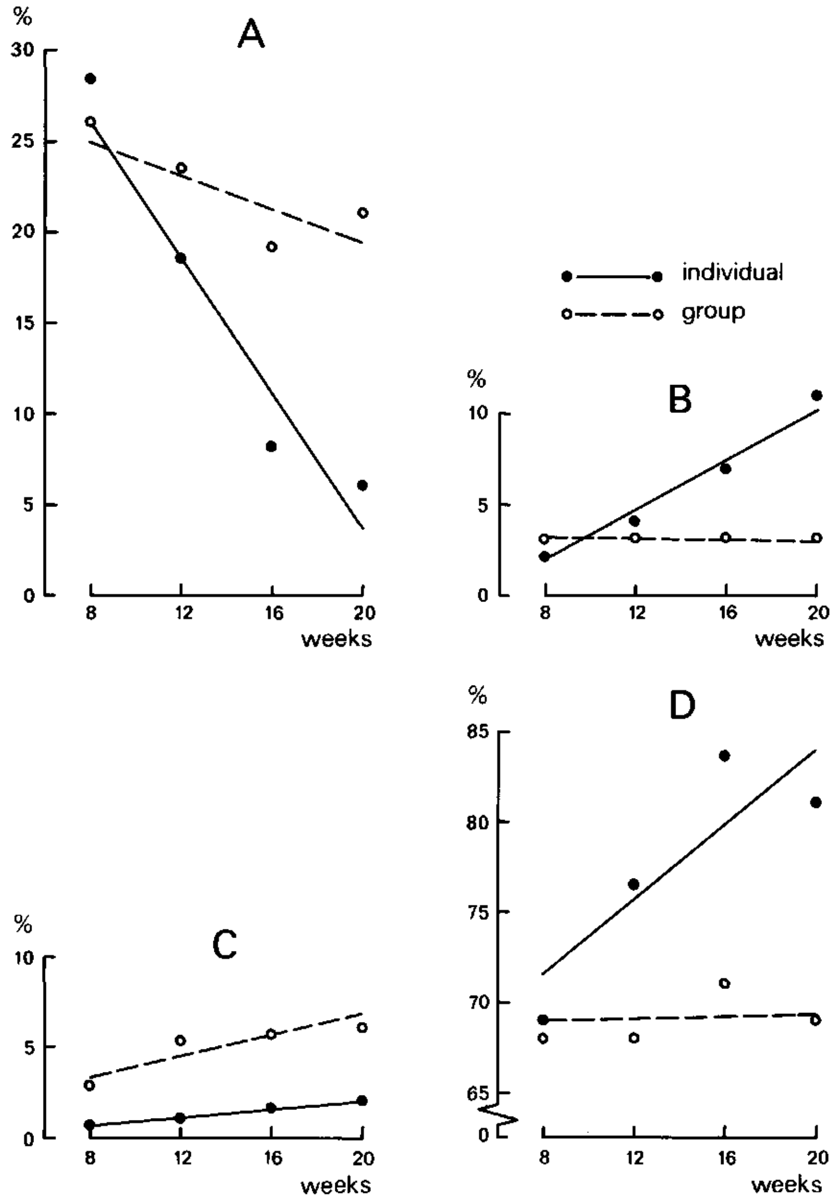

Fig. 4.4 Lying with the head turned backwards (A), reclined forwards (B), on objects or congeners (C) or upright (D) in individual crates and group pens with slatted floors from week 8 to 20. The lines show the overall average and trend of these lying postures in both housing systems, while the dots indicate averages per week. The values indicated are percentages of total lying. N_{ind} = 46; N_{group} = 28.

The rubbing and scratching, mainly directed at the head, neck and shoulders, as reported previously by Kiley-Worthington and De la Plain (1983), contributes to the cleaning of the haircoat on spots that cannot (easily) be licked. The incidence of scratching was higher in the group pens than in the crates, but rubbing was equally frequent in both housing systems (table 4.1).

Nose licking probably serves the removal of mucus and dust particles from the nostrils and the wetting of the muzzle. It occurs regularly following grooming, but it is also frequently observed in connection with other activities. This is illustrated by the total incidence of nose lickings which is high in view of their short duration (a few seconds). It occurred more often in the crates than in the group pens (table 4.1). Stretching, which was usually performed after standing up but which also appeared during lying, was recorded more frequently in the group as compared to the crates (table 4.1).

Social activities

Naturally, group housed calves engaged more often in social activities than individually housed calves, which could only touch each other at feeding times, when the fronts of the crates were open. Only at the end of the fattening period, when the calves were able to stick the snout above the sidewalls, they incidentally engaged in physical contacts with congeners outside of the feeding periods. The calves then held their snout upwards, which was subsequently licked by one of the neighbours. The incidence of this mutual licking was much lower in the crates than in the group pens (table 4.1).

Table 4.3 Playlike activities in group pens with slatted floors, in group pens with straw bedding and in the corresponding individual crates. The values shown are mean percentages of total observations over weeks 8, 12, 16 and 20.

Behaviour	Ind. (N = 46)	Group on slats (N = 28)	p	Ind. (N = 37)	Group on straw (N = 8)	p
Head butting congener		0,58			0,51	
Head butting object	0,11	0,05	n.s.	0,25	0,03	**
Mounting congener		0,26			0,25	
Running		0,08			0,17	
Jumping	0,26	0,11	*	0,37	0,18	*

n.s.: not significant /*:0,01 $< p \leq 0,05$ /**: $p \leq 0,01$

Playlike behaviours comprised head butting, running, jumping and mounting (Reinhardt, 1980). In the group pens, all these activities which usually involved the participation of several penmates, were regularly performed, especially head butting (table 4.3). When running, the calves moved repeatedly from one fence to the other, stopped, turned around and started again. These activities were interspersed by jumping and sometimes a typical baa-ock sound (Brownlee, 1954) was uttered. Running and jumping seemed slightly more frequent in the group pens provided with straw bedding than in those with slatted floors, but head butting and mounting congeners appeared equally often in both types of group housing (table 4.3).

In the crates, the variety of playlike actions was low: only head butting against objects and jumping were observed. Both of these activities were more frequent in the crates than in the group pens (table 4.3). The total incidence of playlike actions however, was higher in group housing than in individual housing (table 4.1). In both housing systems, play occurred predominantly in the evening. Other activities directed at penmates, such as smelling, sucking and urine drinking were seldom or never observed in the crates and somewhat more often in the group pens (table 4.1).

Exploration

Apart from the performance of exploratory activities such as smelling and licking, calves show a constant alertness to visual and auditory stimuli, which even persists during a major part of sleep. In the group pens, the calves move around and occasionally sniff at the walls, railings and floor and lie down preferably with their backs to the wall, which allows them to survey the environment. The crated calves too, spend considerable time smelling at parts of their pen (comparable to group housed calves, table 4.1) but here, only the front of the crate could be explored. Furthermore, visual contact with the surroundings was very limited in the crates, particularly during lying.

When lying, nearly all the calves in the crates rose to their feet at the sound of the door, in contrast to the group housed calves, which in major part remained recumbent, while turning their heads towards the door. Similarly, the sudden appearance of a person in the passage behind the crates startled most of the calves, as indicated by their immediate rising and the movements of the ears, which were directed forwards and backwards in quick alternation. This reaction to someone inspecting the calves did not occur in the group housed calves, which were observed from the feeding passage only.

The licking and scraping of objects is part of tactile and gustatory exploration. Most of these behaviours, however, are characterised by a prolonged repetition of fairly identical movements of the tongue and the teeth at one particular spot. This selectivity, which leads to local excavations of wooden bars and walls, can hardly be attributed to any explorative motivation.

Stereotypies

Sequences of mutually comparable movements, performed over and over again without any apparent function, which regularly occur during the licking or scraping of objects, are also very common in tongue playing. These characteristics fit the general description of stereotypies (Broom, 1983; Wiepkema et al., 1983) which may develop under circumstances of long-term frustration (Wood-Gush, 1973; Ödberg, 1978; Cronin, 1985).

The incidence of both licking and scraping objects was higher in the group pens than in the crates, while the frequency of tongue playing was similar in both housing systems (table 4.1). Contrasting with these results, the occurrence of licking objects and scraping objects was not increased in the group pens on straw bedding as compared to the individual crates with limited straw. Here, the level of licking objects and tongue playing tended to be even lower in the group pens than in the crates (table 4.4). This discrepancy may be related to differences in the availability of roughage, as will be discussed later.

Table 4.4 Some aspects of behaviour in individual crates (100 g straw/calf/day) and group pens with straw bedding and ad libitum straw in baskets. The values shown are mean percentages and standard deviations over weeks 8, 12, 16 and 20 in two experiments, comprising a total of 552 observations per individual.

Behaviour	Ind. (N = 37)	Group (N = 8)	p
Stereotypies (b)			
Licking object	3,64 (1,94)	2,65 (0,21)	n.s.
Scraping object	0,78 (0,72)	0,61 (0,28)	n.s.
Tongue playing	1,67 (1,96)	0,55 (0,26)	n.s.
Eating and ruminating (b)			
Eating	2,25 (1,02)	7,22 (1,31)	**
Ruminating	12,12 (2,91)	21,90 (2,94)	**
Lying on brisket, foreleg(s) stretched (a)	23,20 (6,48)	21,90 (1,39)	n.s.

a: percentage of total lying / b: percentage of total observations
n.s.: not significant / **: $p \leq 0{,}01$

Eating and ruminating

The performance of eating straw cobs and ruminating is computed over experiments 3 and 4 only, since in week 8 of experiments 1 and 2, no straw cobs were provided. During these latter observations in the absence of roughage, the calves indulged in sham rumination for 5-8% daily, in agreement with Gordon (1968). This behaviour consists of slight, irregular and relatively fast chewing movements, following the eructation of hairs and ruminal fluids.

After the provision of 1 kg of straw cobs per pen, once a day in the morning, the group housed calves crowded around the trough for 15 to 20 minutes, standing shoulder to shoulder and eating in turn. They gained access to the trough by pushing one or two penmates aside. When all calves had ceased eating at about half an hour after the supply of straw cobs, only a handful of cobs was left to be eaten later that day. The supplies of straw cobs were consumed completely soon after the first provision in week 7, both in the crates (appendix 3A) and in the group pens. All individuals were regularly observed eating. When given this 200 grams of straw cobs/calf/day, the time required for intake and rumination tended to be higher in the group pens than in the crates, but this difference was not significant (table 4.1).

The calves in the group pens with straw bedding consumed not only straw from the baskets but also from the bedding (appendix 3C). Eating straw and ruminating occurred far more frequently in these group pens than in the individual crates with limited straw supply (table 4.4). As shown in appendix 3B, the intake of straw in the crates was initially low, but gradually increased until at 14 weeks the daily ration of straw (100 g/calf) was in general consumed completely.

Floor type

The three types of floors utilized in the group pens (straw bedding and wooden and concrete slats) differ substantially in qualities essential for lying comfort, such as deformability and isolation (Hannusch, 1970; Wander, 1971). The total duration of different lying postures as measured in the present study can be used to assess the effects of floor type on lying comfort, although other measures may be more sensitive (Unshelm, 1980; Irps, 1983; Graf, 1984). The only difference in lying postures between straw bedding and bare slatted floors of wood or concrete concerned the stretching of one or both forelegs during lying, which seemed reduced on the slats as compared to the bedding (tables 4.1 and 4.4).

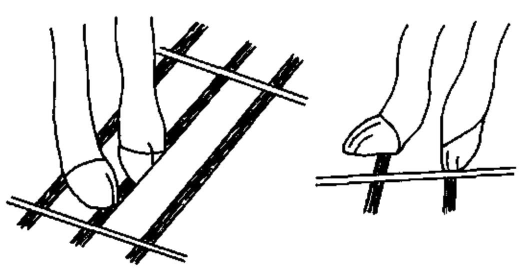

Fig. 4.5 Claws partly in slots.

The grip on the floor while standing is particularly important in the group pens, because of the mobility of the calves. Slipperiness results in the reduction of strenuous activities such as head butting and mounting, as Andreae (1980) has found in fattening bulls on concrete slatted floors, and of running and butting in calves (Brownlee, 1954). In the present study, such effects were not found (table 4.3), although slipping was frequent on wooden slats. This usually occurred in the longitudinal direction of the slats; the small laths on these floors (fig. 4.5) guarded the animals against landing in a straddle as a result of this slipperiness. In the transverse direction, hold was provided by the slots, as indicated by the finding that one in 20 calves standing on wooden slats had one or more claws partly in the slots (fig. 4.5). These phenomena were not observed on concrete slatted floors, which had wider slats and smaller slots and which seemed less slippery than the wooden ones.

DISCUSSION

The fact that group housed calves spend more time standing than those in individual crates is well established in literature (Graf et al., 1976; Reissig-Berner, 1979; Gjestang, 1983) but its significance is puzzling in most cases. Most investigators attribute the longer standing times in group pens to the greater variety of stimuli in this housing system. This may well be the major cause of this phenomenon, but on the other hand, it can not be excluded that the occasional mounting and treading of lying calves by penmates contributes to this difference (Liebenberg, 1965; Czakó et al., 1969; Kreukniet, 1984). Because of these contradictory possibilities, standing time as such is not a very clearcut parameter in relation to calf well-being.

A most obvious purpose of lying is to relax the body musculature. The huge variety of lying postures may aid the relaxation of particular muscle groups. In addition, the usual alternation of lying with the hindlegs to the right and next to the left side of the trunk in consecutive lying periods seems functional for the same reason. This shows that lying represents more than just relieving the weight off the legs. The restriction of most of these lying postures in the crates may counteract the relaxation of the body, in particular of the hindquarters. Attempts to stretch the hindlegs, which persist until the last weeks of the fattening period, suggest that these restrictions cause considerable discomfort to the calves. The lower incidence of stretching in the crates as compared to the group pens is in accordance with this conclusion. Stretching is obviously impaired during lying in the crates.

Moreover, the lying on the side or on the brisket with the legs stretched increases heat loss as demonstrated in pigs (Baldwin, 1974). According to Webster (1984), impairments to lying on the side or on the brisket with both hindlegs stretched may cause thermal discomfort to calves at high environmental temperatures. The present study indicates that the crated calves may compensate for the obstruction of these lying postures by stretching the forelegs, as appears from table 4.2. Behavioural thermoregulation in the crates may therefore merely be altered rather than impaired. In this view, the restriction of the stretching of the hindlegs due to crate design constitutes no major threat to thermoregulation. Still, the actual effect of these restrictions on thermoregulatory processes such as sweating and panting remains to be investigated.

Impairments of lying with the head backwards, which develop in the crates (fig. 4.4), may cause discomfort to the calves for the same reasons as restrictions to other lying postures do. In this case, the relaxation of the neck muscles is pursued by reclining the head forwards on the floor instead, but quantitatively this does not compensate for the thwarting of lying with the head backwards and as a result the head is more often held upright. Apparently, restrictions to lying behaviour in individual crates of 0,65-0,70 m width not only concern lying on the side and on the brisket with the hindlegs stretched, but they also involve lying with the head supported.

In particular, the support of the head is relevant to the performance of various states of sleep (Ruckebusch and Bell, 1970; Merrick and Scharp, 1971). The consequences of the restrictions to reclining the head, as imposed in the crates, cannot be deduced reliably from existing data. It is known that paradoxical sleep (PS), which requires the relaxation of the neck muscles, occurs during 13-14% of a 24 hour period in neonates (Ruckebusch and Barbey, 1971) and 2-3% in adult cows (Ruckebusch and Bell, 1970). The level of PS of the calves in the present study will be in between these values. Since PS occurs less than lying with the head supported (at least 15% of 24 hours) and other states of sleep may be performed with the head in an upright position, the calves in the crates need not be sleep deprived. On the other hand, it is not established if reclining the head forwards is as effective in performing PS as sustaining it backwards. In view of the clear preference for supporting the head backwards on the shoulder, belly or hindlegs, there may be a difference. The performance of sleep and especially of paradoxical sleep in these restricting conditions requires further investigation.

The licking and rubbing of the haircoat serves to clean it, as indicated by the increase of these activities in the presence of lice. In the crates, the licking of all body parts except the forelegs is impaired by the sidewalls and maybe also by the chain, which both restrict the movement of the head. Probably for the same reason, scratching is also reduced in the crates; this behaviour usually implies a sideways stance of the head. Rubbing, which merely requires the presence of constructions such as walls, fences, etcetera was not impaired in the crates.

Apart from its role in haircoat maintenance, grooming is sometimes connected to conflict situations (Immelman, 1976). Such a conflict may arise from the premature termination of an ongoing activity or from the absence of necessary external signals during the action. For instance, the increase in grooming in the absence of roughage (Webster and Saville, 1982) or in social, visual and spatial isolation (Broom, 1982) may be explained in this way. In the present study, the increase in the licking of the forelegs and of the muzzle in the crates may represent such conflict behaviours. Possible causes for underlying conflicts are abundantly present in the crates, as for instance the impossibility to assume particular lying postures, to unrestrictedly groom the fore- and hindquarters, to move around, to explore the environment or to interact with congeners.

The licking of the forelegs may also be termed redirected behaviour (Heymer, 1977): instead of at the fore- and hindquarters, licking is directed at the forelegs. Obviously, this does not fulfill the biological need underlying this behaviour, which is to clean the back, belly or hindlegs. In this context, the restrictions to the licking of the fore- and hindquarters in the crates clearly reduce calf well-being.

Various interactions between penmates can be observed in the group pens, such as the smelling at congeners for individual recognition and mutual licking, which probably has an affiliative and appeasing function. Playful head butting and mounting in order to exercise and explore individual skills are interspersed by jumping, which often serves as an invitation to play (Reinhardt, 1980). Other aspects of social behaviour are reflected by the appearance of clear resting and activity periods, per pen and over different pens (fig. 4.1), indicating mutual synchronisation of behaviour. Also, the relatively long duration of rumination in the group pens was probably a result of social facilitation. Apparently, calves in group pens adjust their behaviour to each other. These social interactions and mutual adjustments lead to the forming of associations between penmates, which in dairy cattle may last for years after mixing with other groups (Broom and Leaver, 1978).

Of course, the number of social behaviours in the crates was very low. Head butting was performed, but only against inanimate objects. Jumping, as an introduction to social play activities (Reinhardt, 1980) may constitute an appetitive act, expressing a need for engagement in social play. Similarly, the sticking of the muzzle over the sidewall of the crate, as an attempt to establish contact with another calf, reveals a need for the formation of affinitive bonds with congeners. The importance of such contacts is demonstrated by

Broom and Leaver (1978) who found that from these, weak associative relations between neighbouring calves may develop. Nevertheless, the ability of these individually raised calves to effectively compete with congeners when housed in groups at the age of 8 months, was seriously impaired for at least one year.

In conclusion, crate housing restricts the forming of affinitive relationships between congeners and the development of social abilities. Both aspects, which are essential to normal social development, are actively pursued by the crated calves. Therefore, the impairment of social behaviour by individual housing is detrimental to the welfare of these animals.

The crated calves are seriously impaired in their ability to attain information about their surroundings, since their mobility and visual field is restricted. They are easily alarmed by sudden noises or the sudden appearance of people, after which they rise to their feet, sometimes exhibiting excited ear movements. These reactions seldom occur in individual pens with partitions consisting of bars which allow surveyance of the immediate surroundings (personal observation) and they are also rare in group pens. Apart from the possibility to visually locate a stimulus before it is in close proximity, the presence of congeners and the opportunity of evasive action in the group pens, may have a reassuring influence on the calves. In this respect, crate housing may be critisized since it enhances the irritability of the calves.

The occurrence of stereotypies is in no way confined to the individual housing in crates; in fact, the licking and scraping of objects was more frequent in group housed calves as compared to crated calves on the same diet (table 4.1), while tongue playing was equally frequent in both systems. It would be premature however, to conclude that group housing promotes frustration in veal calves. First, not all licking and scraping represent stereotypies; they also include exploratory activities or they may be aimed at the ingestion of materials, as suggested by Van Putten (1981). Furthermore, the expression of these aspects of behaviour may be stimulated by social facilitation or by the presence of objects which are particularly suited for this purpose (such as the feeding trough and the railings in the group pens, that were frequently used for licking and scraping).

In the group pens with straw bedding, the incidence of licking objects and tongue playing seems lower than in the crates. This may be connected to the ad libitum provision of straw in the group pens. The relation between the presence of straw and the frequency of these activities has been established previously by Elshof and Van Putten (1978) and Papendieck (1979). These results indicate that the occurrence of licking and scraping objects and tongue playing is affected by the available roughage rather than by individual or group housing as such. This neither denies nor confirms the contribution of group housing to the well-being of the calves; it just draws attention to the relevance of roughage supply for calf welfare.

The importance of roughage is further indicated by the performance of sham ruminating in the absence of solid feed. This shows the strong motivation (Heymer, 1977) underlying processes connected to the intake of roughage. This is not surprising, since roughage consumption and rumination are major occupations of even young calves, which start eating and ruminating as early as 5-7 days after birth (Swanson and Harris, 1958). At an age of about 3 months, they may spend up to 9 hours grazing and 8 hours ruminating daily (Roy et al., 1955; Chambers, 1959). The provision of even small amounts of straw is apparently essential to the well-being of the calves. Therefore, some roughage should be available to all calves from the first week after arrival.

The total duration of intake and rumination of limited amounts of straw or straw cobs, as provided in the present study, amounts to slightly more than sham rumination time and is in no way comparable to the time spent grazing and ruminating of calves on pasture, as mentioned earlier. When straw is presented ad libitum, as in the group pens with straw bedding, eating time remains less than that of grazing calves or of calves fed hay and concentrates (Swanson and Harris, 1958). This results from the poor digestibility of straw (Hafez, 1969), the consumption of large amounts of milk (Stephens, 1974) and the reduced fermentation activity in the rumen (Van Hellemond, 1982). In spite of this low intake, rumination time may still reach considerable levels, due to the poor digestibility of the straw (Hancock, 1953; Swanson and Harris, 1958) and significantly changes the way veal calves budget their time. This prolonged engagement in the intake and rumination of straw reduces frustation as apparent from the decrease in "stereotypies" (licking or scraping of objects and tongue playing), mentioned above. In this respect, an ad libitum provision of straw is more favourable than a limited supply of straw or straw cobs.

The information on the influence of the floor type in group pens (bare slats or straw bedding) on behaviour, as obtained in the present study is very limited. The duration of most lying postures seemed not affected by floor type, with the exception of reduced lying with the forelegs stretched on slatted floors. Maybe the calves on the slatted floors avoided intense contact of the chest with the floor surface in order to diminish heat loss or to prevent the pressure of the slats on the ribs. If so, this would indicate that bare slats are undesirable as a lying area but this conclusion can not be drawn from the limited data presented here.

Furthermore, wooden slatted floors being slippery and unequal are not well suited for group housing, in which the mobility of the calves is higher than in crates. If roughage is omitted, which increases the relative water content of the calves' excrements, the slipperiness of the floor will be even higher, due to the wetting of the wooden slats. Improvements of these floors, which promote the grip on the surface and prevent the claws from slipping partly into the slots, are very desirable. Still, the mobility of the calves was not essentially reduced on slatted floors as compared to straw bedding, suggesting that the animals have in some way adapted to these seemingly unfavourable conditions. This process of adaptation, however, which then becomes relevant to animal welfare, has hardly been investigated (cf. Andreae and Smidt, 1982).

CONCLUSIONS

- Calves in crates spend more time lying than those in group pens; this is probably due in major part to the greater variety of stimuli in the group pens, but the occasional mounting and treading of calves may also have contributed to this difference.
- Lying on the side or on the brisket with both hindlegs stretched is severely restricted in the crates as compared to the group pens. Behavioural thermoregulation in the crates is related mainly to the bending or stretching of the foreleg(s).
- Lying with the head turned backwards, which is highly preferred for supporting the head, becomes progressively more restricted in the crates towards the end of the fattening period. Although the head is supported otherwise to some extent, the total duration of lying with the head supported is clearly reduced in the individual crates as compared to the group pens.
- The licking of the belly, back, thighs or hindlegs and the scratching of the head, neck or shoulders are hindered by the sidewalls of the crates, whereas rubbing is not impaired. The licking of the forelegs, which are easily reached and of the muzzle is increased in the crates as compared to the group pens. Stretching is more frequent in the group pens than in the crates.
- In the crates, physical interactions with congeners are usually limited to sucking and licking during feeding, but occasional licking occurs outside feeding times at the end of the fattening period as soon as the calves are able to touch each other over the sidewalls. This shows their desire for social contacts. Head butting against inanimate objects and jumping are relatively frequent in the crates. In the group pens, social

activities such as the smelling, licking, head butting and mounting of congeners are performed regularly throughout the day. Preputial sucking and urine drinking however, were seldom seen in this period from 8 to 20 weeks after arrival.

- Exploration is confined to the sniffing and licking at the front part of the crate and the viewing of the area directly in front of and behind the crate. Due to this restriction of exploration the calves are easily alarmed, as appears from their immediate rising when they hear or see something unexpected, in contrast to calves in group pens.
- The frequency of licking or scraping at objects and of tongue playing, being mainly stereotypies, is not influenced by individual or group housing as such, but the frequency of these activities decreases when straw supply is ad libitum instead of restricted.
- Wooden slatted floors are slippery and uneven, but the mobility of the calves seems not impaired.

It is suggested that:

- the restrictions to lying behaviour in the crates may interfere with the relaxation of the body during lying;
- the restrictions to lying with the head supported in the crates may hinder the performance of sleep;
- the increase of nose licking and of the licking of the forelegs in the crates may be related to conflict situations;
- the frequent head butting against inanimate objects and jumping of the calves in the crates may indicate their need for social play;
- data on the process of adaptation of calves in group pens to moving and lying on different floors during the first weeks after arrival are required for the evaluation of these floortypes in terms of animal welfare.

V The development of sucking behaviour in individual calves

INTRODUCTION

The housing of veal calves in groups of five substantially improves calf welfare in comparison to the individual housing in crates, as shown in the previous chapter. The occurrence of preputial sucking however, which leads to poor health and production (Pesch, 1968) counteracts this advantage of group housing and reduces its feasibility (chapter III).

The prevention of preputial sucking as a form of intersucking may be accomplished in various ways; tethering during the first 6 weeks after arrival strongly reduces its occurrence (chapter III) and also delayed grouping (after 4 weeks) results in a lower number of calves intersucking, just like muzzling and the application of ointment to navels and ears (Wood et al., 1967). When the calves are tethered for 30 minutes after each feeding, the frequency of intersucking is almost nil (Illés, 1964; Kittner and Kurz, 1967). Finally, the provision of concentrates diminishes the incidence of non-nutritive sucking in breeding calves by 70% (Kittner and Kurz, 1967). However, most of these methods imply either restraint, repulsion or distraction of the calves in order to prevent intersucking; they do not concern the biological regulation of sucking behaviour.

This latter aspect was indeed considered by Scheurmann (1974b) and Mees and Metz (1984), when allowing the performance of sucking during milk intake from teat buckets or automatic feeders equipped with teats. These methods of reducing intersucking are highly favourable from a welfare point of view, but their practical application runs up against disadvantages of a technical nature (Van Putten, 1982).

The present study does not pursue a reduction of intersucking as such, but aims at the question of how the orientation of intersucking towards the prepuce develops in individual calves. Knowledge of this development may help in designing a method to regulate this harmful behaviour adequately.

In bovines, neonate sucking movements and butting occur directly after birth, even before the young stands for the first time (Scheurmann, 1974b) and without contact with any object. The newborn calf, just able to stand, usually orientates towards the cow and investigates the ventral surfaces with its muzzle, poking its head upwards into angles between limbs and trunk (Schuller, 1957; Lent, 1974). During these first attempts, the calf mouths and sucks various protrusive parts of the mother's body, such as the brisket, elbow, axilla or even neck and ears. The neonate shows a preference for right angled bends, as between the brisket and forelegs or between the udder and hindlegs (Kiley-Worthington and De la Plain, 1983). Occasionally, the calf also explores man-made structures such as railings and corners of stalls (Brownlee, 1950; Espmark, 1971; Lent, 1974). It may linger at hairless spots (Scheurmann, 1974b) and spend considerable time sucking the afterbirth, mucus and manure adherent to the cow's haircoat (Hafez and Lineweaver, 1968; Derenbach, 1981). Eventually, the calf seizes a teat and suckles; thereafter, it has little difficulty in relocating a teat (Walker, 1950; Kiley-Worthington and De la Plain, 1983). These observations show that initially udder sucking is not directed at the appropriate position, nor is the induction of sucking limited to only few stimuli (Schuller, 1957; Stephens and Linzell, 1974). Locating the teat is apparently accomplished by trial and error learning.

When sucking, the calf's shoulders are lowered by spreading the forelegs and placing them several inches anterior to the shoulders, shifting the body weight to posterior. The head is extended forwards with the muzzle lifted. The tongue, which slightly protrudes out of the mouth, is aligned with the teat (Hafez and Lineweaver, 1968; Porzig, 1969;

Scheurmann, 1974b). Tail wagging may accompany peaceful sucking, while the butting, prodding and striking of the udder by the calf's muzzle is particularly frequent at the end of each sucking period and this may stimulate milk flow (Hafez and Lineweaver, 1968; Lent, 1974).

The most common nursing position is the reverse parallel one, in which the body axes of cow and calf form an acute angle. This position enables the mother, which will normally not allow strange calves to suckle, to inspect the young (Lent, 1974). Incidentally, the mother may lick the anogenital region of the young, inducing urination and defaecation (Walker, 1950; Pilters, 1955; Hafez and Lineweaver, 1968; Espmark, 1971; Kovalčik et al., 1980; Metz, 1984). The urine and faeces are sometimes ingested by the mother (Schloeth, 1958; Reinhardt, 1980). Among older infants, the angle of suckling varies considerably and even suckling from between the cow's hindlegs is not unusual. The latter is probably due to the intermittent walking of the cow while nursing (Ritter and Walser, 1965; Finger and Brummer, 1967; Lent, 1974). Calves kept with their mothers will normally not suckle other cows. This is mainly the result of cows preventing alien calves to suckle (Ritter and Walser, 1965; Espmark, 1971; Lent, 1974; Nicol and Sharafeldin, 1975). In fostering herds, cows cannot effectively discriminate between alien and fostered calves and this results in extensive cross-suckling (Ritter, 1961; Finger and Brummer, 1967; Kilgour, 1972).

The duration of suckling in the first weeks of life is about one hour daily, divided over three to eight suckling periods, which decrease in number and duration until weaning. Scheurmann (1974b) reports a reduction in suckling time from 60 minutes in the first month to 30 minutes in the sixth. Weaning occurs at 6-10 months (Müller, 1975; Reinhardt, 1980) but yearlings may occasionally start suckling again in the subsequent lactation period (Reinhardt, 1980; Kiley-Worthington and De la Plain, 1983).

The objective of this chapter is to monitor the orientation of the sucking response in individual calves over several weeks in order to detect possible cues which direct this activity.

— In the first of two experiments, the development of preputial sucking and other sucking in individual calves during the first 7 weeks after arrival is presented; for this purpose, observations were carried out both during 24 hours and during 30 minutes after feeding.
— In the second experiment, the orientation of preputial sucking and other sucking in individuals is studied over the same weeks, but now only around feeding;
  - the sucking at the prepuce, legs, scrotum, mouth, ears and physical objects is described quantitatively;
  - the orientation of preputial sucking towards different penmates is also recorded.

Experiment 1

MATERIALS AND METHODS

Animals, housing and management

Ten black and white male calves were observed; they entered the calf house at about one week of age. Individual data concerning the treatment of the calves during the first week of life were not available (cf. chapter II). The calves were housed in two groups of five in pens consisting of iron barred fences and a concrete slatted floor covered with straw, as described in chapter III.

A milk replacer was fed around 8.30 and 16.30 h and 1,5 l water/calf/day was supplied during the first two weeks after arrival. Additional straw was available in a basket in a back corner of the pen. During the first two weeks, temperature was maintained at 13 to 16°C by supplementary heating. Thereafter, it varied between 8 and 17°C, while relative humidity fluctuated between 70 and almost 100%.

Observations

The calves were observed by video-cameras for the first 18 days after arrival and on days 23, 30, 37, 44 and 51. In this way, the development of sucking behaviour and especially the arising of preputial sucking could be followed in detail. In addition, the calves in one pen were observed directly in weeks 2 to 8, for half an hour after feeding, eight times weekly. The results of video and direct observations will be compared.

With video observations, preputial sucking and other sucking (sucking at different body parts (except the prepuce) or at physical objects) were noted for each calf once every minute[1]. The total number of observations per calf per day amounted to 1440. With direct observations after feeding, the same activities were monitored for each calf once every 20 seconds. The weekly total of these observations per calf amounted to 720.

RESULTS

In fig. 5.1 the development of preputial sucking and other sucking behaviour of four representative calves from both pens is described graphically for the first 7 weeks of the fattening period. Initially, little or no sucking behaviour was performed. In the second week, most calves engaged in sucking for some time daily, varying from a few minutes to about one hour. This sucking was mainly directed at protrusive body parts of penmates, particularly at the ears, legs or mouth, whereas physical objects were rarely sucked. Preputial sucking was observed for the first time in the second week, but not in all ten calves: two calves started sucking the prepuce only after 3 weeks and two others not at all.

[1] Urine drinking could not be discriminated reliably from the angle and distance of the camera.

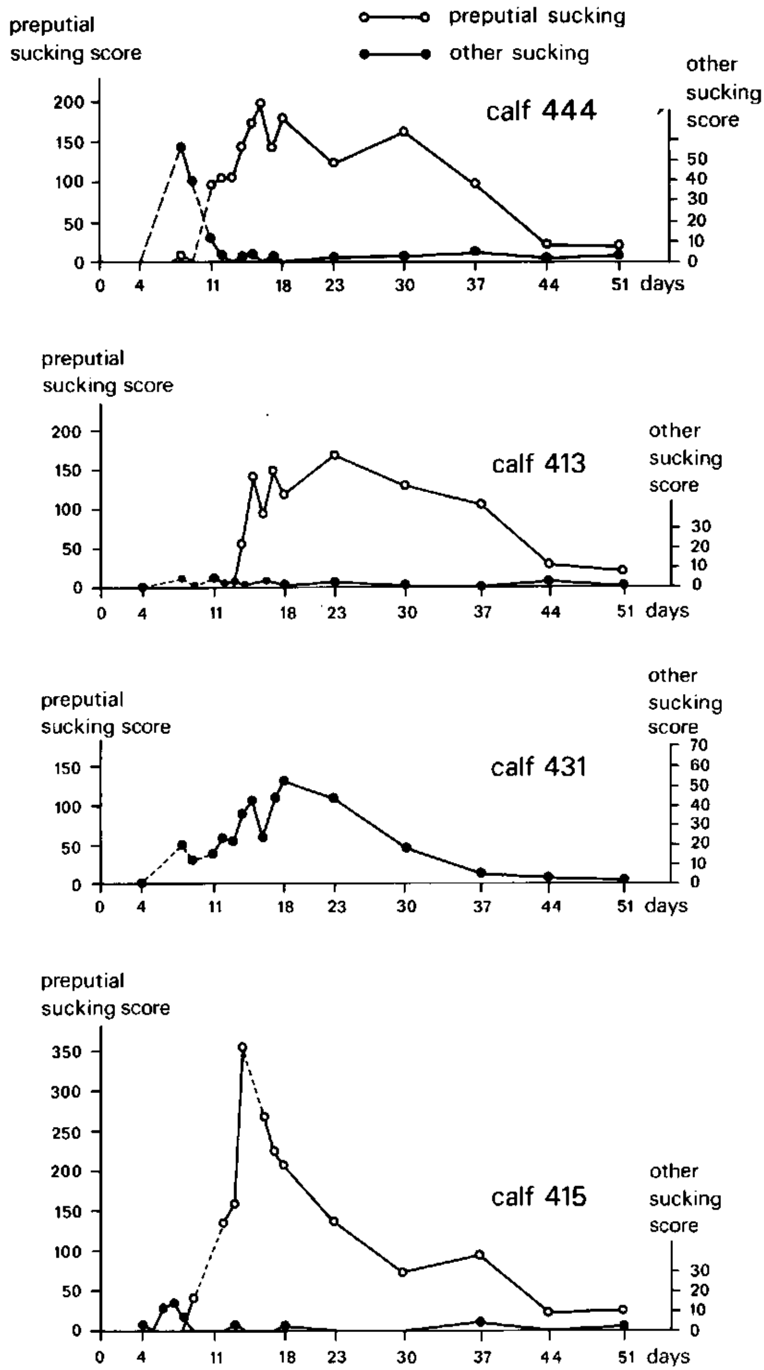

Fig. 5.1 Preputial sucking and other sucking in four representative calves during the first 7 weeks after arrival. The values indicated are numbers of observations per day (daily total of observations per calf = 1440). Preputial sucking and other sucking are projected on different scales. ---: observations missing

Within a few days following the first performance of preputial sucking, its incidence in most calves rapidly increased to scores which corresponded to 1-3 hours daily (fig. 5.1). Thus, the frequency of preputial sucking by far exceeded the appearance of other sucking behaviour, which was subsequently reduced. The two calves which did not engage in preputial sucking spent more time in sucking other parts of penmates and objects than their congeners. One calf initially sucked and licked its own prepuce for prolonged periods, occasionally while urinating. After a week, this behaviour waned and sucking was mainly directed at the prepuce of congeners. In all calves, the incidence of both preputial sucking and other sucking was low on day 44 and 51 after arrival.

Fig. 5.2 shows the occurrence of preputial sucking and other sucking behaviour at different times during an average observation day for five individual calves in one pen. Whereas other sucking mainly occurred at feeding times, preputial sucking was in addition frequently observed in activity periods at other times of the day.

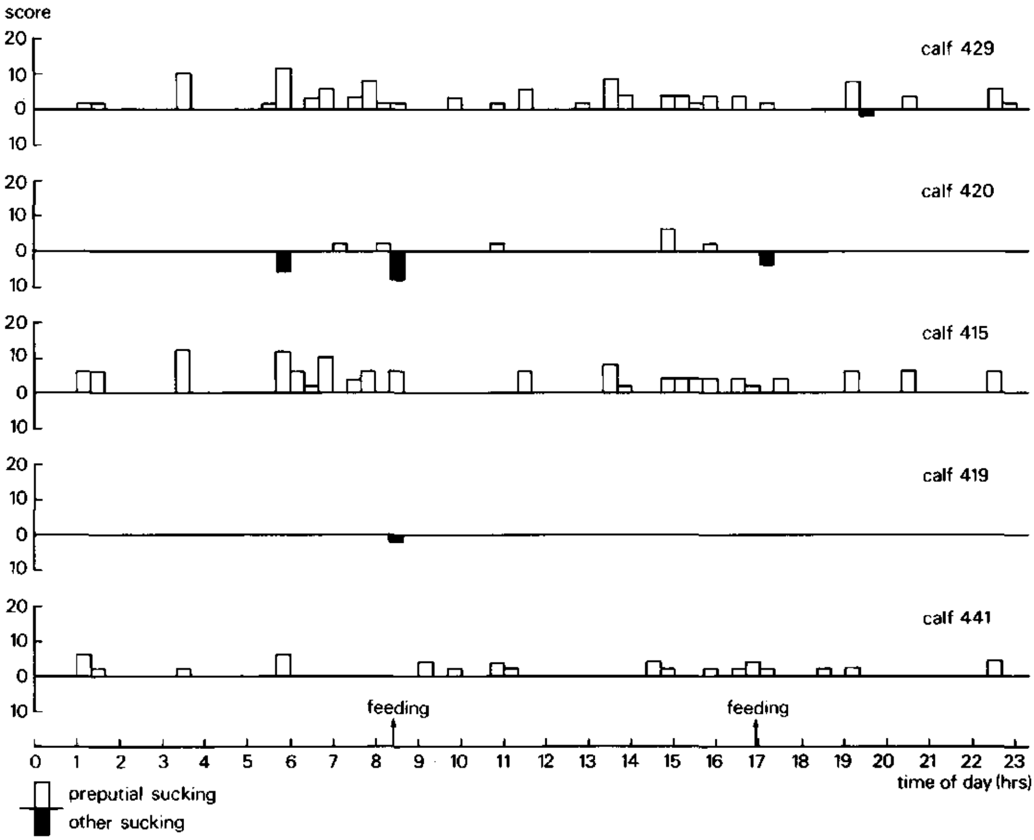

Fig. 5.2 Distribution of preputial sucking and other sucking during a natural day for five calves in one pen (day 23). The values shown are numbers of observations per 20 minute period (total observations/calf/period = 20).

The development of preputial sucking and other sucking behaviour in individual calves, assessed by direct observation after feeding (fig. 5.3), closely resembled that of preputial sucking and other sucking in 24 hours of observation. The incidence of preputial sucking was nil at first when other sucking was regularly performed. A strong rise in the frequency of preputial sucking coincided with a decrease in the occurrence of other sucking, which remained low thereafter. In most calves preputial sucking was extremely frequent for several weeks and then gradually decreased. In calves which did not engage in this activity or only after a few weeks, other sucking was relatively frequent. Urine drinking was only occasionally observed.

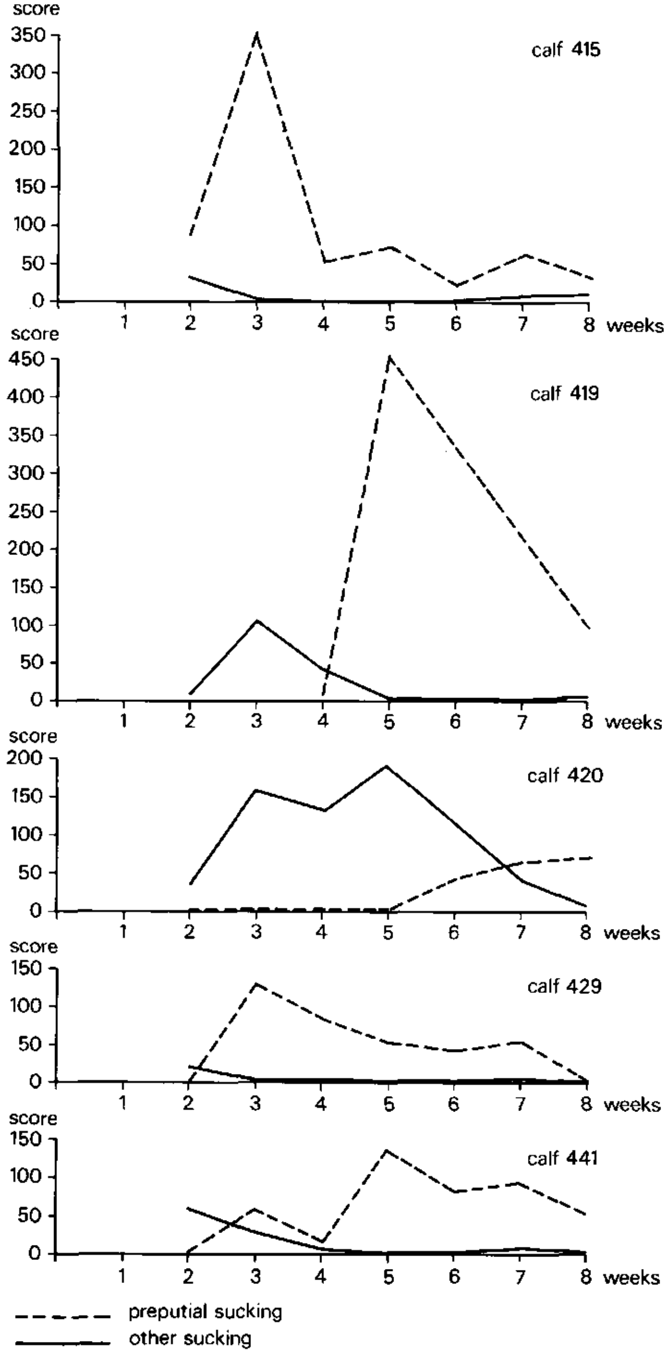

Fig. 5.3 Preputial sucking and other sucking in five individual calves in one pen as observed during 30 min after feeding in the first 8 weeks after arrival. The values indicated are numbers of observations per week (weekly total of observations per calf = 720).

Experiment 2

MATERIALS AND METHODS

Animals, housing and management

30 black and white calves were used (24 males, 6 females). The calves were one week of age on arrival in the unit. They were housed in six groups of five; three groups on straw bedding and three groups on slatted floors[1]. A milk replacer was provided at approximately 8.30 and 16.30 h with extra water (1,5 l/calf/day) supplied after the morning feeding for the first two weeks after arrival. In all pens (with and without straw bedding) straw was available ad libitum in a basket in a back corner of the pen. In the first two weeks with supplementary heating, the temperature ranged from 10 to 15°C and later it fluctuated between 2 and 9°C. Relative humidity was between 60 and 70% in the first two weeks and 70 to 90% thereafter.

Observations

In four pens, the calves were observed directly for half an hour before until one hour after both feedings on four days per week. This was done in weeks 2, 3, 4, 5 and 7 after arrival. The behaviour of each calf was recorded once every 20 seconds by two observers; each observer stood on the feeding passage between two pens and turned from one pen to the other every 15 minutes. Both observers interchanged positions daily between feeding periods. In this way, eight feeding periods were monitored in each observation week. The weekly total of observations per calf amounted to 1080. In two other pens (comprising three female and two male calves each) the same method was applied, but observations were performed in week 7 only.

The following behaviours were recorded:

lying	leg sucking	other sucking
eating straw	scrotum sucking	other sucking
licking object	mouth sucking	other sucking
scraping object	ear sucking	other sucking
licking congener	object sucking	other sucking
self licking	remaining sucking	other sucking
	preputial sucking	
	urine drinking	

Statistics

The Mann-Whitney-U-test (Siegel, 1956) was used for the statistical analysis of the differences in sucking behaviour between preputial and non-preputial suckers.

RESULTS

The frequency of some activities observed during half an hour before until one hour after feeding in several weeks is presented in table 5.1. At this particular time of day, predominant behaviours were lying, eating straw and sucking. Oral activities such as licking objects or self licking occurred regularly, but were not prevailing. Scraping objects, licking congeners and urine drinking were in general relatively rare.

[1] On straw bedding, seven out of ten male calves engaged in preputial sucking, whereas on slatted floors, six out of ten male calves performed this activity. The possible influence of the floortype on the occurrence of preputial sucking seems small and will be disregarded.

Table 5.1 Mean frequency per calf of several activities in different weeks after arrival, as observed around feeding in four pens with a total of 20 calves. The values shown are numbers of observations per calf per week (weekly total of observations per calf = 1080).

	Week 2	Week 3	Week 4	Week 5°	Week 7°
Lying	275	171	254	275	319
Eating straw	68	128	183	155	126
Licking object	19	19	20	21	40
Scraping object	5	4	6	9	15
Licking congener	19	5	3	3	3
Self Licking	18	24	38	46	47
Other sucking	56	71	59	49	19
Preputial sucking	26	87	77	85	45
Urine drinking	2	6	4	2	1
Total sucking	82	158	136	134	64

°: based on 19 animals.

In fig. 5.4 the sucking behaviour of the calves which engaged frequently in preputial sucking is analysed in comparison to that of the other calves. For this purpose, calves which were observed sucking the prepuce 20 times or more in one week were classified as "preputial suckers" for that week. The others were assigned to the group of "non-preputial suckers" (compare appendix 4). The number of calves in each group varied from week to week.

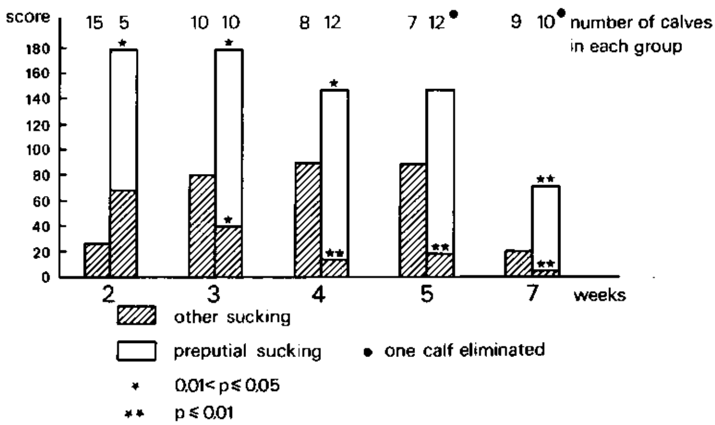

Fig. 5.4 Mean frequency per calf of preputial and other sucking among preputial suckers (right column) and non-preputial suckers (left column) in different weeks after arrival. The values indicated are numbers of observations per calf per week (weekly total of observations per calf = 1080).

The majority of calves that engaged in preputial sucking during the observation weeks started sucking the prepuce before week 4. In preputial suckers, the incidence of other sucking was significantly lower than in non-preputial suckers in all weeks except in week 2. Nevertheless, total sucking was markedly higher in the former, due to frequent preputial sucking. Licking the urine jet of a urinating calf was not restricted to calves engaged in preputial sucking; it also occurred in non-preputial suckers (appendix 4).

Other sucking may be directed at parts of penmates such as the ears, mouth, legs, scrotum or at parts of the pen. The sucking of these different parts, including the prepuce, is presented for some representative calves (fig. 5.5). The majority of calves showed a clear preference for sucking one particular part (ear, leg, mouth, physical object) for several consecutive days. Over weeks, the focus of the sucking usually changed from one part to another, ending up in sucking at the prepuce in 13 calves out of 20 (appendix 4). A

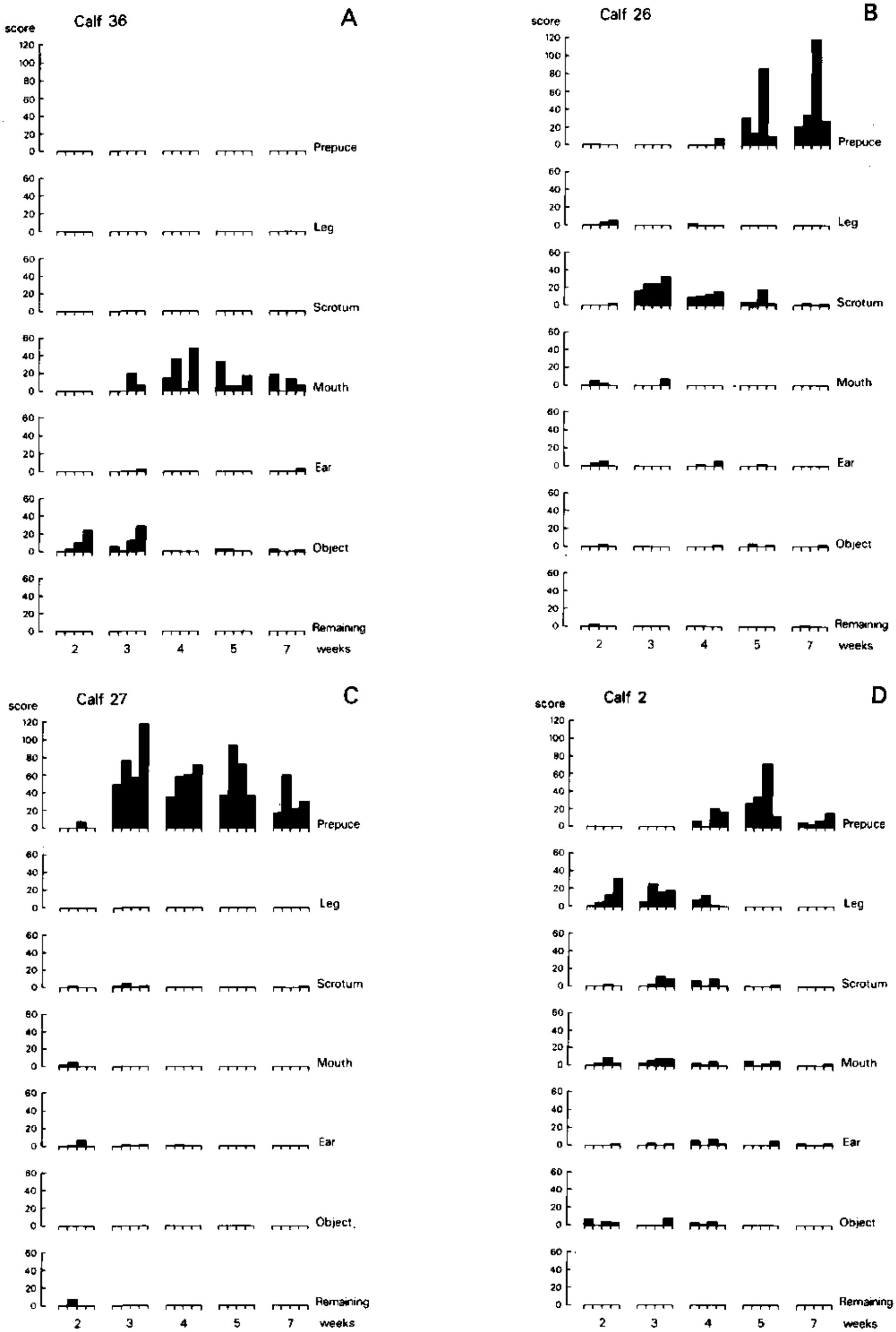

Fig. 5.5 Sucking at different body parts or physical objects in four individual calves as observed around feeding in several weeks after arrival. The values indicated are numbers of observations per week (weekly total of observations per calf = 1080).

transition from preputial sucking to other sucking, however, was not registered in any one calf. Of seven non-preputial suckers, five were never once observed to suck the prepuce of penmates (appendix 4).

Not only are various body parts and physical objects available for sucking, but also various partners. The choice of partners in calves performing preputial sucking is presented in appendix 4. The great majority of calves tended to suck the prepuce of all four penmates without preferring or avoiding one of them. Only calves 2, 11 and 26 showed some consistency in their choice of partners.

Interindividual relationships with respect to sucking behaviour of male and female calves (two pens) are given in fig. 5.6. In these pens, some of the females were engaged in

preputial sucking — pen 2 (active partner ↓, passive partner →)

	6	7♀	8♀	9♀	10	tot
6						0
7♀					29	29
8♀	1					1
9♀						0
10						0
tot	1	0	0	0	29	

urine drinking — pen 2

	6	7♀	8♀	9♀	10	tot.
6				1		1
7♀						0
8♀	2			2		4
9♀		3				3
10	1					1
tot	3	3	0	3	0	

preputial sucking — pen 5

	21♀	22	23	24♀	25♀	tot.
21♀		15	17			32
22			1			1
23						0
24♀		8	46			54
25♀		32	13			45
tot.	0	55	77	0	0	

urine drinking — pen 5

	21♀	22	23	24♀	25♀	tot.
21♀		2	1			3
22				1		1
23					1	1
24♀		1				1
25♀				3		3
tot.	0	3	1	4	1	

Fig. 5.6 Interindividual relationships between female (♀) and male calves in two pens, concerning preputial sucking and urine drinking during week 7 after arrival. The values shown are observations per week (weekly total of observations per calf = 1080).

preputial sucking. Female calves themselves, however, were never sucked in the umbilical region, although their navel was still clearly protruding. On the other hand, the urine of urinating females was drunk by penmates (males and females) in the same way as the urine of male calves.

DISCUSSION

Sucking is considered to be a reflexive action resulting from the stimulation of the mouth and lips (Brassell and Kaye, 1974; Scheurmann, 1974b), which however can be modified by tactile, visual, auditory and gustatory stimuli (Sameroff, 1967; Lipsitt et al., 1966; Stanley et al., 1963; Seltzer, 1969; Brown, 1972; Brassell and Kaye, 1974). In the great majority of calves in the present study, daily sucking behaviour was altered rapidly and considerably after the initiation of preputial sucking: within two or three days after the start of preputial sucking, its incidence by far exceeded previous levels of other sucking (fig. 5.1).

Whereas preputial sucking appeared in several activity periods throughout a natural day, other sucking was mainly observed during both feeding periods (fig. 5.2). But even in the main periods of other sucking behaviour around feeding times, prepuce directed sucking was predominant (table 5.1). Calves which engaged in preputial sucking spent significantly more time in sucking than those which only sucked other parts of penmates and objects (fig. 5.4). Apparently, the duration of the sucking response was increased when directed at the prepuce as compared to other body parts or objects.

The preference for preputial sucking was accomplished after a period of sucking at various other parts of penmates and objects (fig. 5.5). During this initial period, most calves consistently sucked some particular body part or object. The variety of preferences among different calves was large and furthermore, these preferences usually changed with time.

A similar random search precedes the neonates' detection of a teat at the cow's udder, as mentioned in the introduction. This trial and error seeking starts immediately after birth and usually results in the obtainment of a teat. If the udder is not located within a few days after birth, teat seeking activity may wane as found in lambs (Alexander and Williams, 1966). In calves which were exposed to a lactating cow for the first time after the age of 6 days, the ability to find a teat was strongly impaired (Finger and Brummer, 1969). After that age, a teat was only discovered by exception. In much the same way, the omission of preputial sucking in some of the calves may be attributed to a failure to locate the prepuce, as indicated by the total absence of this behaviour in most of the non-preputial suckers. This possible analogy raises interest in the influence of early sucking experience on the development of preputial sucking. Data on this point will be reported in chapter VI.

Furthermore, the similarities in the development of preputial sucking and udder sucking may relate to common reinforcing characteristics of both activities. In this respect, the induction of fluid release and the ingestion of these fluids in both preputial and udder sucking may be particularly meaningful. Other features, such as the posture of the calf during sucking, with shoulders lowered and muzzle lifted or the bunting and prodding at the belly, the contact with soft and warm surfaces or the shape of the sucked object may be important, but they are not exclusively connected to preputial and udder sucking. These phenomena also accompany scrotum sucking and sucking at the navel of female calves; scrotum sucking, however, was left in favour of preputial sucking (fig. 5.5B) and the navels of female calves were not sucked at all (fig. 5.6). Therefore, the latter characteristics may not be crucial factors in the reinforcement of preputial sucking, in contrast to the intake of urine.

Urine does not seem to be repelling and may even be attractive, regarding the fact that all calves, including non-preputial suckers, lick and ingest urine from urinating calves. These urinations may facilitate the detection of the prepuce, since the sound of urination usually attracts the attention of penmates, which may approach to lick in the urine jet and smell and lick at the prepuce. Sometimes, two or three calves simultaneously drink from the same jet, preputial suckers as well as non-preputial suckers. This collective urine drinking is now and then followed by preputial sucking, which – in this situation – may easily be imitated.

In mother-nursed calves, sucking is gradually reduced until weaning at 6-10 months (Müller, 1975; Reinhardt, 1980; Kiley-Worthington and De la Plain, 1983). The reduction of sucking is accelerated, however, in the absence of milk reward (Koepke and Pribram, 1971; Stoloff et al., 1980). This strongly suggests that the decrease of sucking at different body parts and objects (including the prepuce) between 6-8 weeks already is probably due to the lack of nutritional rewards from this sucking behaviour.

In contrast to the selection of particular body parts or objects while sucking, the choice of partners in preputial sucking appeared to be random (appendix 4). This is not surprising, since the close relationship that normally exists between a suckling calf and its mother is merely due to the intolerance of cows towards alien calves; the calves themselves will usually try to suckle other cows (Lent, 1974). Similarly, the fact that a firm bond exists between the suckler and the sucked cow in milk-sucking among dairy cows (Schlüter et al., 1975; Grommers, 1979) may also be the result of such an intolerance; the suckled cow is probably the only one to permit this behaviour.

As opposed to udder sucking in cows, preputial sucking in calves is tolerated well and even vigorous butting is permitted. It seems as if calves have an inhibition to move while being licked or just touched in the perineal region, as assumed previously by Gosling

(1969), who found that young bovids even stopped walking as a response to being touched there. The tolerance of the calves towards these contacts, which are normally performed by the mother, may be related to their significance in promoting the first urinations (Metz, 1984). This permissiveness leads to extensive cross-sucking, reflected by the absence of partner bonds in preputial sucking.

However, the tolerance to preputial sucking is only transitory. Increasingly often, a calf will interrupt prolonged sucking by lifting its leg, kicking or moving a few steps away. These signs of irritation may be attributed to the sensitivity of the prepuce (which often becomes hairless and reddish in colour) and to the vigour of the butting. Among the physical consequences of preputial sucking in the calves which actively performed this behaviour were hairloss around the muzzle, due to frequent wetting (Walker, 1950) and a rough, dull haircoat. Poor growth was confined to some calves whereas others seemed to thrive well in spite of vigorous preputial sucking. This difference may be related to milk intake that was conspicuously reduced in some of the calves which engaged in preputial sucking, but not in all (personal observation). A case of milk intake reduction and poor growth due to preputial sucking was also reported by Hafez and Lineweaver (1968).

Urine drinking, the licking in the urine jet of a urinating congener, does not seem to result in a substantial intake of urine, nor does it affect the condition of the prepuce. The deleterious effects of preputial sucking on behaviour and performance, however, are numerous and the prevention of this activity is therefore important for the well-being of the calves. Consequently, methods which merely restrain the calves from engaging in preputial sucking should not be rejected outright but must be evaluated with regards to their effectiveness and implications for animal welfare.

CONCLUSIONS

- The incidence of sucking increases during the first two weeks after arrival and decreases again to low levels after six weeks.
- Initially, nearly all calves suck at physical objects or at body parts other than the prepuce.
- The great majority of calves prefer a particular body part or (more seldom) a physical object for sucking, such as the ears, mouth, legs and scrotum of penmates or the rim of a bucket.
- These preferences vary among individuals and usually change over time.
- In the second and third week after arrival, many calves develop a preference for sucking at the prepuce, which in general persists until 6-8 weeks, when the frequency of sucking strongly decreases. Some calves, however, never suck the prepuce.
- Preputial sucking is more frequent than sucking at other body parts or at physical objects and it occurs during several activity periods throughout the day and night, whereas other sucking is concentrated at feeding times.
- Individual preferences or aversions for sucking at the prepuce of particular penmates are uncommon.
- In contrast to preputial sucking, urine drinking seems relatively harmless and is performed by preputial suckers and non-preputial suckers alike.

It is suggested that:
- the attraction of preputial sucking is related to the intake of urine during this activity;
- the absence of preputial sucking in some calves has to do with their early sucking experience.

These suggestions will be investigated in the next chapter.

VI Experiments concerning the prevention of preputial sucking

The development of preputial sucking in group pens, described in the previous chapter, has provided some starting points that may help in finding means to prevent this activity. First, in many calves sucking was predominantly orientated at the prepuce, which moreover was sucked for extremely long periods. The attraction of the prepuce as an object for sucking may well be related to the excretion of urine (chapter V). If water, which is the major constituent of urine, influences sucking behaviour, then the manipulation of fluid supply should change the incidence of preputial sucking.

Secondly, preputial sucking requires detection of the prepuce and this does not seem to be accomplished by some of the calves (chapter V). The discovery of the prepuce may be a matter of chance, but on the other hand, it may also be dependent on early sucking experience, just like the finding of the udder in calves (Finger and Brummer, 1969) or the nipple in kittens (Kovach and Kling, 1967) and in rat pups (Stoloff et al., 1980). The question arises as to how far the occurrence of preputial sucking is affected by the method of milk intake (open bucket, teat bucket or udder) in the first days of life.

These two points, the possible role of fluids in the performance of sucking behaviour and preputial sucking in particular and the possible influence of the early feeding method on the detection of the prepuce are investigated in this chapter. It is hoped that this may lead to finding practical solutions for the prevention of preputial sucking. The relevance of these factors is first checked in a preliminary way (section 1) and next, the same factors are studied separately in a larger number of animals (section 2 and 3).
In these experiments, single calves were not allowed to continue preputial sucking for several weeks. Preputial suckers were tethered to the feeding gate immediately after they were detected, mainly to reduce the unfavourable effects of persistent sucking at the prepuce on the health and performance of the calves. As a result of this method, the effect of experimental manipulations on the occurrence of preputial sucking is to be drawn from the number of calves engaging in this behaviour; this parameter is also most meaningful in practical terms.

1. Pilot study

INTRODUCTION

The first experiment is a pilot one and aims at obtaining information on the role of fluids in sucking behaviour and on the influence of early sucking experience on the development of preputial sucking.

- If fluids indeed reinforce sucking, then rubber teats supplying water should be sucked more than empty rubber teats. Furthermore, if the ingestion of fluids is a major objective in sucking, rubber teats next to water jets should be sucked less than rubber teats presented alone.
- If early sucking experience is relevant for the development of preputial sucking, then the number of preputial suckers among calves fed by open bucket, teat bucket or udder during the first days of life, should differ.

MATERIALS AND METHODS

Animals, housing and management

Black and white male calves were observed. They were on average 5 days old (range 2-12 days) when entering the veal calf house. 22 calves had been fed with open buckets during the first days of life at the dairy farm. The 18 other calves were accustomed to teat sucking, since they had been fed with teat buckets during at least the first 4 days of life (eight calves) or they had been nursed by their mother for the first 1-2 days after birth (ten calves). This information was obtained from the farmer and is considered reliable. The calves were housed in eight groups of five; four groups on straw bedding (pens 5, 6, 7 and 8) and four groups on wooden slatted floors (pens 1, 2, 3 and 4). Most bucket reared calves were kept separately from those with teat feeding experience (fig. 6.1). They were fed a milk replacer twice daily (appendix 1) with omission of the usual extra water given after the morning feedings. Apart from the straw bedding in pens 5, 6, 7 and 8, no roughage was provided.

Several sucking and drinking devices were constructed (fig. 6.1) in front of each pen. In pens 2 and 5, rubber teats were attached just above the open buckets (fig. 6.2). In pens 4 and 7, the teats were connected by tubes to a water reservoir, containing a maximum of 50 l of water at ambient temperature (about 20°C). This reservoir was emptied and filled with fresh water each day around 10.00 h and cleaned twice a week. In pens 3 and 8, three water jets were running continuously between the teats into waterproof leggings underneath the buckets. Each jet supplied 20 l of water/hour at 35°C. In pens 1 and 6, water was provided continuously in the same way as in pens 3 and 8, but teats were only available during feeding (fig. 6.1).

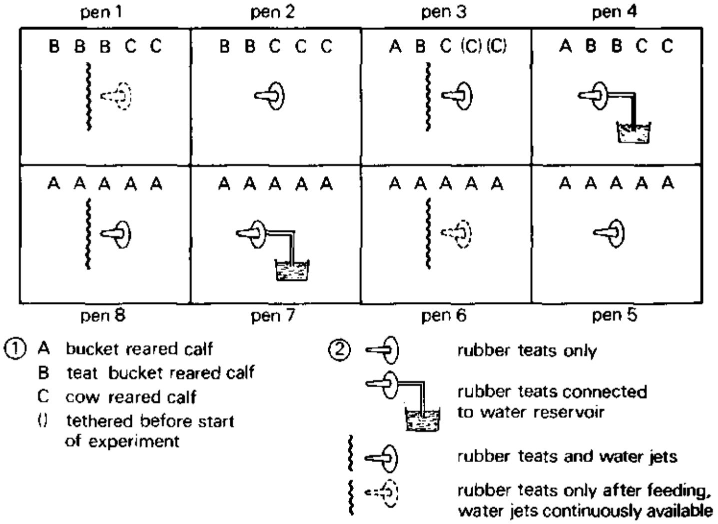

Fig. 6.1 The pens in this experiment: each pen contains 5 calves.

The feeding gate was constantly open to allow continuous access to the facilities provided. During the first 7 days after arrival, the calves were tethered to the feeding gate and separated individually by wooden partitions. After this period of adaptation to the use of teats and jets, the calves were released. However, two calves in pen 3 (cow reared),

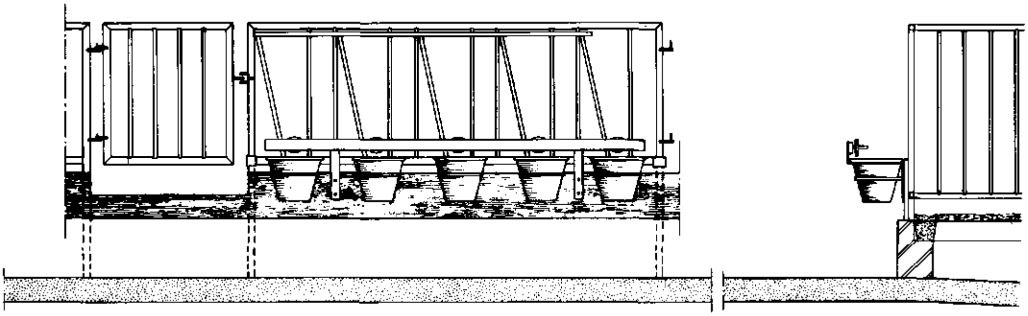

Fig. 6.2 Teat construction (front view and side view).

which engaged in preputial sucking on arrival in the unit, were kept tethered (fig. 6.1). Lights were on continuously. Temperature fluctuated between 18 and 25°C and humidity was close to 100%.

Observations

Each group of calves was monitored by video-cameras during one 24 hour period per week in the first three weeks after release. Every two minutes, the following aspects of behaviour were recorded for each calf in the pen: teat sucking, preputial sucking, other sucking and drinking from a water jet. The total number of observations per calf per 24 hours was 720. Water intake from the containers was measured daily around 10.00 h.

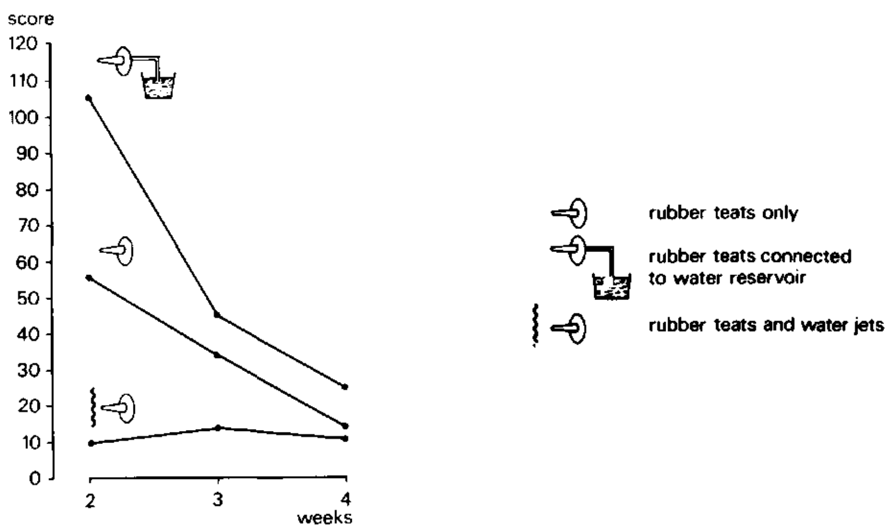

Fig. 6.3 Mean frequency per calf of teat sucking in pens with various sucking and drinking facilities in different weeks after arrival. Each treatment involved two pens with a total of ten calves. The values indicated are numbers of observations per 24 hours (total of observations/calf/24 hours = 720).

RESULTS

The teats and fluid resources offered were employed by all calves, regardless of previous sucking experience. Teat sucking frequency tended to be higher in pens with teats connected to a water reservoir as compared to those with empty teats and decreased with time in both treatments. The teats which were next to water jets were sucked least often (fig. 6.3). The frequency of sucking at teats which were only presented at feedings is not meaningful in this comparison.

Water intake from the containers was initially 2-3 times higher than milk replacer intake, but gradually decreased thereafter (table 6.1). Total fluid intake was maintained at about 11 l/calf/day. When ingesting water from the jets, the calves reached out and intercepted a water jet for consecutive periods of 5-15 seconds. Activities aimed at the intake of water from the jets were not frequent and decreased with time from 15 to 10 observations/calf/24 hours on average. Other sucking, mainly directed at body parts of penmates other than the prepuce, was relatively infrequent (less than 10 observations/calf/24 hours on average) and variable, without consistent differences between treatments.

Table 6.1 Mean intake of milk replacer, water and total fluid in l/calf/day during different weeks in two pens with teats connected to a water container.

Weeks	Milk replacer	Water	Total fluid
2	3,3	8,1	11,4
3	5,2	5,3	10,5
4	7,7	3,1	10,8

Preputial sucking was observed in all calves in pen 5 (with empty teats) and in pen 7 (with teats supplying water) during weeks 3 and 4. In pen 8 (with water jets and teats continuously available) one calf engaged in preputial sucking. All these calves were bucket reared. Apart from two cow reared calves in pen 3, mentioned earlier, all other calves refrained from preputial sucking.

DISCUSSION

This pilot study shows a high incidence of sucking at teats supplying water, which indicates that fluid release by the sucked object reinforces sucking. This finding indirectly supports the assumption that the excretion of urine may stimulate preputial sucking. Moreover, since empty teats next to water jets were sucked less than empty teats alone, it seems that water provision without sucking reduces sucking. Therefore, the provision of additional fluids may reduce the incidence of preputial sucking.

Concerning this point, however, the data presented are conflicting. On the one hand, supplying water in jets seemed to have some effect: out of 20 calves only one engaged in preputial sucking as opposed to five out of ten in the absence of additional water. On the other hand, the provision of water through teats did not appear to reduce this evil. In this case, preputial sucking was observed in five calves out of ten, despite a considerable daily intake of water (table 6.1).

Furthermore, the data suggest an influence of early sucking experience on the development of preputial sucking. It is interesting that the eight teat bucket reared calves refrained from preputial sucking whereas 11 out of 22 bucket reared calves and 2 out of 10 cow reared calves were engaged in this activity.

PRELIMINARY CONCLUSIONS

- Fluid release seems to be an incentive for sucking; however, the effect of water supply on the occurrence of preputial sucking is not clear.
- Teat bucket feeding during the first days of life appears to reduce the incidence of preputial sucking as compared to open bucket and cow feeding.

These conclusions will be investigated further in the next sections.

2. The effect of water supply on the occurrence of preputial sucking

INTRODUCTION

Veal calves are provided only 3,0 l of milk replacer daily in the first 2 weeks (usually supplemented by 1,5 l of water), which increases to 8 l at 4 weeks (appendix 1). Suckled calves, however, drink 6-12 l daily in the first days after birth (Walker, 1950; Kovalčik et al., 1980). It may be that this discrepancy causes a fluid deficit in bucket fed veal calves during the early weeks of the fattening period. This presumption is supported by measurements of water intake as reported in the preceding section. Also, Bogner (1981b) found additional water intake in veal calves in the first weeks after arrival. A fluid deficit may stimulate the intake of urine, as well as the licking of spilled water (Gropp et al., 1978). Similarly, restrictions in the availability of water may enhance urine drinking in fattening bulls (Kirchner, 1982).

In this section, the effect of additional water supply on the occurrence of preputial sucking is investigated. In three replicate experiments, water was provided in open buckets two or three times daily to a total of 60 calves in groups of five, whereas 60 other group housed calves did not receive additional water. All calves were observed every two days to detect preputial sucking. Furthermore, in the third experiment the drinking intensity of calves with and without extra water was measured to check if this was indeed reduced by water supply, as expected.

MATERIALS AND METHODS

Animals, housing and management

120 black and white male calves were used; they were about one week old upon arrival in the unit. Presumably all had been bucket reared prior to the experiments. In each experiment, they were housed in eight groups of five in pens consisting of wooden slatted floors and iron barred fences. All calves were fed twice daily around 8.00 and 16.00 h (appendix 1). The milk replacer powder contained 0,48% sodium and 1,37% potassium and it was supplied at a concentration of about 125 g/l liquid milk replacer. These concentrations were far below limit values for hypernatraemia indicated by Gropp et al. (1978). No roughage was provided.

The calves were tethered during the first 3-4 days after arrival and separated from each other by wooden partitions. From day 2 onwards, extra water was supplied at 15-20 minutes after feeding in all three experiments (table 6.2): in the first experiment 3 l (25°C), in the second 5 l (35°C) and in the third 4 l (35°C) in the first 7 days and 5 l (35°C) thereafter. In the third experiment, the calves also obtained 4 or 5 l water (35°C) between 13.00 and 13.30 h, after the presentation of 1 l water for a duration of 15 seconds (see below). Daily intake was registered per pen (exp. 1) or individually (exps. 2 and 3).

The observations started immediately after release of the calves (table 6.2). During the

Table 6.2 Data on management and observations for three experiments.

Experiment	1	2	3
Number of animals	40	40	40
Arrival	day 0	day 0	day 0
First release	day 3	day 4	day 4
Start observations	day 5	day 4	day 4
End observations	day 21	day 21	day 21
Water gift (l/calf/day)	2 × 3 l	2 × 5 l	2 × 4 (5) l
Water temperature (°C)	25	35	35
Lights on	continuously	continuously	8.00 - 16.30 h
Temperature (°C)	10-16	14-22	8-15
Humidity (%)	60-90	60-90	60-90
Frequency of tethering	–	every fourth day	every second day
Frequency of observation	every second day	every second day	every second day
Time of observation	14.00 - 10.00 h	14.00 - 10.00 h	8.30 - 16.00 h
Method of observation	video	video	direct

observation period in experiments 2 and 3, the calves were tethered either every fourth or every second day respectively. In experiment 2, the calves in two pens out of eight were tethered on one day and released on the next; then the calves in two other pens were tethered, and so on. In experiment 3, the same procedure involved four pens at a time. This was done in order to minimize the time spent in preputial sucking before detection; thus the detrimental effects of this behaviour on health and growth were reduced. For the same reason, any calf which engaged in preputial sucking for more than 20 times on one day was tethered permanently. This procedure was carried out for the first 3-4 weeks after arrival. Thereafter, the provision of extra water was stopped and all calves were tethered until release at 7 weeks.

Observations

In experiments 1 and 2, the calves were observed by video-cameras every two days between 14.00 and 10.00 h on the next day. Each calf was observed once a minute to assess preputial sucking. In experiment 3, the behaviour of individual calves was monitored by direct observations every 20 seconds in between feeding periods.

The day on which the score of preputial sucking in a particular calf exceeded 20, was called day of detection. Subsequently, the calf in question was tethered. This criterion level excluded the tethering of calves which only incidentally mouthed the prepuce. In practice, this criterion was not critical since usually the score of preputial sucking was either much lower or much higher than 20.

Drinking tests

In addition to registering water intake and preputial sucking, the intensity of drinking was assessed for all calves throughout experiment 3. Each day between 12.30 and 13.00 h, four groups of five calves which were tethered to the feeding gate were submitted to the following procedure. With the feeding gate closed, 1 litre of water (35 °C) was provided in a clean 20 cm deep tray. Immediately thereafter, the feeding gate was quickly opened to allow the calf to move forwards and start drinking. 15 seconds after it had touched the water surface, drinking was interrupted by the observer. The time between the opening of the feeding gate and the touching of the water surface (latency time) and the volume of water drunk were measured.

The timing of these drinking tests in relation to the water gifts per day is given in fig. 6.4. On day 12 and 13, the calves were also tested within half an hour after the supply of water between 13.00 and 13.30 h.

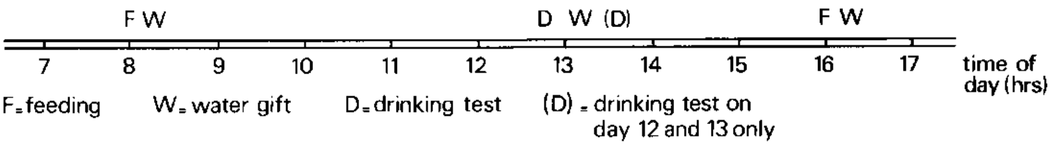

Fig. 6.4 Timing of water gifts and drinking tests in relation to feeding.

The procedure described above was applied to all 20 tethered calves in succession. The remaining 20 calves, which were loose housed that day, were tested on the next day, when they in turn were tethered (p. 60) and so on, during the whole observation period of 3 weeks. This implies three separate tests per calf per week. After 3 weeks, the water supply was terminated and all calves were tethered until release at 7 weeks. During this 4 week period of continuous tethering, drinking tests were performed only once a week.

Statistics

The statistical significance of differences in preputial sucking between groups of calves with and without additional water supply was calculated using the Mann-Whitney-U-test (Siegel, 1956). The independent variable in these calculations was the number of preputial suckers in each pen.

The reliability of correlations between latency time, volume of water consumed during tests and total daily intake in experiment 3 was assessed by Spearman's rank correlations test (Siegel, 1956).

Differences between calves with and without extra water supply in latency time and volume of water consumed during tests were checked for statistical significance by the Mann-Whitney-U-test (Siegel, 1956). In this case, the results of individual calves were regarded as independent estimates, since the animals were tested when separated from each other.

Table 6.3 Mean daily intake (l) of milk replacer and water per calf during the first three weeks in experimental groups with water supply and control groups of calves without water supply in three consecutive experiments.

	Week 1			Week 2			Week 3		
	Milk repl.	Water	Total	Milk repl.	Water	Total	Milk repl.	Water	Total
Experiment (20)	3,0	3,6	6,6	3,3	4,2	7,5	5,2	4,8	10,0
Control (20)	3,0		3,0	3,3		3,3	5,2		5,2
Experiment (20)	3,0	4,1	7,1	3,3	3,8	7,1	5,2	4,6	9,8
Control (19[a])	3,0		3,0	3,3		3,3	5,2		5,2
Experiment (20)	3,0	4,8	7,8	3,3	8,2	11,5	5,2	9,1	14,3
Control (17[b])	3,0		3,0	3,3		3,3	5,2		5,2

( ): number of calves
a: one calf eliminated due to illness
b: one calf died, two calves eliminated due to illness

Table 6.4 Mean water intake (l/calf) in the morning, at noon and in the afternoon on days 9 to 21 in three experiments.

	Morning	Noon	Afternoon
Experiment 1 (20)	2,33		2,23
Experiment 2 (20)	2,25		2,05
Experiment 3 (20)	2,94	3,17	2,58

( ): number of calves

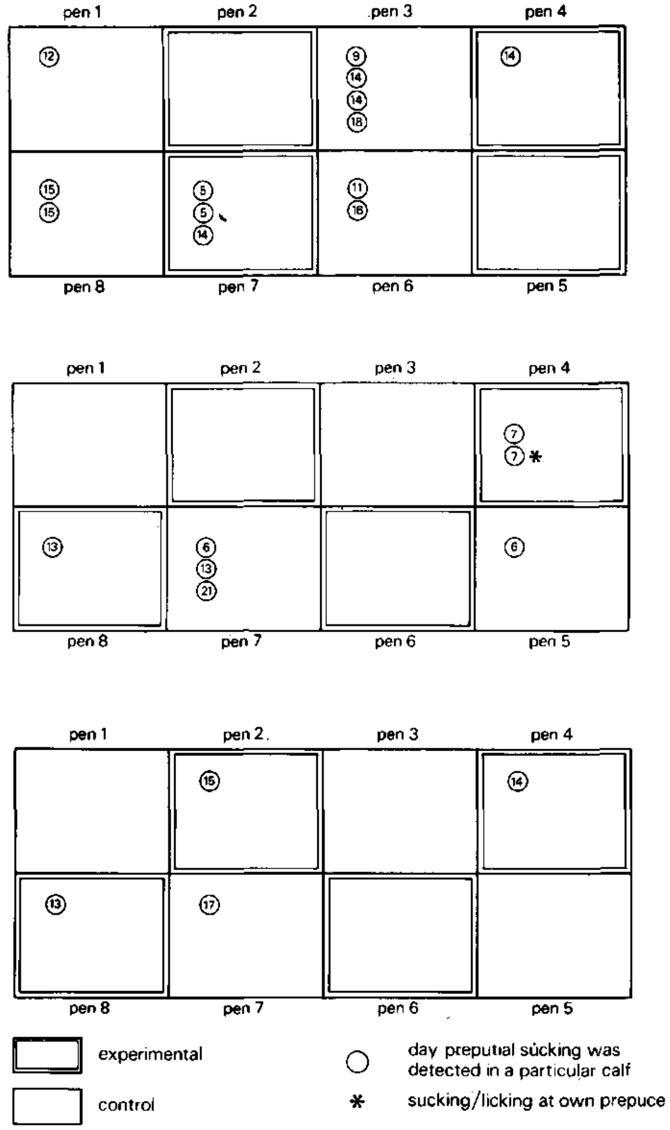

Fig. 6.5 Calves engaged in preputial sucking in three consecutive experiments; their distribution over the eight pens per experiment (four experimental pens with water supply and four control pens without water supply) and the day preputial sucking was detected in each calf. Each pen contains five calves, except for pen 1 in experiment 3 (four calves).

RESULTS

In the experimental groups with extra water, total fluid intake was much higher than in the control groups of calves (table 6.3). This difference was especially large in experiment 3, in which water was supplied three times daily instead of two times. Both milk replacer consumption and additional water intake increased with time (table 6.3). Water intake per presentation was similar at all two or three times of the day (table 6.4).

As shown in fig. 6.5, a total of 24 calves started preputial sucking; the first at 5 days, the last at 21 days after arrival when the observations stopped. In experiment 1, preputial sucking was observed in four experimental and nine control calves; in experiment 2 in three experimental and four control calves; and in experiment 3 in three experimental and one control calf. So, relatively few calves started preputial sucking (24 out of 120); such animals were equally represented in extra water (10) and in control groups (14).

Measurements on individual water intake in experiments 2 and 3 showed a large variation among calves but a fair consistency within calves over time, as illustrated for experiment 3 in appendix 5A. In each of these two experiments, three calves which were provided with additional water started preputial sucking. The individual water intake of these calves was high, average or low (fig. 6.6).

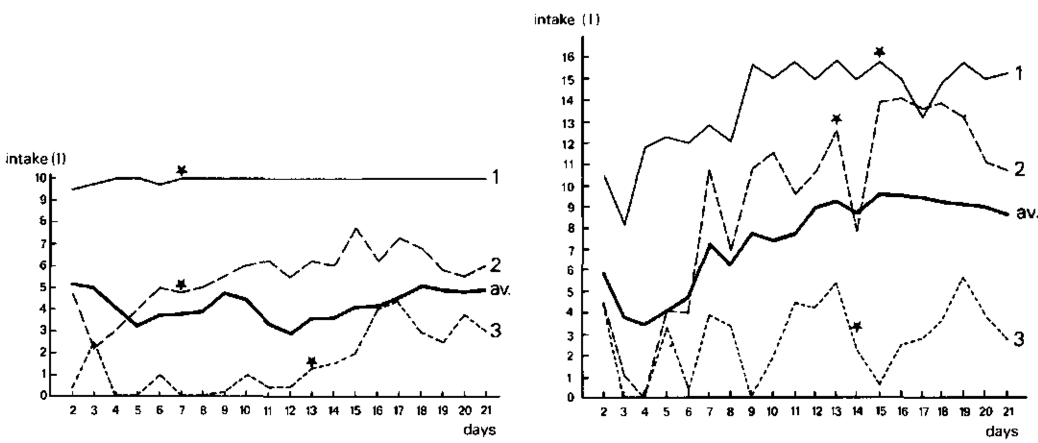

Fig. 6.6 Average daily intake of water in calves provided with additional water (av.) and daily intake of water in individual preputial suckers (1, 2, 3) in the first 21 days after arrival in experiment 2 (left) and experiment 3 (right). $N_{exp2} = N_{exp3} = 20$.
*: preputial sucking detected in the calf concerned

The outcome of the drinking tests of experiment 3 is summarized in table 6.5. The results of the individual calves are presented in appendix 5A and 5B. The tests of weeks 4 to 7 have been combined. Three calves of the control groups which were ill or died during the observation period were excluded. Two calves of the control groups and three of the experimental groups failed to touch the water surface and were therefore also excluded from the calculation of the mean latency time.

The great majority of the calves moved forwards and drank the water presented, immediately after the opening of the feeding gate. In the first week, latency time tended to be higher in the control groups as compared to the experimental groups. In both groups, latency to drink decreased during the observation period and no significant differences were detected.

After touching the water, nearly all calves drank without interruption; once having stopped a calf seldomly resumed drinking. The volume of water consumed during these

Table 6.5 Mean latency and standard deviation (1/100 min) and mean volume of water consumed and standard deviation (l/calf) during tests in experimental calves provided with additional water and in control calves without extra water supply during the first 3 weeks after arrival in experiment 3. Idem, during weeks 4, 5, 6 and 7 after the additional water supply was discontinued.

		Week 1	Week 2	Week 3	Weeks 4 - 7
Exper.	Latency time (N = 17)	4,73 (1,21)	3,15 (0,95)	3,30 (1,15)	2,70 (0,53)
	Volume (N = 20)	0,32 (0,27)	0,38 (0,28)	0,39 (0,28)	0,53 (0,26)
Control	Latency time (N = 15)	6,39 (2,22)	3,27 (0,99)	3,02 (1,51)	2,46 (0,71)
	Volume (N = 17)	0,40 (0,29)	0,47 (0,30)	0,48 (0,29)	0,57 (0,23)

tests increased in both groups over the course of the experiment. The water intake appeared to be constantly larger in groups without extra water as compared to groups receiving water three times daily; this difference, however, was not significant.

Spearman rank correlations between latency time, volume of water consumed during the tests and total daily intake of water were significant ($p \leqq 0,01$) in most weeks; there was a close relationship between the two latter factors in particular (appendix 5C).

On days 12 and 13 after arrival, drinking tests were performed directly before and directly after water supply at noon (fig. 6.4). The latency time and volume of water consumed during the tests after the water supply were markedly prolonged and reduced respectively (table 6.6) as compared to before the water supply. In the control calves, which did not receive additional water, these changes did not occur.

Table 6.6 Mean latency time and standard deviation (1/100 min) and mean volume of water consumed and standard deviation (l/calf) in tests before and after the water gift between 13.00 and 13.30 h in experimental calves provided with additional water and in control calves without extra water supply, as measured on days 12 and 13 of experiment 3.

		Before	After
Exper.	Latency time (N = 17)	3,38 (1,29)	5,44 (1,98)
	Volume (N = 20)	0,37 (0,29)	0,22 (0,22)
Control	Latency time (N = 15)	3,11 (0,96)	3,48 (1,40)
	Volume (N = 17)	0,48 (0,31)	0,45 (0,28)

DISCUSSION

The provision of additional water resulted in a substantial intake, which on average exceeded the amount of milk replacer consumed. This huge intake of fluid, however, did not reduce the occurrence of preputial sucking, since the numbers of preputial suckers in this group (10 out of 60 calves) was comparable to that in the control group without extra water (14 out of 60 calves). The relatively low incidence of preputial sucking in experiments 2 and 3 (a total of 11 out of 80 calves) may be due to the intermittent tethering of the calves, which reduces their chances to detect the prepuce.

Variation in water intake between individuals was extreme; whereas some calves consumed the total amount of water supplied daily, others hardly ever touched the water (appendix 5A). Calves with a low intake were seen to engage in preputial sucking as readily as those with a high intake (fig. 6.6). Apparently, preputial sucking occurs regardless of the water balance of the calves. Therefore, fluid ingestion as such seems to be no major goal in preputial sucking; the intake of urine during this activity may be merely adventitious to its role as a key-stimulus in sucking.

While this answers the main question of this research, it also raises new ones. They concern the regulation of fluid intake in calves. It is interesting that some of the calves showed a great urge to ingest water, which is apparent from their high drinking intensity (as measured during drinking tests) and their extremely high daily intake, which amounted to 40% of their liveweight. Given the opportunity, these calves might have consumed even more than this. Moreover, the average consumption of substantial quantities of water reduced the drinking intensity only for a short period, as appeared from the drinking tests (tables 6.5 and 6.6) and water intake per presentation was hardly affected by supplies shortly before (table 6.4).

At a young age, the calves obtain both water and feed from the udder. In this case, the regulation of water and feed intake is not separated, and it seems that fluid intake is largely dependent on the caloric content of the milk (Pettyjohn et al., 1963; Hafez and Lineweaver, 1968). When the caloric content of the milk is low, the physical capacity of the gastro-intestinal tract will limit fluid intake. Other factors such as taste (cf. Bell, 1959) and temperature (cf. Walker, 1950) of the fluid as well as the method of its ingestion (sucking, drinking; cf. chapter IX) may also influence fluid consumption. Not much is known about the physiology of water intake regulation in calves, which may differ from that in adult cattle. Further research on the development of fluid intake regulation in cattle may not only help to explain the high interindividual differences in water consumption found in this study, but it may also be relevant to the way in which calves should be fed.

CONCLUSIONS

- Extra supplies of water do not reduce the occurrence of preputial sucking.
- The huge variation in daily water consumption among different calves and the absence of a clear effect of water intake on drinking intensity raises interest in the regulation of fluid intake in these animals.

3. The effect of early sucking experience on the occurrence of preputial sucking

INTRODUCTION

Early experience in nutritive sucking may affect the incidence of preputial sucking, as suggested before (chapter VI.1). Among calves fed by different methods during the first days of life, the teat bucket reared ones seemed to refrain from preputial sucking in contrast to the bucket reared or mother nursed ones. The present section provides more data concerning this point.

Besides the possible effect of teat bucket feeding immediately after birth on preputial sucking, early experience with teat sucking may promote spontaneous sucking at a teat when the calves are fed by automatic feed dispensers, as assumed by Stephens (1974). If so, teat bucket reared calves should more quickly contact an available teat than bucket reared calves.

In this section it is investigated:

- if teat bucket feeding during the first days after birth indeed reduces the incidence of preputial sucking later in life, as compared to bucket or cow rearing just after birth;
- if teat bucket reared calves touch and suck an available teat more quickly than bucket reared calves.

MATERIALS AND METHODS

Animals, housing and management

Out of 40 male black and white calves in the first experiment, 20 had been bucket reared, 15 teat bucket reared and 5 kept with the mother during the first week of life. Average age of these groups on arrival in the unit was 5,7 (4-9) days, 6,2 (5-10) days and 7,0 (6-8) days respectively. This information was obtained from notes made by the purchaser of the calves; these data are reliable. Similarly reared calves were housed together in groups of five on wooden slatted floors as illustrated in fig. 6.7.

Out of 19 male black and white calves in the second experiment 8 were bucket reared during 8,8 (5-11) days, while 11 were teat bucket reared during the first 9,1 (7-11) days of life. These calves had been reared on three experimental farms for dairying, and the information about their feeding method is reliable. By adding one calf with unknown background, four groups of five calves each were composed using four pens with wooden slatted floors (fig. 6.7).

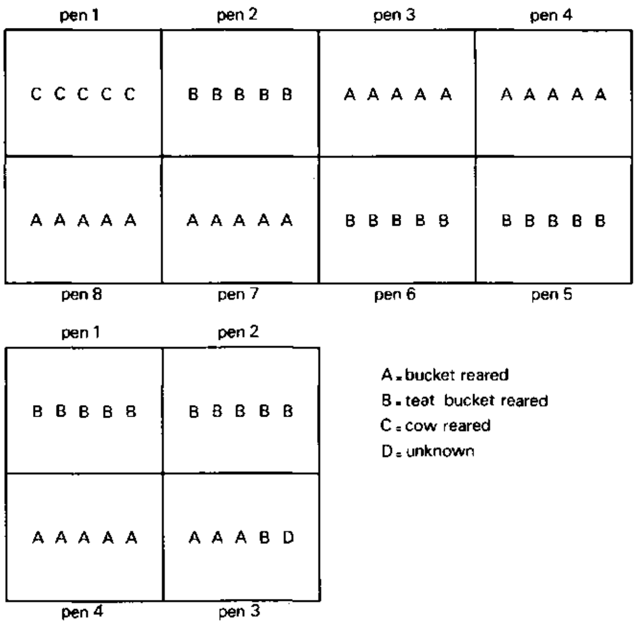

Fig. 6.7 Location of the calves in each pen during the first experiment (above) and during the second experiment (below).

In both experiments, the calves arrived in different batches over a period of seven days and they were subsequently tethered by 0,34 m long chains and separated individually by 0,80 m high and 0,60 m long partitions. All calves were released simultaneously for a period of three weeks (table 6.7).

In these experiments, a milk replacer was fed twice daily around 8.00 and 16.00 h without additional water. No roughage was supplied. During days 4 to 10 of the first experiment, water (at 13-15°C) was supplied in automatic drinking bowls in pens 1, 2, 7 and 8, but since most of the calves failed to drink, the bowls were removed and the calves were regrouped. Three bucket reared calves that had started preputial sucking were transferred to pen 7 and tethered, just like two other bucket reared calves which were engaged in preputial sucking. In this first experiment, the feeding gate was open continuously to allow access to rubber teats which were positioned above the buckets (fig. 6.2).

Table 6.7 Data on management in two experiments.

Experiment	1	2
Number of animals	40	19
Arrival [a]	day 0[b], 3[c]	day 0, 5, 7
Release	day 4	day 14
Start observations	day 5	day 14
End observations	day 26	day 35
Lights on	continuously	7.30-16.30 h
Temperature (°C)	8-18	10-15
Humidity (%)	70-90	60-90

a) day of arrival of the first batch = day 0
b) arrival of bucket reared calves
c) arrival of teat bucket and cow reared calves

Observations

The calves in both experiments were observed during three weeks after release; three times a week for 45 minutes after feeding. The total number of observations per feeding period was 135. Each calf was checked on the performance of preputial sucking once every 20 seconds by two observers, standing in front of the pens. When in a particular calf preputial sucking was registered more than 10 times in one observation period of 45 minutes, this calf was tethered to the feeding gate in between wooden partitions. That day was termed day of detection. Furthermore, teat sucking activity was recorded in the first experiment.

Sucking tests

In addition to the observations on preputial sucking, the first reaction of bucket and teat bucket reared calves upon the presentation of a rubber teat was monitored in the second experiment. This was done for all calves individually, at 3 and 6 days after arrival when they were still tethered. At that time, the average age of the calves was 12 (8-14) days and 15 (11-17) days respectively.

During a period of 5 minutes, while the feeding gate was open, each calf could suck at a teat which was attached above the open bucket. The time between the opening of the gate and first sucking (latency time) and the duration of sucking was recorded. This procedure was conducted at approximately 7.30, 11.00, 13.30, 15.30, 18.00 and 20.30 h. For the duration of these tests the lights were on; the calves were raised to their feet when it was time to permit sucking of the teat.

Statistics

See the previous section.

RESULTS

In the first experiment, a total of 16 calves started to suck the prepuce of penmates, most of them in the third week after arrival (fig. 6.8): 13 out of 20 bucket reared calves and 3 out of 5 cow reared calves. In contrast, not one of the 15 teat bucket reared calves was observed to engage in preputial sucking. The difference between bucket and teat bucket reared calves was significant (p (one-tailed) = 0,028). Interindividual variation in teat sucking frequency was large (0-115 in one feeding period) and there was no significant influence of the earlier rearing method on this activity.

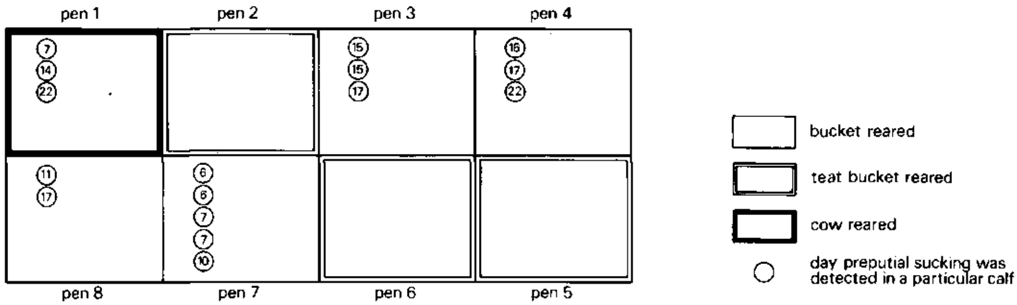

Fig. 6.8 Calves performing preputial sucking and day of detection in eight pens with differently reared calves. Each pen contains five calves.

In the second experiment, none of the eight bucket reared or the nine teat bucket reared calves were observed to suck the prepuce of penmates in excess of the criterion score during a three week period after release. In sucking tests before release, most calves usually contacted the teat and sucked within seconds after the opening of the feeding gate, whereas others commonly hesitated, looked around, smelled and licked at the bar construction and the teat before eventually sucking it (table 6.8, appendix 6A). This seemed unrelated to former experience with teat sucking.

However, complete failures to contact the teat within five minutes were predominantly observed in bucket reared calves (table 6.8, appendix 6A). These calves were excluded from the calculation of the mean sucking duration. The duration of sucking in calves which usually contacted the teat within five minutes was comparable in bucket and teat bucket reared calves on both days (table 6.9, appendix 6B).

DISCUSSION

The data presented in this chapter provide evidence on the effect of the feeding method during the first days after birth on the occurrence of preputial sucking later in life. In a total of three experiments (see also chapter VI.1), none of the 32 calves fed by teat buckets just after birth engaged in preputial sucking, whereas 24 out of 50 open bucket reared calves and 5 out of 15 cow reared calves regularly sucked the prepuce of penmates.

During the first days of life, a calf in proximity of the mother will locate a teat by trial and error learning (Lent, 1974). Early experience in teat sucking is required for spontaneous

Table 6.8 Latency time of teat sucking (s) for bucket and teat bucket reared calves on two days after arrival. The values shown are medians over six tests per calf per day.

Bucket reared calves	Day 3	Day 6	Teat bucket reared calves*	Day 3	Day 6
1	1,0	14,5	9	22,5	8,0
2	5,0	1,0	10	4,0	1,5
3	1,0	24,5	11	1,0	41,0
4	–	73,0	12	3,5	1,0
5	–	–	13	3,0	4,0
6	–	–	14	1,5	1,0
7	50,0	4,5	16	1,0	1,0
8	–	–	17	5,5	4,5
			19	5,0	107,5

* : calves 15 and 18 were eliminated due to persistent illness
–: failed to suck at the teat within 300 s in more than three tests per day

Table 6.9 Mean duration of teat sucking (s) per 5 minute test (six tests/calf/day) for bucket and teat bucket reared calves on two days after arrival.

	Day 3	Day 6
Bucket reared	120,5 (4)	138,8 (5)
Teat bucket reared	121,0 (9)	131,3 (9)

( ): number of calves

relocation of the teat (Kittner and Kurz, 1967), which is accomplished by the use of visual and tactile cues (Stephens and Linzell, 1974). These cues may closely resemble stimuli obtained in preputial sucking. Similarities between preputial and udder sucking may therefore promote the development of preputial sucking in cow reared calves, which is rapid in some cases (chapter VI.1).

In teat bucket reared calves, the association between preputial sucking and nutritive sucking at the artificial teat may be less obvious due to discrepancies in social and tactile stimuli. On the other hand, bucket reared calves which are inexperienced in nutritive sucking may still perform trial and error learning, leading to attachment at the prepuce, as described in chapter V. These points will be discussed in more detail in chapter IX.

In infants, Brassell and Kaye (1974) found a decrease in latency time before sucking when presenting a more attractive sucking object and Seltzer (1969) reported that nipple fed babies sucked more on those nipples which were associated with feeding. Apparently, latency time and sucking duration reflect the subject's responsiveness to a teat. In the present study, teat bucket reared calves nearly always sucked the teat within 5 minutes, whereas some of the bucket reared calves regularly failed in doing this. The performance of teat sucking in bucket reared calves, once attached to the teat, seemed not impaired. These observations seem relevant to the feeding of calves from automatic feed dispensers equipped with teats, since they suggest that bucket reared calves are less likely to find the teats on their own as compared to teat bucket reared calves. Consequently, they may need more guidance from the herdsman to assure sufficient intake.

CONCLUSIONS

- Preputial sucking occurs significantly less among calves which are fed by teat buckets during the first days of life as compared to those reared with open buckets. In fact, teat bucket reared calves may refrain completely from this behaviour, in contrast to bucket and cow reared calves.
- The obtainment of a teat for sucking seems promoted by early teat bucket feeding. Further investigations on these points may be useful and of practical significance.

VII The influence of different tethering methods on lying behaviour

INTRODUCTION

The welfare of veal calves is improved by housing them in group pens as compared to individual crates (chapter IV), but a disadvantage of group housing is the occurrence of preputial sucking (chapter III), which is detrimental to health and production (chapter V). In order to find methods of preventing preputial sucking, the development of this behaviour was analysed in chapter V and subsequently, the influence of two factors (water supply and early sucking experience) on its occurrence was investigated (chapter VI). Although this analysis advanced the understanding of the causation of preputial sucking, it did not provide a practical method of preventing this activity without restraining the calves.

Other possibilities of avoiding preputial sucking, such as the application of St. John's wort oil (an olfactory deterrent) to the prepuce of all calves upon arrival or the tethering of the animals in a self-yoking feeding gate for half an hour after each feeding, were not effective (De Wilt, 1982. Unpublished data). At present, tethering the calves during the first 6-8 weeks after arrival seems to be the only effective and practical way to prevent harmful preputial sucking (chapter III).

Tethering involves fixing the calves to the feeding gate by neck chains and separating individuals by partitions (photo 3.4). This method has already been applied successfully on several farms and may become a general practice for housing veal calves in group pens with bucket feeding during the first weeks after arrival (Smits, 1984). The behavioural consequences of tethering, however, are largely unknown. Van Putten (1982) reports that the chains used for tethering are often very short, which restricts grooming and lying down freely, but he presented no quantitative information. This chapter describes some preliminary data on the behaviour of tethered calves.

The tethering of cattle is not unusual and neither is the separation of individual lying spaces by partitions. For instance, tying stalls and cubicle housing are in common use on dairy farms. The influence on cow behaviour of various designs of these constructions has been evaluated (Kämmer and Schnitzer, 1973; Westendorp, 1983). These studies mainly focussed on standing up and lying down and on the lying postures of the trunk and legs.

This chapter provides data on the same aspects of behaviour and in addition the position of the head during lying is discussed. Lying with the head supported, which occurs during paradoxical sleep, was severely restricted by the sidewalls of the crates (chapter IV) and it is not unlikely that the performance of this posture is also affected by tethering.
Objectives are:

- to evaluate the effect of tethering on the incidence of several lying postures and on patterns of standing up and lying down. For this purpose, the lying behaviour of calves in tethering stalls and in crates or group pens (chapter IV) was compared;
- to investigate the influence of different stall designs on these aspects of behaviour.

In the first experiment, both narrow and wide stalls were equipped with either long or medium length chains. The long chains were held extended by contraweights to avoid entanglement of the forelegs; the medium-sized chains were attached to the feeding gate, which is normal practice. In the second experiment, the same stalls were used and again equipped with chains of medium length, but instead of the long chains attached to contraweights, short fixed chains were used. These two experiments will be presented consecutively and will then be discussed.

Experiment 1

MATERIALS AND METHODS

Animals, housing and management

40 black and white male calves of about one week old arrived in the unit. They were tethered immediately after arrival in stalls consisting of wooden partitions (0,80 m high and 0,60 m long), which were firmly attached to the feeding gate, either 0,48 or 0,58 m apart. Two types of neck chains were used: one was 0,40 m long and attached to the feeding gate at about 0,20 m above floor level, the other was 0,48 m long and glided through a hole in the feeding gate (as a result of a 0,2 kg contraweight). Both types of chains, which will be referred to as fixed and gliding chains respectively, were used in stalls of different width (fig. 7.1). The floor was constructed of wooden slats (slat 70 mm, slot 30 mm). A self-yoking feeding gate was installed (photo 3.4), which was employed after the untethering of the calves (at 8 weeks after arrival) for fixating them individually at feeding times.

	pen 1	pen 2	pen 3	pen 4
stall	48	58	48	58
chain	48°	48°	40	40
	pen 8	**pen 7**	**pen 6**	**pen 5**
stall	58	48	58	48
chain	40	40	48°	48°

Fig. 7.1 Diagram of 8 pens (each containing 5 calves) with 4 different combinations of stall width and chain length and construction. Stall width and chain length are in cm. °: gliding chains

All calves were fed a milk replacer at approximately 8.00 and 16.00 h and for the first two weeks, additional water was provided after the morning feeding (appendix 1). No straw cobs were supplied during tethering.

The weight of the calves was checked at 0, 2, 6 and 8 weeks after arrival, since this is related to the space requirements of the animals. The lights were on continuously. On observation days the minimum and maximum ambient temperatures were measured; these temperatures (fig. 7.2) are relevant when evaluating the occurrence of different lying postures. The minimum temperatures on these days were higher than the lower critical temperature for veal calves of this age (Webster et al., 1978). Humidity varied between 50 and 95%.

Observations

Direct observations were used to record the lying postures of the calves, whereas the patterns of standing up and lying down were evaluated by video observations. In direct observations, the behaviour of each calf was registered every 7½ minutes during 24 hour periods (one per week) in weeks 2, 4 and 6 and 48 hour periods in weeks 7 and 8. At feeding times, the observations were interrupted for 30 minutes. The following types of behaviour were recorded (chapter II):

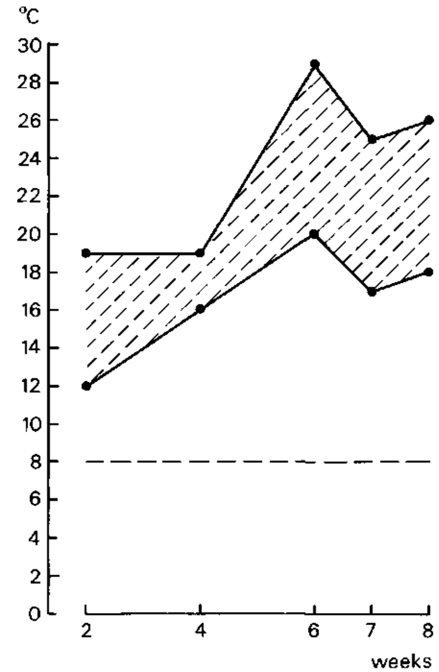

Fig. 7.2 Range of ambient temperatures during direct observations in different weeks after arrival. The lower critical temperature for veal calves in the first two months of life (Webster et al., 1978) is indicated by the dotted line.

- total lying;
- lying on side : lying on the side with legs stretched;
- hindlegs stretched : lying on the brisket, with both hindlegs stretched regardless of the position of the forelegs;
- foreleg(s) stretched : lying on the brisket, with one or both forelegs stretched regardless of the position of the hindlegs;
- head backwards : lying with the head turned backwards;
- head forwards : lying with the head forwards;
- head on object : lying with the head on/against object;
- head upright : lying with the head upright.

The incidence of all lying postures was calculated as a percentage of total lying. In video observations, the three middle calves out of five calves in each pen were used to record the performance of standing up and lying down. The observations were carried out from 18.00 until 6.00 h once in week 6 and once in week 8. Physical contacts with the feeding gate, partitions and chains when standing up or lying down were registered as follows:

Feeding gate
- protruding the muzzle forwards between the vertical bars of the feeding gate
  - with collision
  - without collision
- no protruding of the muzzle between the bars

Partitions
- bumping against partition, causing it to move sideways
- no bumping against partition

Chains

- chain tugging, indicated by a sudden stop of the backwards and/or upwards movement of the head
- no chain tugging

Furthermore, the sequence of standing up and lying down was evaluated using the following criteria:

Standing up - normal (fig. 7.3A)
The body is pushed forwards by the hindlegs to rest on both forelegs, which are bent: the head is swung forwards and the hindquarters upwards until both hindlegs are stretched. Both forelegs are then stretched consecutively.

Standing up - interruption
Standing up, but resting on both bent forelegs for a few seconds, before or after stretching the hindlegs (fig. 7.3A, phases 2, 3 and 5).

Standing up - attempt
Standing up, but before fully extending the hindlegs (fig. 7.3A, phase 2 and sometimes phase 3), the hindquarters are lowered again and the forequarters are also lowered by crawling forward a little on bent forelegs.

Standing up - abnormal
Standing up, but the forelegs are stretched before the hindquarters are raised.

Lying down - normal (fig. 7.3B)
After placing the hindlegs slightly forwards, the forelegs are bent one by one. The hindlegs are then placed even further forwards, slightly to one side, which pushes the body forwards and thus takes the load off the hindlegs. Only one hindleg is used for support when the hindquarters are lowered on the unloaded side. When the hindquarters touch the floor, the bodyweight is shifted more to the rear. The forequarters are lowered by crawling forwards a little on both bent forelegs.

Lying down - interruption
Lying down, but after bending the forelegs (fig. 7.3B, phase 4) the sequence is interrupted for a few seconds before lowering the hindquarters.

Lying down - attempt
Lying down, but after bending one or both forelegs (fig. 7.3B, phases 3 and 4), they are stretched again and the hindlegs are placed backwards.

Lying down - abnormal
Lying down, but the hindquarters are lowered before the forelegs are bent.

Statistics

The statistical significance of differences in behaviour (and growth) between calves in different types of stalls was calculated by using the Mann-Whitney-U-test (Siegel, 1956). The behaviour of individual calves was taken as an independent variable.

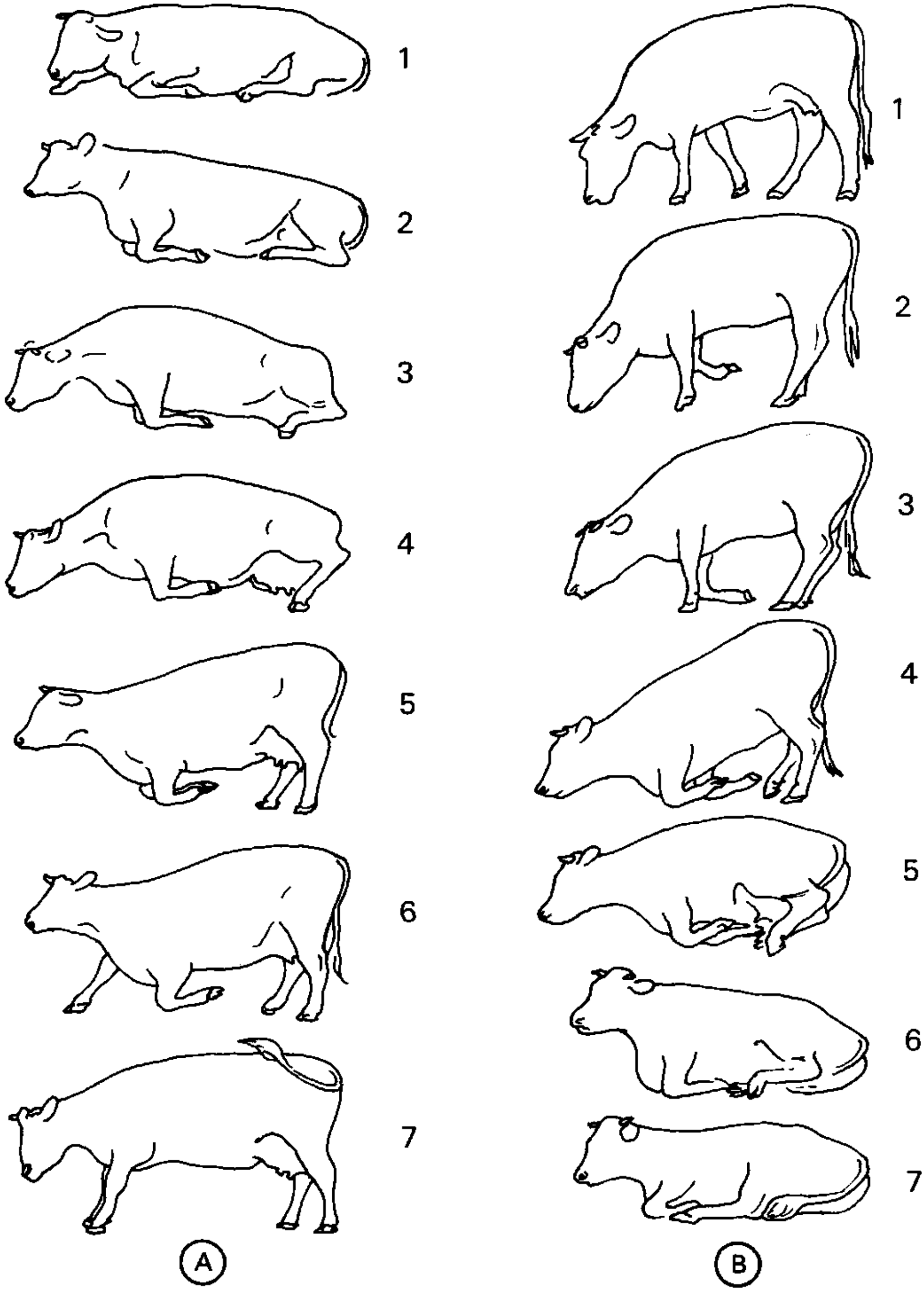

Fig. 7.3 Normal patterns of standing up (A) and lying down (B) of a cow.
From: Kämmer and Schnitzer (1975).

RESULTS

The mean weight of the calves in the different tethering stalls was comparable (approximately 40, 42, 68 and 86 kg in weeks 0, 2, 6 and 8 respectively) and this allows a comparison of behaviour that is unbiased with respect to the space requirements of the animals.

Total lying in all tethering stalls varied between 65-80% of the observation time in the different weeks. Lying on the side or on the brisket with the hindlegs stretched did not occur in week 2, but increased gradually thereafter (fig. 7.4). No significant differences were detected concerning the incidence of lying on the side in the various types of stalls, but lying on the brisket with the hindlegs stretched was more frequent ($p \leqq 0{,}025$) in the wide stalls in week 7 and 8 as compared to the narrow stalls. Lying on the brisket with one or both forelegs stretched was relatively rare in week 2, but increased rapidly to considerable levels in week 4 and more gradually from then on, with no significant difference between the stalls (fig. 7.4).

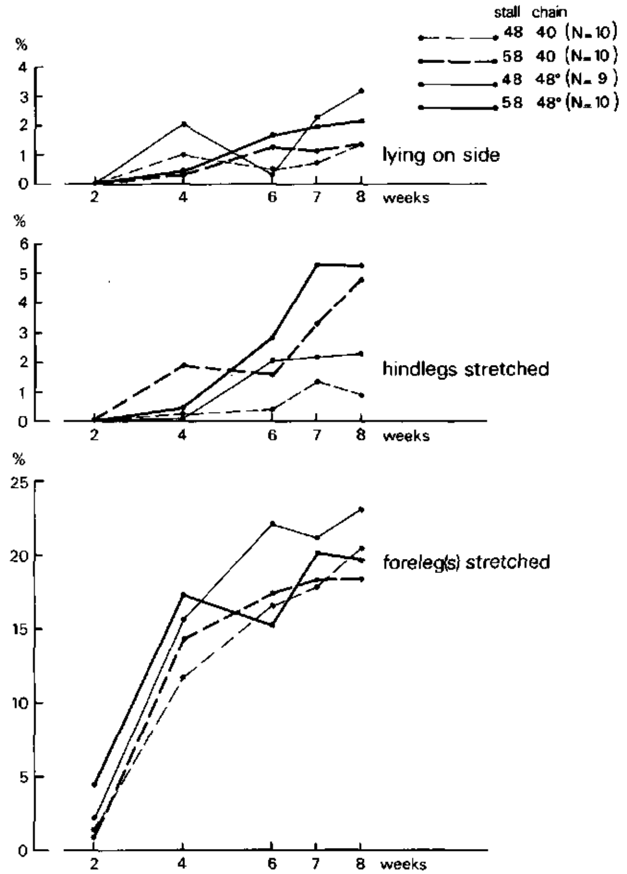

Fig. 7.4 Lying postures of the trunk and legs in four types of stalls in different weeks after arrival. The values indicated are percentages of total lying. Legend: stall width and chain length are in cm. °: gliding chains

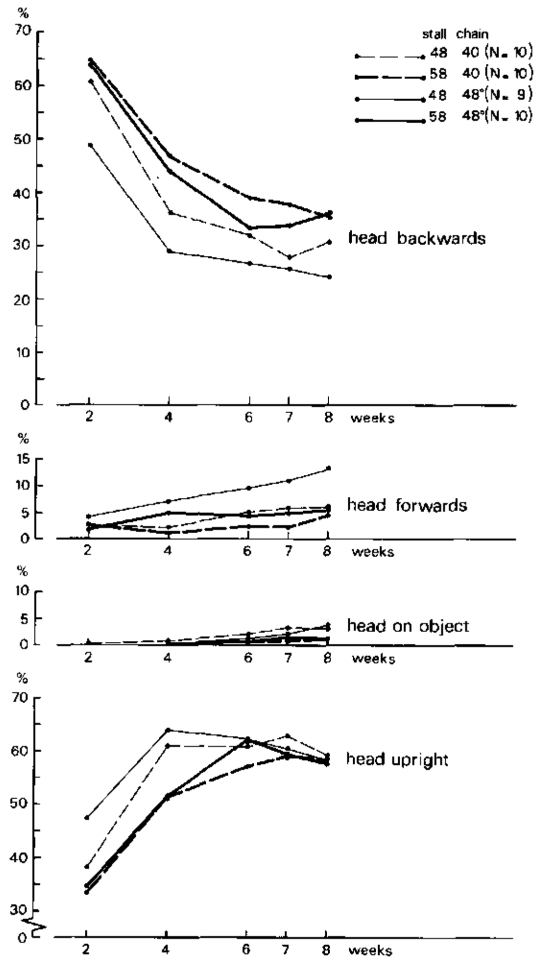

Fig. 7.5 Lying postures of the head in four types of stalls in different weeks after arrival. The values indicated are percentages of total lying. Legend: stall width and chain length are in cm. °: gliding chains

The incidence of lying with the head turned backwards was gradually reduced in all types of stalls (fig. 7.5). Generally, this lying posture was more frequent in the wide than in the narrow stalls ($p \leq 0{,}025$ in weeks 2, 4 and 7). In stalls with gliding chains, the occurrence of this posture was lower as compared to stalls of identical width but equipped with fixed chains. Thus, the frequency of lying with the head turned backwards was lowest in the narrow stalls with gliding chains ($p \leq 0{,}025$ in most weeks). In these stalls, lying with the head forwards was most frequent. The leaning of the head against a partition was rarely observed, but tended to increase with time. Lying with the head upright was more frequent in the narrow than in the wide stalls in weeks 2 and 4 after arrival ($p \leq 0{,}025$), but these differences later disappeared (fig. 7.5).

Entanglement of the forelegs in the chains, a possibility which motivated the use of contraweights for the longer chains, was not observed with any of the chains used in this study. Some of the calves, however, wound the fixed chains up by rotating the neck collar. This was subsequently avoided by the use of a rotating attachment of the chain to the feeding gate.

Contacts with the feeding gate, partitions or chain when standing up and lying down in each type of stall are presented in table 7.1. When standing up, the head was swung forwards with the muzzle lifted (fig. 7.3A, phases 3, 4 and 5), and then protruded between the vertical bars of the feeding gate in most cases. In some calves, the head showed swellings on the points of contact with the bars. It is not certain however, if this was due to these collisions or to the rubbing of the head in between the bars immediately before feeding when the calves became excited at the sight of the milk.

Table 7.1 Contacts with the feeding gate, partitions or chain when standing up and lying down in four types of stalls in weeks 6 and 8 after arrival. The values shown are percentages of the total number of sequences.

	Standing up				Lying down			
Stall width (cm)	48	58	48	58	48	58	48	58
Chain length (cm)	48°	48°	40	40	48°	48°	40	40
Calves (N)	5*	6	6	6	5*	6	6	6
Sequences (N)	147	139	160	173	147	137	159	176
Protruding the muzzle	86,0	85,6	70,1	92,9	8,2	2,2	9,5	4,5
- with collision	43,6	44,6	33,8	55,9	0,7	0,7	0,7	1,1
- without collision	42,4	41,0	36,3	37,0	7,5	1,5	8,8	3,4
No protruding	14,0	14,4	29,9	7,1	91,8	97,8	90,5	95,5
Bumping partition	13,6	18,7	5,6	11,6	28,6	27,3	10,1	19,8
No bumping partition	86,4	81,3	94,4	88,4	71,4	72,7	89,9	80,2
Chain tugging	0,7	1,4	0,0	0,0	20,4	11,7	10,7	9,1
No chain tugging	99,3	98,6	100,0	100,0	79,6	88,3	89,3	90,9

*: one calf eliminated due to illness °: gliding chains

The calves refrained from thrusting their muzzle through the feeding gate in only 10-30% of the times they stood up (table 7.1). In these cases, the muzzle was held downwards while the head was bent sideways. This suggests the deliberate avoidance of a collision. When raising the hindquarters, the partitions were sometimes bumped, but in the majority of times a calf stood up no such contact was recorded (table 7.1). Exceptionally, the raising of the forequarters (as the final phase in the standing up sequence; fig. 7.3A, phases 6 and 7) was accompanied by chain tugging (table 7.1).

The feeding gate, partitions and chains also interfered with lying down. While the animals were on bent forelegs (fig. 7.3B, phases 3, 4 and 5) the muzzle was occasionally pushed forwards between the bars of the feeding gate, but far less than when standing up and it was unusual for the head to collide (table 7.1). On the other hand, when the hindquarters were lowered onto the floor (fig. 7.3B, phases 5 and 6), the partitions moved fairly often and when shifting the body weight to the posterior (fig.7.3B, phase 6), the backwards movement of the head was sometimes stopped by the extended chain (table 7.1). These difficulties in standing up and lying down occurred in all four types of stalls with no significant difference between them.

Table 7.2 shows that the great majority of standing up sequences were performed in the normal way: the hindquarters were raised before the forequarters without interruption and this nearly always resulted in the calf standing. Sometimes however, the standing up movements were interrupted for a few seconds, mostly just before the hindquarters were raised (fig. 7.3A, phases 2 and 3). When the calf then continued to stand up, this was termed an interrupted sequence; when it lay down again, this was registered as an attempt. In the latter case, the distance of the calf to the feeding gate was reduced as compared to before the attempt. This phenomenon, due to the crawling forwards of the forelegs after

Table 7.2 Patterns of standing up and lying down in four types of stalls in weeks 6 and 8 after arrival. The values shown are percentages of the total number of sequences.

	Standing up				Lying down			
Stall width (cm)	48	58	48	58	48	58	48	58
Chain length (cm)	48°	48°	40	40	48°	48°	40	40
Calves (N)	5*	6	6	6	5*	6	6	6
Sequences (N)	147	139	160	173	147	137	159	176
Normal	97,3	84,2	86,3	90,2	91,2	86,9	85,5	86,9
Interruption	2,0	10,8	6,3	6,9	8,8	13,1	13,2	11,9
Attempt	0,0	2,2	3,1	1,7	0,0	0,0	0,6	0,6
Abnormal	0,7	2,9	4,4	1,2	0,0	0,0	0,6	0,6

*: one calf eliminated due to illness °: gliding chains

lying down (fig. 7.3B, phase 7), further complicated standing up. Nevertheless, the subsequent sequence nearly always resulted in standing; consecutive repetitions of attempts were seldom. On other occasions, the forequarters were raised before the hindquarters (abnormal sequence).

When lying down, the hindquarters were always lowered before the forequarters and no abnormal sequences occurred. After bending the forelegs and with the hindquarters still raised (fig. 7.3B, phase 4), a calf sometimes shuffled its feet for a few seconds, which was followed by lying down (interruption) or by a return to the standing position (attempt).

No significant influence of stall width or chain length and construction on the sequence of standing up and lying down was detected, although in the narrow stalls with long chains, standing up seemed practically unaffected (table 7.2). The results of the individual calves are presented in appendix 7A.

Experiment 2

MATERIALS AND METHODS

Animals, housing and management

Similarly to the previous experiment, 40 black and white males were used; their age was one week on arrival. They were tethered in the same way as those in experiment 1 and two lengths of neck chains were used (0,40 m and 0,34 m); both were fixed to the self-yoking feeding gate. Four different combinations of stall width and chain length were involved in this study (fig. 7.6). The floor was again of wooden slats (slat 70 mm, slot 30 mm).

	pen 1	pen 2	pen 3	pen 4
stall	48	58	48	58
chain	40	40	34	34
stall	58	48	58	48
chain	34	34	40	40
	pen 8	pen 7	pen 6	pen 5

Fig. 7.6 Diagram of 8 pens (each containing five calves) with four different combinations of stall width (cm) and chain length (cm).

The calves received a milk replacer and water as in experiment 1, but no straw cobs were supplied until they were untethered at 10 weeks. The calves were weighed at 0, 2, 6 and 10 weeks after arrival. Lights were on continuously. Ambient temperature was measured as in experiment 1; the minimum temperature during direct observations was just above the lower critical temperature for veal calves (Webster et al., 1978) in weeks 3 and 6, but dropped below this value in week 9 (fig. 7.7).

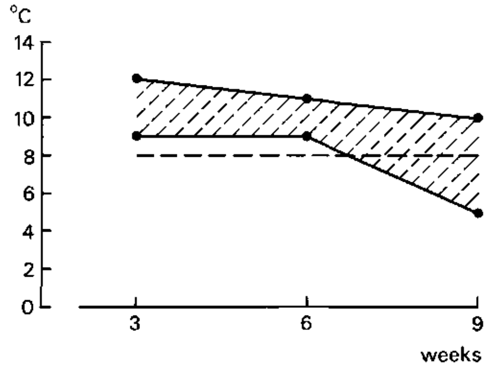

Fig. 7.7 Range of ambient temperatures during direct observations in different weeks after arrival. The lower critical temperature for veal calves during the first two months of life (Webster et al., 1978) is indicated by the dotted line.

Observations

Direct observations were made for 24 hour periods (one per week) in weeks 3, 6 and 9 after arrival in the same way as in experiment 1 and the same lying postures were recorded. Video observations were made on the three middle calves out of the five in one pen from 20.00 to 6.00 h once in weeks 6, 7, 9 and 10 to record standing up and lying down. These sequences were evaluated as in experiment 1, but physical contacts with the feeding gate, partitions or chains were not registered.

Statistics

See experiment 1.

RESULTS

There was little variation in the mean weight of the calves in the different tethering stalls (approximately 39, 41, 67 and 98 kg in weeks 0, 2, 6 and 10, respectively). This allows an unbiased comparison of lying behaviour in the stalls.
The occurrence of all lying postures up to week 6 is very similar to that established in the previous experiment (compare figs. 7.4, 7.5, 7.8 and 7.9). However, the decrease in stretched postures (fig. 7.8) and the increase in lying with the head backwards (fig. 7.9) in week 9 contrasts with these previous results and those of Kersten (1983). This deviation is related to the ambient temperature in week 9, which fell below the lower critical temperature for veal calves of this age (fig. 7.7). This point will be returned to later.

A comparison of the lying behaviour in the four types of tethering stalls gave the following results. Total lying amounted to 68-75% of the observation time in all stalls. Lying on the side or on the brisket with both hindlegs stretched differed only in week 6; these postures were more frequent in the wide than in the narrow stalls ($p \leq 0,025$; fig. 7.8). The incidence of lying on the brisket with one or both forelegs stretched was comparable in all stalls (fig. 7.8).

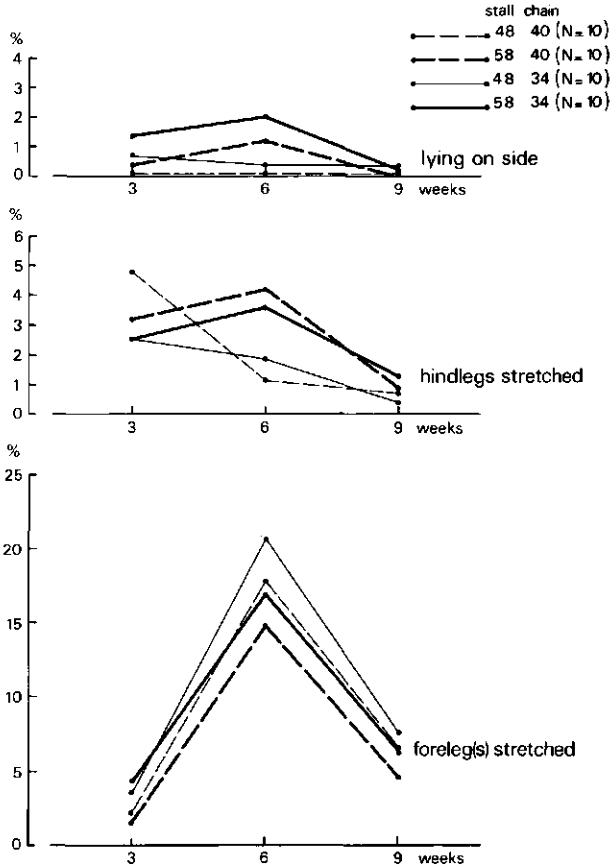

Fig. 7.8 Lying postures of the trunk and legs in four types of stalls in different weeks after arrival. The values indicated are percentages of total lying. Legend: stall width and chain length are in cm.

Lying with the head turned backwards was equally frequent in all stalls in week 3, but in weeks 6 and 9 this posture was performed most in the two types of wide stalls ($p \leqq 0,025$; fig. 7.9). In stalls of equal width, the occurrence of lying with the head turned backwards tended to be reduced when the tethering chains were shorter. The time spent lying with the head forwards on the floor was generally short, with no significant differences between the stalls. In both types of narrow stalls, the head was more often leaned against the partitions than in the wide stalls in weeks 6 and 9 ($p \leqq 0,025$). The frequency of lying with the head upright did not differ significantly between these stalls, although it seemed lowest in the wide stalls with long chains (fig. 7.9).

Standing up and lying down showed the same limitations as described in the previous experiment, although the incidence of attempts and abnormal patterns was somewhat higher in the present experiment (table 7.3). In general, standing up appeared to be more difficult than lying down; abnormal sequences for example only occurred when standing up.

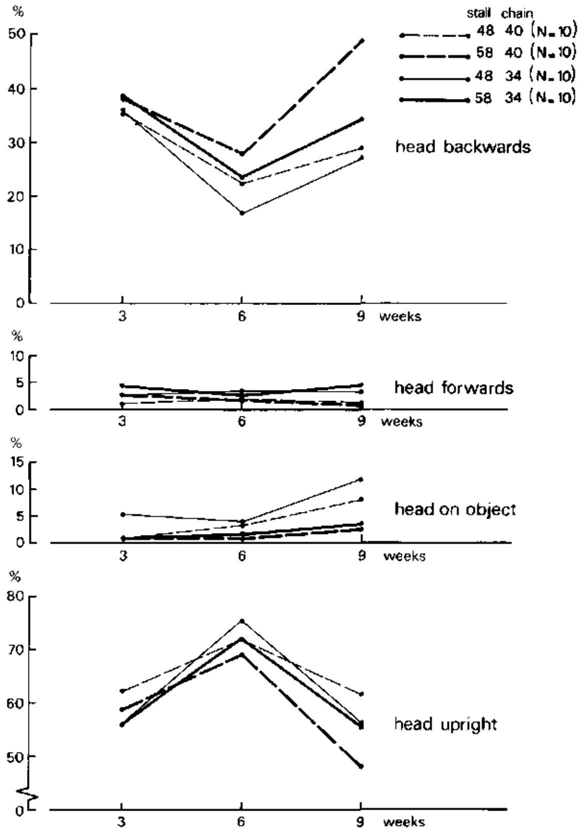

Fig. 7.9 Lying postures of the head in four types of stalls in different weeks after arrival. The values indicated are percentages of total lying. Legend: stall width and chain length are in cm.

The incidence of difficulties experienced during these activities was similar in all four types of stalls (table 7.3). In the narrow stalls with long chains, standing up seemed relatively uncomplicated, but lying down in these stalls seemed more difficult than in other stalls. These differences, however, were not significant. The individual results are shown in appendix 7B.

Table 7.3 Patterns of standing up and lying down in four types of stalls in weeks 6, 7, 9 and 10 after arrival. The values shown are percentages of the total number of sequences.

	Standing up				Lying down			
Stall width (cm)	48	58	48	58	48	58	48	58
Chain length (cm)	40	40	34	34	40	40	34	34
Calves (N)	6	6	6	6	6	6	6	6
Sequences (N)	187	192	192	226	195	178	185	217
Normal	86,6	69,3	76,0	62,4	76,4	89,3	90,3	83,9
Interruption	4,3	10,4	6,8	13,7	19,0	7,3	5,4	10,6
Attempt	2,2	10,9	5,7	10,2	4,6	3,4	4,3	5,5
Abnormal	6,9	9,4	11,5	13,7	0,0	0,0	0,0	0,0

DISCUSSION

In contrast to the sidewalls of the crates (figs. 3.2 and 3.5), the partitions of tethering stalls are only 0,60 m long, reaching from the feeding gate to just behind the calves' shoulders (fig. 3.6, photo 3.4). Although this construction may facilitate the stretching of the hindlegs to some degree, as suggested by Van Putten (1982), the claws were often pushed against the partitions or, when the hindlegs were placed further to the rear, stretching was restricted by the neighbouring calf which was usually lying at the same time. Therefore, stall width remains crucial with respect to the mobility of the hindlegs during lying in tethering stalls, despite the limited length of the partitions.

Lying on the brisket with the hindlegs stretched is facilitated by the wide stalls as compared to the narrow ones at the end of the tethering period (6 and 8 weeks, figs. 7.4 and 7.8). However, in all tethering stalls this lying posture was less frequent than in group pens in the same period (6 and 8 weeks, figs. 4.2, 7.4 and 7.8); this frequency of lying with the hindlegs stretched was (in 0,58 m wide stalls) higher than or (in 0,48 m wide stalls) comparable to that in crates of 0,70 m width at 8 weeks.

Lying on the side, which is usually performed with hindlegs and forelegs stretched forwards (fig. 4.3) was also facilitated in the wide stalls as compared to the narrow ones, although in both stalls this lying posture was restricted in comparison to the group pens (figs. 4.2, 7.4 and 7.8). Finally, the stretching of the forelegs was not impaired. The length and construction of the chain seemed of minor importance to the performance of all stretched postures just mentioned.

The frequency of lying with the head turned backwards was reduced in narrow stalls (0,48 m) when the chains were short (0,34 m) or provided with contraweights, as compared to 0,58 m wide stalls equipped with 0,40 m fixed chains (figs. 7.5 and 7.9). The incidence of alternative postures to support the head while lying, such as those with the head forwards or against the partitions, was most frequent in stalls in which lying with the head backwards was lowest (figs. 7.5 and 7.9). The consequences of these postural changes for the performance of paradoxical sleep (PS) will be discussed in the next chapter.

However, except for the narrow stalls equipped with short or gliding chains, the level of all lying postures of the head recorded in the tethering stalls at 6 and 8 weeks was comparable to that in crates and group pens at 8 weeks (figs. 4.4, 7.5 and 7.9). This suggests that the turning of the head backwards is in general not seriously obstructed in these tethering stalls.

Since entanglement of the forelegs or other problems related to the chain length and construction did not occur with 0,40 m fixed chains, using shorter chains or longer chains provided with contraweights is unnecessary. Consequently, the use of chains which are 0,34 m or shorter and of gliding chains with contraweights should be avoided since they somewhat restrict lying with the head turned backwards.

The data from week 9 of experiment 2 (figs. 7.8 and 7.9) have not been included in the comparison of lying postures, since they deviated considerably from values usually obtained at this time (experiment 1; Kersten, 1983). In this week, the calves were lying far more often than usual with the legs tucked under or close to the body and with the head buried in the side. This behaviour, which reduces heat loss, was observed by Gonzales-Jimenez and Blaxter (1962) in acute cold. In the present study, it reflects the calves' reaction to a decrease in environmental temperature below the lower critical value of approximately 8 °C for veal calves of this age (Webster et al., 1978). The lower critical temperature marks the point at which the animals start increasing their heat production to maintain body temperature by enhancing the catabolism of food energy or tissue reserves (Thompson, 1973). Obviously, this has a negative influence on production efficiency.

The curling up of the body, the tucking in of the legs and occasional shivering indicate that the calves experience discomfort in these cold conditions. It can be concluded that temperatures below critical values are detrimental to calf well-being and should therefore be avoided.

When standing up, the mobility of the head, which is swung forwards while raising the hindquarters, is crucial. There was not enough space available in the tethering stalls for the unobstructed performance of the head swing, as was apparent from regular collisions of the muzzle with the feeding gate (table 7.1). Apart from the possible discomfort caused by the collisions of the head with the feeding gate, this lack of space interfered with the most essential phase of standing up, viz. the swinging of the head forwards, which is necessary to raise the hindquarters. On this point, improvement of the present design of tethering stalls is desirable.

When lying down, the spatial requirements in the forwards direction are less than when standing up, since the head is not swung forwards but merely extended to shift the body weight, while slowly lowering the hindquarters. Moreover, the position of the forelegs as a balancing point when lying down is further to the rear than when standing up, since the forelegs are shuffled forwards after lying down. This explains why collisions with the feeding gate were rare during lying down but frequent during standing up (table 7.1).

Occasionally, the partitions were moved when a calf displaced its hindquarters sideways when lying down, and in some cases the partitions were also bumped when standing up (table 7.1). Finally, the chain sometimes interrupted the backwards movement of the head when lying down (table 7.1). In general however, the partitions and the chain did not hinder standing up or lying down, since these contacts were casual and had no real effect on the pattern of these activities.

The patterns of standing up and lying down were comparable in all stalls. As a guideline, the mean percentage of attempts and abnormal patterns in both experiments is compared in table 7.4 with that of veal calves in crates of 130 × 0,62 m during the first three months after arrival (Graf et al., 1976).

Table 7.4 Comparison of attempts and abnormal patterns when standing up and lying down in tethering stalls (2 experiments) and in crates. The values shown are mean percentages of the total number of sequences.

		Standing up	Lying down
Tethering stalls (exp. 1)	Sequences (N)	619	619
	Attempt	1,8	0,3
	Abnormal	2,3	0,3
Tethering stalls (exp. 2)	Sequences (N)	797	775
	Attempt	7,3	4,5
	Abnormal	10,4	0,0
Crates (Graf et al., 1976)	Sequences (N)	944	985
	Attempt	13,4	9,1
	Abnormal	11,2	4,5

In the present experiments, the level of difficulty in standing up and lying down was fairly low; most complications occurred in experiment 2, especially with standing up. In contrast to calves in crates (Graf et al., 1976), prolonged sitting during abnormal patterns or interruptions which lasted several minutes did not occur with the calves in the tethering stalls. It can be concluded therefore, that although standing up and lying down in the tethering stalls were not performed without difficulty, these problems were generally not of a serious nature.

The increase in difficulty of standing up or lying down in experiment 2 may be connected with the low ambient temperatures; a similar seasonal influence on these activities was observed with fattening bulls in open cattle houses in summer and winter (Wierenga, 1985. Unpublished results). A reduction in the blood supply to the extremities, which occurs in such cold conditions (Thompson, 1973), may be responsible.

CONCLUSIONS

- The tethering of calves in stalls of 0,48 m in width restricts lying on the side or on the brisket with the hindlegs stretched at 6 and 8 weeks, but to no greater extent than housing in crates of 0,70 m width at 8 weeks; in 0,58 m wide stalls, both lying postures are hindered less. The stretching of the forelegs in these tethering stalls is not impaired. Chain length and construction do not influence the postures of the trunk and legs during lying.
- Stalls of 0,48 m in width hinder the performance of lying with the head turned backwards as compared to stalls of 0,58 m in width, but these restrictions are not serious. The use of chains of 0,34 m and shorter or chains provided with contraweights is discouraged since this is unnecessary and it restricts the turning of the head backwards during lying.
- In tethering stalls, not enough space is available in front of the animals to let them swing the head forwards freely when standing up. Casual contacts with the partitions or restrictions by the chains are of minor importance since they do not actually hinder standing up or lying down.
- In general, standing up and lying down occurred without great difficulty, but their performance may deteriorate under circumstances such as cold. At temperatures below the lower critical value the calves experience discomfort, reflected in extreme postural changes and shivering. Such conditions should therefore be avoided.

VIII The effect of restrictions to lying behaviour on paradoxical sleep

INTRODUCTION

The complete relaxation of the neck muscles during paradoxical sleep (PS) requires support of the head. In calves, this is commonly accomplished by turning the head backwards on the shoulder, belly, hindlegs or floor. In individual crates and in some tethering stalls, however, the performance of this posture is restricted. As a result, the head is generally leaned forwards on the floor or sideways against the partitions. The consequences of these modifications of lying behaviour for the performance of sleep are not clear (chapter IV and VII).

The nature of sleep in ruminants was controversial until a few decades ago (Balch, 1955) when for the first time the electrical activity of the brain and muscles was monitored in this type of animals by electroencephalography (EEG) and electromyography (EMG) respectively (Bell, 1960; Ruckebusch, 1962). As in other mammalian species (Jouvet, 1967), two states of sleep were recognized: slow wave sleep (SWS) and PS. In SWS, the electrical activity of cortical brain cells is synchronized and muscle tone is slightly reduced as compared to the waking state, whereas in PS cortex activity is desynchronized and muscle tone, especially of the neck muscles, is absent.

In a further study on sleep in cows, Ruckebusch and Bell (1970) reported PS to be accompanied by brief and jerky movements of the eyes, ears, muzzle, mouth and legs. Similar twitches have been recorded in other species and they can be used successfully to determine the onset and end of PS, but in SWS behavioural criteria are imprecise (Jouvet, 1967). In the present study, the registration of EEG and EMG could not be performed, but a description of several twitches and their temporal dispersion was made in order to assess PS behaviourally.

The aim of this chapter is:
- to investigate the possibility of measuring paradoxical sleep (PS) by the use of behavioural criteria;
- to assess the effect of obstructions to lying with the head turned backwards on the performance of PS.

In a pilot experiment, the occurrence of various twitches of the eyes, ears, muzzle, mouth and legs and the position of the head during lying are recorded by direct observation to gain insight into the behavioural characteristics that accompany PS in calves. In the main experiment, PS is assessed by ear twitches only, during consecutive days before, during and after obstruction of lying with the head turned backwards. Thus, the influence of these obstructions on the occurrence of PS is studied. These two experiments, both performed at the experimental farm "De Ossekampen" of the Agricultural University, are presented separately but discussed conjointly.

Experiment 1

MATERIALS AND METHODS

Animals, housing and management

Three black and white calves, born on the experimental farm and kept with the mother for the first 1-2 days after birth (table 8.1), were successively housed in a calf box, which was 1,12 m long, 0,85 m wide and 0,92 m high. This box consisted of wooden partitions at the sides and back and a barred fence in front. The floor was made of wooden slats which were well covered with straw. The calves were tethered to the front with neck chains of about 0,50 m in length.

They were fed 1,5-3,0 liter of cow's milk twice daily around 7.30 and 16.30 h. No additional water was provided and apart from the straw bedding, no roughage was available. The straw bedding was replaced twice a week. The light regime consisted of daylight between 7.30 and 18.00 h and reduced lighting at night consisting of one bulb lamp. Ambient temperature and humidity are given in table 8.1.

Table 8.1 Additional data about the calves and the environment.

	Calf 1	Calf 2	Calf 3
Weight at birth (kg)	30	38	35
Age at observation (days)	8	13	10
Temperature (°C)	1-16	5-13	3-12
Humidity (%)	45-97	70-98	60-98

Observations

Direct observations were carried out continuously from 10.00 until 15.00 h by one observer, sitting beside the calf box on a platform of about 1 m in height. Each calf was observed on one day only. The start and ending of the following activities were recorded on audiotape:
- lying;
- lying with the head turned backwards
- lying with the head forwards on the floor

In addition, the following twitches were registered:

eyeball(s) : jerky movements of the eyeball(s) behind relaxedly closed eyelids;
eyelid(s) : abrupt contractions of orbital muscles around the eye(s), often accompanied by slight movements of the head;
ear(s) : very subtle ear rotations (one per 3 s with an amplitude of 2-3 cm at the tip of the ear(s)) alternated by more rapid movements of higher amplitude (one per second, about 20 cm respectively);
muzzle : twitches of the muzzle in upward direction;
mouth : slight movements of the lower jaw, up and down;
leg(s) : convulsions of the muscles of one or more claws or legs, sometimes resulting in the shaking of the body.

By definition, the above mentioned muscle contractions, performed in fast repetition, constitute one burst; several bursts of these contractions which are no more than 30 seconds apart, are regarded as belonging to the same bout.
- Bout of *"Paradoxical Sleep" ("PS"):* time during which bursts of twitches of the eyes, ears, muzzle, mouth or legs occur without an interruption for more than 30 seconds.
- Bout of *Ear Movement Sleep (EMS):* time during which bursts of twitches of the ears occur without an interruption for more than 30 seconds.

Single bursts, more than 30 seconds before or after other bursts and shorter than 10 seconds were neglected. In this way, occasional blinks of the eyes or rotations of the ears in reaction to external stimuli (flies, sounds) were excluded from the calculation of "PS" and EMS. As a rule, bursts of twitches succeeded each other well within 30 seconds, indicating the usefulness of this criterion, which was employed previously by Kuipers and Whatson (1979) for piglets.

RESULTS

In experiment 1, the calves were lying for most of the observation time between 10.00 and 15.00 h (table 8.2). When lying, the head was supported regularly, most commonly turned backwards but also forwards; this latter posture was particularly frequent in calf 1.

After lying down, the calves usually engaged in several activities including self licking, eating straw and ruminating. During these activities, the head was upright (fig. 8.1). The turning of the head backwards on the shoulder, belly or hindlegs always appeared as a clear and resolute movement, whereas the laying of the head forwards on the floor occasionally resulted from a very gradual increase in the relaxation of the neck musculature when lying with the head upright. During lying with the head backwards it used to slide forwards gradually, as a result of increasing relaxation. When sustained forwards on the lower jaw, the head often tumbled sideways a little, probably for the same reason. Sometimes, the drooping of the ears and the closing of the eyes could be observed.

Table 8.2 Lying behaviour between 10.00 and 15.00 h in three calves as a percentage of observation time.

	Calf 1	Calf 2	Calf 3
Lying	80,3	95,7	66,7
Head backwards	21,5	10,6	25,7
Head forwards	23,4	0,0	4,5

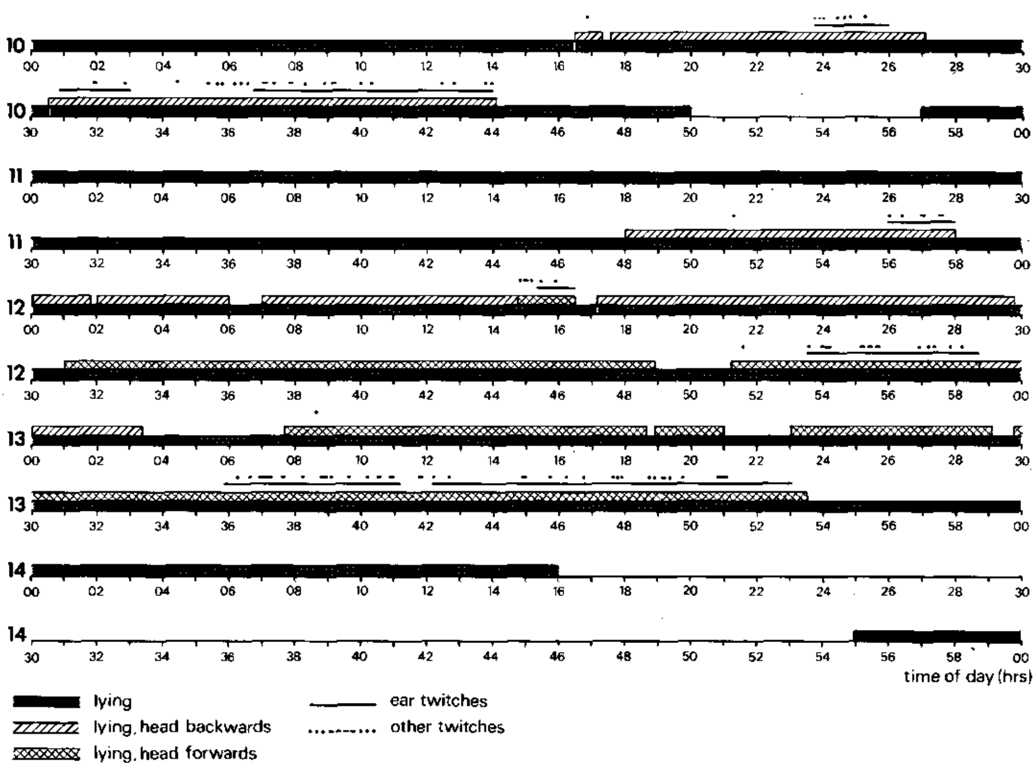

Fig. 8.1 Periods of lying, lying with the head backwards or forwards, ear twitches and other twitches during direct observations from 10.00 - 15.00 h for calf 1. When the head is not backwards or forwards during lying, it is upright.

In many cases, these movements preceded the occurrence of the first twitches, some time after the laying down of the head (fig. 8.1). These twitches occurred in bursts lasting only a few seconds, ear movements excepted (table 8.3). The latter usually continued for several minutes, accompanied by other twitches (fig. 8.1). Speed and amplitude of ear movements was variable and so was the density in time of other bursts. Therefore, convulsive activity was high at some times, when various bursts appeared simultaneously or in procession and low at other times, when only slight movements of the ears were visible. Due to the synchronism of ear twitches with other twitches, the estimation of PS on the basis of Ear Movement Sleep (EMS) only is comparable to the assessment of PS from all twitches together (''PS''; table 8.4).

Table 8.3 Frequency, average duration (s) and minimum/maximum duration (s) of various bursts of twitches in three calves between 10.00 and 15.00 h.

	Frequency			Average duration			Min.-max. duration		
Calves	1	2	3	1	2	3	1	2	3
Eyeball(s)	9	7	2	4,6	4,9	4,5	2-11	3-12	2-7
Eyelid(s)	36	16	19	4,6	2,9	1,6	1-20	1-12	1-7
Ear(s)	8	6	6	271,9	174,8	170,7	70-657	144-243	92-266
Muzzle	20	0	6	3,6	.	3,3	2-10	.	1-7
Mouth	16	2	2	13,6	1,5	5,0	3-43	1-2	1-9
Leg(s)	10	9	12	2,7	3,1	1,3	1-11	1-8	1-2

. : not relevant

Table 8.4 Paradoxical sleep, inferred from all twitches (''PS'') and from ear twitches only (EMS) as a percentage of observation time (10.00 - 15.00 h) in three calves.

	Calf 1	Calf 2	Calf 3
''PS''	13,3	6,0	6,1
EMS	12,1	5,8	5,7

Experiment 2

MATERIALS AND METHODS

Animals, housing and management

The five calves used in this experiment were four black and white females and one red and white male (table 8.5), born at the experimental farm and kept with the mother for the first 1-2 days thereafter. They were transferred in four consecutive pairs (for practical reasons some calves were used twice) to a separate room, the observation unit (fig. 8.2). The outer wall of this room was insulated with bales of straw to reduce noise from outside and to exclude daylight. In this way, disturbances were minimized and the light regime could be controlled. The four boxes in this room were identical in size and construction to those in experiment 1. The front part of the floor, however, was covered with a rubber mat and little straw, the back part with plentiful straw. The calves of each pair were placed in box 2 and 3; box 1 and 4 were occupied by other calves, which were not observed.

All animals were tethered with a neck chain of 0,50 m in length. In this situation, the movements of the head while lying were not impaired by the chain or the sidewalls. A few days after tethering, one calf (the experimental one) of each pair was restrained by a halter

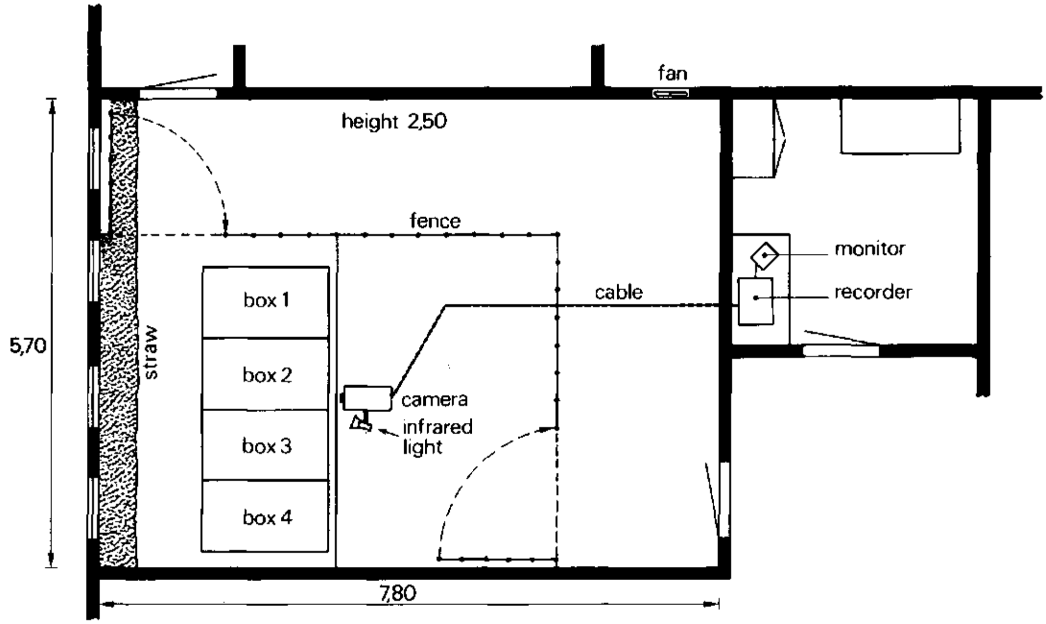

Fig. 8.2 General view of the observation unit and the registration room. Dimensions in metres.

(fig. 8.3); the other, the control one was not haltered. The halter was fastened to a vertical bar by a chain of 0,20 m in length. Thus, haltering prevented the turning of the head backwards. Generally, the halter was removed again after 24 hours. In pair 4, however, one calf was haltered for three consecutive days to assess the effects of a more prolonged obstruction of lying with the head turned backwards (table 8.5). This calf was unchained at feeding times for about half an hour to enable grooming.

The calves were fed as in experiment 1. The straw bedding was replaced twice a week, but not immediately before or during the observations. The room was illuminated from 6.00 until 18.00 h, using four artificial fluorescent lights. Ambient temperature and humidity are presented in table 8.5.

Fig. 8.3 Experimental calf provided with a halter and a neck chain.

Observations

The behaviour of the calves was continuously recorded from 24 hours before haltering until 48 hours after removal of the halter. The experimental calf and the control calf were monitored simultaneously (fig. 8.4). For this purpose, a video-camera paired with an infrared light was installed behind both boxes, about 2 m above floor level. A recorder and monitor were placed in an adjacent room (fig. 8.2), allowing the operation of the equipment without disturbing the calves.

From the videotapes, the duration and frequency of lying, lying with the head turned backwards ("head backwards") and lying with the head forwards on the floor ("head forwards") were recorded. Of all possible twitches, only those of the ears were registered. The other twitches could not always be recognized clearly.

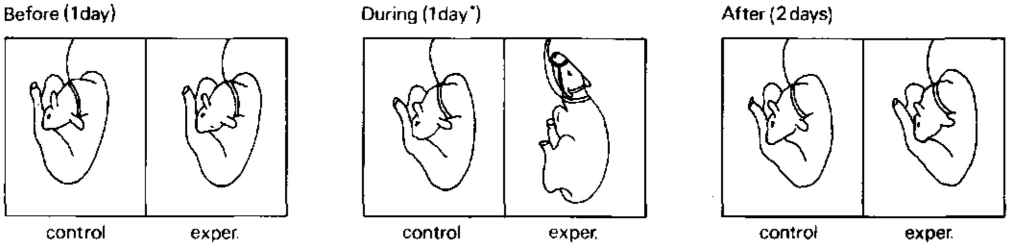

Fig. 8.4 Overview of one pair of calves before, during and after haltering. *: 3 days in pair 4

Table 8.5 Additional data on the calves, the management and the observations.

	Pair 1		Pair 2		Pair 3		Pair 4	
Calves[a]	C+	E*	C°	E	C°	E[b]	C+	E*
Sex	♀	♀	♀	♀	♀	♂	♀	♀
Weight at birth (kg)	29	29	.	.	.	.	29	29
Age at start of observation (days)	7	8	9	12	19	.	45	46
Days in room before observation	6		5		15	6	10	
Observation days before haltering	1		1		1		1	
Observation days during haltering	1		1		1		3	
Observation days after haltering	2		2		2		2	
Temperature (°C)	13-15		9-11		5-8		7-11	
Humidity (%)	80-90		78-93		71-91		81-98	

[a]: control (C) and experimental (E) calves
[b]: red and white calf
+/ */ °: three calves which are used twice
.: unknown

RESULTS

In contrast to other twitches, ear movements could be detected easily by video observations. This possibility was employed in experiment 2, by continuously recording Ear Movement Sleep (EMS) on several consecutive days. The shortest single EMS bout registered during a normal head backwards posture lasted only 31 seconds, the longest about 17 minutes. The number of these bouts per 24 hours varied between 16 and 40 and their average duration per 24 hours fluctuated between 163 and 355 s. The total duration of EMS per 24 hours ranged from 57,6 min to 151,2 min (4,0 to 10,5% of 24 hours).

The temporal relationship between standing, lying, lying with the head supported (head backwards + head forwards) and EMS during a natural day is illustrated in fig. 8.5. Periods of lying with the head supported were extremely variable in duration. They tended to be concentrated in intervals of 30-60 min, separated by extended periods of lying with the head upright; these in turn were often interrupted by standing. EMS mostly occurred at the end of longer periods of lying with the head supported; the termination of EMS regularly coincided with the lifting of the head. Sleep cycles, characterized by a regular reoccurring of EMS bouts within a period of lying with the head supported (Ruckebusch and Bell, 1970) were seldom observed. Standing was most frequent and prolonged during the daytime, when lying periods were relatively short with few extended spells of lying with the head supported and only occasional bouts of EMS.

The diurnal pattern of all these activities was comparable before, during and after haltering (fig. 8.6). Generally, during each hour from 18.00 until 6.00 h, when the lights

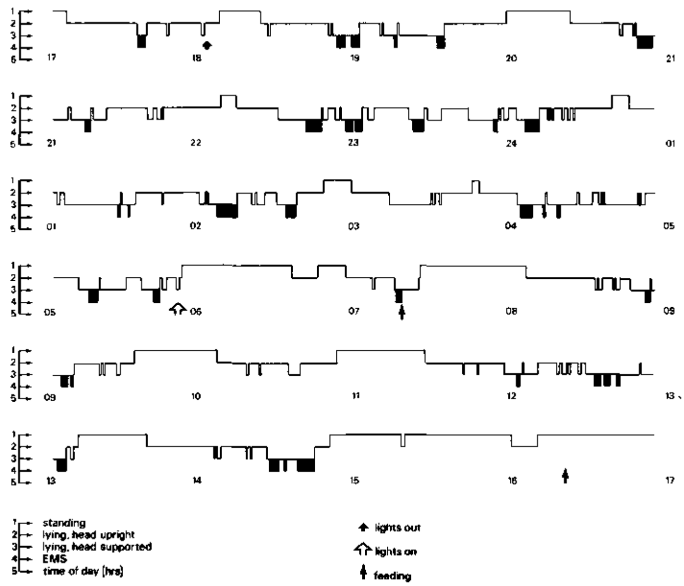

Fig. 8.5 Distribution of standing, lying with the head upright or supported and Ear Movement Sleep (EMS) during 24 hours (control calf of pair 3 on observation day 1).

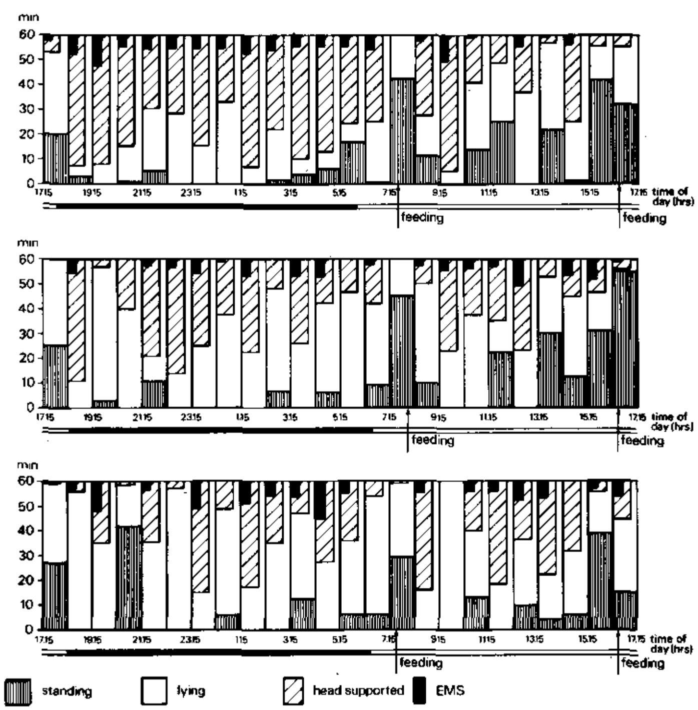

Fig. 8.6 Distribution of standing, lying, lying with the head supported and Ear Movement Sleep (EMS) in the experimental calf of pair 4
- during the day before haltering (above);
- during the first day of haltering (middle);
- during the first day after haltering (below).

were out, the calves were lying nearly all the time. Lying was relatively rare in the early morning and late afternoon, when the milk was provided. Lying with the head supported and EMS were concentrated during hours of darkness, but also appeared in the late morning and early afternoon.

The influence of haltering on lying behaviour and EMS is shown in table 8.6. In control calves, which were not haltered, the results were comparable on all observation days. In experimental calves, haltering affected the position of the head during lying and the occurrence of EMS. Lying as such was not markedly influenced by this procedure.

As shown in table 8.6, supporting the head when lying was predominantly accomplished by turning it backwards on the shoulder, belly or hindlegs and only incidentally by leaning it forwards on the floor. EMS was mainly performed during lying with the head turned backwards and rarely while it was sustained forwards. However, the relative proportion of EMS during both lying postures was comparable: $EMS_{head\ backwards}$/head backwards = 0,25 and $EMS_{head\ forwards}$/head forwards = 0,22.

When the turning of the head backwards was obstructed by haltering, intention movements (Heymer, 1977) of this turning occurred, but eventually the head was sustained forwards on the floor instead. The total duration of lying with the head supported seemed not affected by this obstruction. The incidence of EMS, however, was slightly reduced during haltering: from 7,8% to 5,8% (table 8.6). The proportion of EMS during lying with the head forwards ($EMS_{head\ forwards}$/head forwards) was only 0,14 when haltered.

The frequency and average duration of EMS during haltering, however, were within range of normal variation (appendix 8). After removal of the halter, the incidence of all activities observed was about equal to that before haltering (table 8.6).

In pair 4 with one calf haltered for three consecutive days, similar effects of haltering on lying behaviour and EMS appeared (appendix 8). As the only exception, the occurrence of EMS in the experimental calf on the second day of haltering was the same as before haltering. On the first and third day of haltering, however, EMS was clearly reduced.

Table 8.6 Lying behaviour and Ear Movement Sleep (EMS) on four consecutive days before, during and after haltering. The values shown are mean percentages per 24 hours over three control calves and three experimental calves. The results of the individual calves are given in appendix 8.

Days	Day before		Day during		First day after		Second day after	
Calves	Contr.	Exper.	Contr.	Exper.	Contr.	Exper.	Contr.	Exper.
No. of calves	3	3	3	3	3	3	3	3
Lying	76,4	75,3	79,1	79,5	75,4	78,1	76,7	70,8
Head backwards	31,3	29,9	24,9	0,0	24,4	30,9	28,9	24,7
Head forwards	1,0	9,7	2,2	42,3	2,5	5,7	3,2	6,9
Head supported	32,3	39,6	27,1	42,3	26,9	36,6	32,1	31,6
EMS	7,5	7,8	6,9	5,8	6,9	7,6	7,4	7,1

DISCUSSION

PS in cattle is characterised by a profound relaxation, reflected in the absence of muscle tone, a reduction of blood pressure and periods of lower heart and respiration rates (Ruckebusch 1970). Although much of its function is still obscure, the performance of PS seems important to the organism. It has been proposed that the specific activation of the brain during PS stimulates the development of the central nervous system (Roffwarg et al., 1966). Furthermore, PS probably promotes learning processes (Coenen, 1979) and it may also maintain physiological readiness, as suggested by the frequent awakening of the subject after PS (Snyder, 1966).

The selective prevention of PS by rousing the subject at the onset of this sleep state becomes progressively harder with time (Dement, 1960) and this deprivation leads to an increased irritability of the subject (Jouvet, 1967; Ruckebusch, 1974). After deprivation, PS is recovered (Khazan and Sawyer, 1963; Siegel and Gordon, 1965; Levitt, 1967; Ruckebusch, 1974) proportionally to the extent of its prevention (Jouvet, 1967). These findings indicate the biological signifance of PS and suggest detrimental effects on welfare, when the occurrence of this sleep state is thwarted.

PS may be recognized from several behavioural phenomena. In a calf which is lying with the head supported, the drooping of the ears and partial closure of the eyes and the relaxation of the neck muscles, occasionally visible from the shifting of the head, precede the onset of PS, which is indicated by the appearance of twitches of the eyes, ears, muzzle, mouth or legs (Ruckebusch and Bell, 1970). As opposed to the gradual relaxation of the ears, eyelids and neck, these bursts of convulsions can always be clearly recognized, although they generally last only a few seconds, with the exception of the ear movements. The termination of PS is signalled by the ceasing of ear movements and other twitches, in most cases followed by the immediate opening of the eyes and postural changes, such as the lifting of the head and the shifting of the body. These features have been identified by Siegel and Gordon (1965) in cats, Weiss and Fifkova (1964) in mice, Dement and Kleitman (1957) in man and Ruckebusch and Bell (1970) in cattle.

The continuous monitoring of PS phenomena on consecutive days, in periods of light and darkness was carried out in the present study by using video recording equipment and infrared lighting. In these circumstances the discrimination of twitches of the eyes, muzzle and mouth, which were rather subtle, was very difficult. Therefore, other signs of PS were employed, such as the gentle or more vigorous rotations of the ears. Since these ear movements usually covered extended periods during which several bursts of other twitches appeared, the assessment of PS by ear movements only (EMS) was fairly identical to its estimation from all twitches combined (table 8.4).

However, the question of whether EMS corresponds to "real" PS as measured by EEG and EMG is most important. EMS occupied 7-8% of a natural day (table 8.6), whereas "real" PS amounts to 13-14% in calves of this age (Ruckebusch and Barbey, 1971). In contrast to the latter study, the calves in the present one consumed straw from the bedding, which stimulates the development of the rumen and strongly reduces PS in young ruminants (Ruckebusch and Bell, 1970). Consequently, "real" PS in this study was probably lower than 13-14%; EMS therefore constitutes a major part of this sleep state.

The total duration of EMS per day in the present study agrees with the amount of PS in goats of the same age, supplied with roughage (7-8%; Ruckebusch, 1962) and it is markedly higher than the daily amount of PS in adult cows (2-3%; Ruckebusch and Bell, 1970). The average duration of EMS periods (163-355 s) corresponds with the average duration of PS periods in cows (3-5 min; Ruckebusch and Bell, 1970). It can be concluded that the quantitative characteristics of EMS are sufficiently in agreement with those of "real" PS to justify the use of EMS for approximating changes in PS.

The lying behaviour of the calves was modified by the application of a halter, which was too short to allow the turning of the head backwards. Although the calves did not resist haltering, this was still quite an interference since it also restricted other activities such as grooming, social contacts and exploration. The duration of lying, however, was not affected and neither was the duration of lying with the head supported, since the head was laid forwards instead of backwards. The calves adopted this position already shortly after haltering (fig. 8.6). This indicates the importance of sustaining the head during lying, which may at least be partly attributed to its role in the relaxation of the neck muscles during PS.

The main question is whether reclining the head forwards or backwards are equally effective with respect to the performance of PS. This may be assessed from the relative duration of EMS in both lying postures. Under normal circumstances, this ratio is quite comparable for lying with the head forwards (0,22) and backwards (0,25). During haltering however, when PS is merely performed while leaning with the head forwards on the floor, this ratio is reduced to 0,14.

This suggests first, that sustaining the head forwards on the floor serves the performance of PS just as well as supporting it backwards, if the former lying posture is integrated in the normal lying behaviour, with frequent and extended periods of lying with the head turned backwards and few short periods of lying with the head forwards (appendix 8). Secondly, the forced performance of lying with the head forwards during haltering, without possibilities to assume the preferred position with the head turned backwards, seems less suited for performing PS than the short-lasting engagement in this lying posture as a part of normal lying behaviour. This situation is not improved during 3 days of haltering, as seen in pair 4 (appendix 8). It indicates that on the short term, lying with the head forwards is not an equivalent substitute for lying with the head turned backwards, in terms of PS performance.

However, the decrease in EMS from 7,8 to 5,8%, resulting from this defectiveness, is not recovered after release of the halter, which in turn shows that physiological requirements concerning PS may still be fulfilled, despite this slight reduction. In this respect, the calves seem to deal competently with the restrictions imposed. The implications of these findings with regards to the performance of PS of calves in crates and in tethering stalls will be discussed in chapter IX.

CONCLUSIONS

- It is possible to identify paradoxical sleep (PS) in calves by using behavioural criteria. Ear twitches are particularly useful in this respect, since they can be recognized easily from videotapes and they represent a major part of PS.
- A complete but short-lasting obstruction of lying with the head turned backwards by haltering results in reclining the head forwards and a slight reduction of PS. However, this manipulation probably does not interfere with physiological processes occurring during PS.

IX General discussion

This chapter encompasses sucking behaviour, sleeping behaviour and a comparison between individual and group housing. First, the biological significance of non-nutritional sucking and possible ways of reducing the incidence of preputial sucking are discussed. Attention is paid to the mechanisms which may be responsible for the effect of early sucking experience on the occurrence of preputial sucking. Furthermore, conditions for sleeping and resting in individual crates are evaluated and finally, the perspectives for housing veal calves in groups of five as an alternative to the traditional housing in individual crates are discussed.

SUCKING BEHAVIOUR

In young mammals like calves, sucking provides for the ingestion of milk from the udder. When milk is supplied in open buckets, however, sucking is still performed, predominantly following the intake of the milk (Kittner and Kurz, 1967). Obviously, this non-nutritional sucking serves some other purpose. The suggestion of Scheurmann (1974b) that sucking is a reflex activity, evoked by the stimulation of the mouth and lips, may account for the immediate initiation of sucking after drinking, but it does not explain why this sucking lasts several minutes, why it is now and then interrupted and why it ultimately stops. The regulation of sucking after milk intake is apparently too complex to be explained by the operation of a simple reflex mechanism.

In rats, oral sensations are essential in establishing satiety after a meal (Holman, 1968) and may therefore be rewarding. Similarly, injecting feed directly into the crop of chickens is reinforcing only if the animals are at the same time allowed to peck at feed-like objects (Sterrit and Smith, 1965). In calves, sucking probably constitutes a similar reinforcing activity (Wiepkema, 1983). The performance of sucking during or immediately after milk intake may contribute to satiety and therefore sucking seems beneficial to calf welfare. If milk cannot be supplied through teats, adequate sucking facilities such as artificial teats should be presented in close proximity of the milk bucket. These teats are sucked intensively (chapter VI.1), which demonstrates their usefulness.

In the absence of an artificial teat, sucking is mainly orientated towards the ears, legs, scrotum and mouth of penmates or towards physical objects such as the rim of the bucket (chapter V). Individual calves prefer to suck at particular body parts or objects, but these preferences are diverse and changeable. This suggests that they are at least not only based upon any well defined property of the body part or object concerned, but that they are also mediated through the reinforcing operation of the sucking act itself. In other words, an individual calf may associate the reinforcement from sucking as such with some randomly chosen part of a penmate's body or a physical object on which the sucking can be performed. Consequently, most sucking behaviour then becomes directed towards this body part or physical object.

The preference for a certain orientation in sucking may be called superstitious, since it has only a subjective and not a real relation to the reinforcer. Associations based on superstition have been described in pigeons (Skinner, 1948) which obtained regular (fixed interval) reinforcement by feeding, when placed in an experimental cage for a few minutes each day. In this situation, each animal developed the habit of performing a typical sequence of movements repeatedly, although of course these actions did not affect the food reward. Superstitious selection of particular activities probably also occurs in the development of stereotypies in tethered sows (Cronin, 1985).

Whereas the details of the individual preferences for certain body parts or objects during sucking seem coincidental, some general characteristics of the orientation of the sucking behaviour exist, that may reveal important cues by which the sucking is directed. First, sucking in group pens is almost exclusively orientated towards penmates and seldom towards physical objects. This shows the importance of cues connected to for instance, the smell, shape, temperature or the position of the sucked object.

Furthermore, the prepuce is generally preferred above other parts of penmates (chapter V), probably because of the excretion of urine in response to sucking. Fluids, as the major constituent of urine, may stimulate sucking when they are released from the sucked object (chapter VI.1). However, the provision of extra water, which diminishes the interest of the calves in fluid intake for a short period, does not reduce the frequency of preputial sucking (chapter VI.2).

Fluid release from the suckled object is an important cue until about 8 weeks of age, when the incidence of non-nutritional sucking at body parts and physical objects has become negligible (chapter V). Nutritional cues such as the caloric value of the milk affect the duration of sucking at least from the age of 29 days onwards (Pettyjohn et al., 1963; Hafez and Lineweaver, 1968) and after 8 weeks of age, only nutritional sucking is maintained (Koepke and Pribram, 1971).

The smell, shape, temperature or position of the sucked object, fluids released from it and the nutritional value of these fluids are probably vital factors since they lead to the contacting of the cow's udder and subsequent suckling and intake of needed energy. The operation of the same cues in group housed male calves with bucket feeding however, facilitates preputial sucking, which is detrimental to the calves' health. The prevention of this harmful behaviour in a biologically sound way should employ the cues mentioned above in order to try and reinforce sucking at other objects rather than at the prepuce of penmates.

Such a method not only implies providing an opportunity to suck at an artificial teat which supplies fluids (this alone is not effective, as found in chapter VI.1), but it also involves overriding social attraction. The necessary reinforcement of teat sucking may be constituted by the satisfaction of hunger as a consequence of this sucking. This means that liquid nutrients should be supplied through these teats. The attraction of the nutritive teat may be further enhanced by adding a sweet flavour to these liquids (Bell, 1959). Finally, since preputial sucking is performed in several periods throughout the day and night (chapter V), the teat(s) should be available at least several times a day.

In practical terms, this implies that the biological prevention of preputial sucking is incompatible with feeding from open buckets. Teat bucket feeding, however, may be adequate for this purpose if the calves are allowed to suck their feed several times per day. This feeding method provides an alternative to open bucket feeding with regards to the ability to ration and to inspect individual intake, which is crucial to growth efficiency and the detection of diseased calves.

However, as the labour requirements of this frequent supply of milk are notably high, automation of feeding seems necessary. In this respect, automatic feed dispensers equipped with teats may be useful, when they are adapted to provide the milk at fixed amounts per calf at certain intervals during the day and when they register individual intake. Such a system involves computerized feeding and individual recognition of calves by the use of collar transmitters as used in dairy farming to record the individual milk yield, to allocate concentrate feeds and to register individual intake of these concentrates (Rossing, 1980). The possibilities for applying this new technology for feeding veal calves are presently being investigated.

The regulation of milk intake during teat sucking may differ from that during drinking from open buckets. For instance, Webster and Saville (1982) found that calves drinking ad libitum from automatic teat dispensers showed a lower milk intake after about 12 weeks and a higher interindividual variation in growth rate (even when housed individually to exclude competition for the teats) as compared to bucket fed calves. They attributed this discrepancy to the very high drinking rate during bucket feeding which might override normal satiety mechanisms. Moreover, since sucking may be important in establishing satiety, as argued above, the functioning of these mechanisms is possibly impaired by the lack of sucking opportunities during bucket feeding.

When such problems with milk intake from teat dispensers indeed occur, they may perhaps be overcome by increasing the supply rate of the milk or the concentration of milk powder. However, in order to solve these practical problems in a biologically adequate way, further study of the regulation of sucking behaviour in calves and its ontogeny will be necessary.

Furthermore, digestive processes seem to be stimulated by teat feeding as compared to bucket feeding. During sucking, salivary flow and lipase potency in the saliva is increased (Grosskopf, 1965) and as a result, lipolysis and associated changes of the milk before it enters the abomasum are facilitated (Wise et al., 1976). In addition, the curdling and proteolytic activity in the abomasum is slightly increased by teat feeding as compared to bucket feeding (Grosskopf, 1959) and the digestion of fats and proteins is promoted accordingly (Kuz'min and Bagrij, 1965). Finally, scouring and related phenomena such as partial anorexia, apathy or dyspnoea are occasionally reduced by teat feeding instead of open bucket feeding (Pritchard, 1982). This evidence suggests that teat feeding promotes normal behaviour and physiology, which further encourages studying the possibilities for using teat dispensers to feed veal calves.

Although the use of teat feeders markedly reduces the incidence of preputial sucking, one or two calves out of 30-40 may still engage in this behaviour (Hafez and Lineweaver, 1968; Stephens, 1974; Maatje, 1984, personal communication). A further reduction of this unwanted sucking may perhaps be achieved by feeding the calves with teat buckets during the first days of life, as shown in chapter VI.3. The drastic inhibitory influence of a relatively short-lasting experience with teat bucket feeding just after birth is biologically not a novelty.

The sensitivity of the organism to particular stimuli is enhanced during certain periods in its development and the responses which then arise are highly resistent to alteration through subsequent experiences. Such sensitive periods occur in the development of filiative and sexual preferences in birds (Immelman, 1972), socialisation in dogs (Scott, 1962) and monkeys (Harlow et al., 1965), singing in birds (Thorpe, 1961) and so on. In this period there is an extremely rapid attachment of behaviour patterns to specific stimuli, which thereafter become important elicitors of that behaviour (Hess, 1973). In precocial species the newborn young is particularly sensitive to stimuli which are crucial to its survival. For example, precocial birds follow the first moving object they see after hatching (which is usually their mother) and after relatively little experience with this object, their responsiveness becomes more or less restricted to it (Lorenz, 1935).

Sensitive periods also occur in the lives of ruminants: maternal behaviour, for instance, is orientated exclusively towards those young which are contacted by the dam within a few hours after parturition; all others are rejected (Collias, 1956; Klopfer et al., 1964; Le Neindre and Garel, 1976; Hudson and Mullord, 1977). During the first days after birth, the precocial calf or lamb is in turn particularly responsive to characteristics of its "mother"; the young lamb will follow any moving object for the first three days of life (Kilgour, 1972) and the newborn goat will usually recognize its mother's voice already at the age of two days (Lickliter and Heron, 1984). This auditory recognition is also of vital importance to the neonate calf which hides during the first days of life, for instance among high grass or maize (Scheurmann, 1974a; Edwards and Broom, 1982). The mother does not look for her calf but calls at a distance (Lent, 1974), after which the young usually approaches, contacts the udder and suckles.

The finding of the udder, which is of course equally important for survival, is also accomplished by quick learning: whereas the first attempts to find the milk source are directed towards various body parts of the mother and also towards physical objects, this non-nutritive sucking before contacting the teat is absent in goats already after three days (Stephens and Linzell, 1974). In calves, the ingestion of milk may reinforce attention to the correct part of the cow, viz. the udder (Edwards and Broom, 1982) whereas visual, tactile and olfactory cues may serve to relocate a teat on subsequent occasions.

Finger and Brummer (1969) found that only 24-36 hours of contact with the mother cow immediately after birth suffices for this relocation, but calves which were bucket fed from birth onwards, usually failed to find the udder when first confronted with lactating cows after the age of 6 days, although these cows tolerated sucking from strange calves. Apparently, there is a short sensitive period just after birth, during which the calves learn to know certain cues that indicate the position of the milk source.

Since both the udder and the prepuce are positioned in the region between the belly and the hindlegs of a conspecific, the stimuli used to locate the udder and prepuce are probably similar. Possible corresponding cues are the warmth (cf. Vince, 1984) and the softness of the belly, its smell, its hairy surface, its mobility and its responsiveness to social interactions. Due to a similar agreement in key-stimuli, the contacting and sucking at the anogenital region of rat siblings may replace experience with the nipple of the mother (Kovach and Kling, 1967). Likewise, the similarity between cues for udder and prepuce location may facilitate the contacting of the prepuce and thus promote preputial sucking in cow reared veal calves in group pens.

On the other hand, experience with sucking at a teat bucket in the first days of life may narrow the preferences of the calves to stimuli associated with a firm attachment of a rigid teat to a hard and usually cold surface which is immobile and irresponsive to social stimuli. Preliminary evidence for this association is presented in chapter VI.3, which tentatively shows that teat bucket reared calves contact an artificial teat more quickly than some of the calves reared with open buckets. A similar association based on visual cues (colour) was demonstrated by Grabowski (1941) in a bottle fed lamb.

The difference between cues obtained during sucking at an artificial teat attached to a metal bucket and those related to preputial sucking may prevent teat bucket reared calves from sucking the prepuce or reduce their chances of finding it. In this case, one would expect these calves to perform less sucking at other body parts of penmates as well, but this was not investigated.

The final question is why calves which are reared with open buckets may start sucking the prepuce, in spite of their lack of similar sucking experience. Bateson (1983) states that the termination of a sensitive period depends upon experience during this period: "experience with a particular object coupled with subsequent evasive responses or indifference to novel objects give rise to the end of the sensitive period". Furthermore, Bateson (1979) refers to pre-existing preferences for certain stimuli; the responsiveness of the animal is different for different stimuli and so is their effect in terms of learning. For example, domestic chicks and mallard ducklings which were raised with near-optimal social stimuli such as their siblings escaped from or were indifferent to new things, whereas those raised in isolation were still responsive to novel objects (Smith and Nott, 1970). Apparently, experience with certain objects during the sensitive period restricts the reactivity of animals to other objects, whereas with the lack of such experience, the responsiveness to novel stimuli is prolonged (Bateson, 1983).

In this context, open bucket reared calves, which are inexperienced in nutritive sucking at the udder or at an artificial teat, may be more responsive to novel objects when sucking than cow or teat bucket reared calves. The open bucket reared calves may therefore readily contact and suck the prepuce of penmates. Whether or not these learned responses are equally resistent to subsequent experience as those which develop during the sensitive period immediately after birth is not known.

The results from the present study suggest that early experience with nutritive sucking is important with regards to the orientation of later sucking behaviour. This phenomenon is not only biologically interesting, it is also of practical relevance. When automatic teat dispensers become employed to fatten calves – which may contribute to their well-being as argued above – it seems desirable to feed them with teat buckets during their first days of life on the dairy farm. This may first reduce the incidence of preputial sucking among these loose housed calves and secondly, this may promote the spontaneous contacting of a teat. For this latter purpose, the teat buckets and teat dispensers should share some characteristics which are essential to the orientation of the sucking response. As the nature of such stimuli is still unknown, the greatest resemblance between teat buckets and teat dispensers should be pursued. Perhaps only a short experience with teat bucket feeding (1-2 days) is sufficient to obtain the effects mentioned.

Further research is necessary to substantiate the present results; one point is to measure the duration of teat bucket feeding required to obtain the possible imprinting effect and another is to investigate the relative importance of different cues for contacting and sucking an artificial teat.

SLEEPING BEHAVIOUR

Sleep comprises behavioural quiescence and an increased threshold of sensory stimulation, which occurs in a circadian rhythm (Pieron, 1913). It may serve diversive purposes, such as energy conservation (Walker and Berger, 1980), the promoting of anabolic processes (Oswald, 1980), the stimulation of brain processes involved in learning (McGrath and Cohen, 1978) and the maintaining of immobility as an optimum strategy for survival (Meddis, 1975). The preparatory movements of sleeping behaviour and the sleeping postures assumed are species specific (Hassenberg, 1965).

Sleep in cattle is polyphasic with most sleeping periods occurring during the night (chapter VIII). Preparatory behaviour includes the search for a suitable lying place and the scraping of the floor with the feet before lying down (Sambraus, 1971). In calves, lying down is followed as a rule by extensive licking of the haircoat (personal observation). Perhaps the removal of potentially irritating substances on the haircoat contributes to undisturbed sleep.

Cattle usually sleep with the thorax upright and the head turned backwards on the shoulder, belly or hindlegs (chapters IV, VII and VIII). In veal calf husbandry, some practices may interfere with the performance of this lying posture, such as the housing in 0,65-0,70 m wide crates (chapter IV), the tethering at the feeding gate with gliding chains or chains of 0,34 m in length, both in 0,48 m wide stalls (chapter VII) and the fixation with a 0,20 m long halter (chapter VIII). In these cases, the calves regularly reclined their heads forwards or against the partitions instead of backwards on the shoulder, belly or hindlegs. By doing this they seemed to aim at achieving a rather fixed amount of lying with the head supported. Biologically, this has to do with the function of lying with the head supported, which enables the relaxation of the neck muscles required for paradoxical sleep (PS). Moreover, the supporting of the head is common during slow wave sleep (SWS; Merrick and Scharp, 1971), when muscle tone decreases (Ruckebusch, 1972).

As an exception, the substantial impairment of lying with the head turned backwards in individual crates, which developed towards the end of the fattening period, was only partly compensated by supporting the head otherwise (fig. 4.4). Perhaps the contact with the hard and uneven slatted floor for extended periods during several weeks is inconvenient and therefore avoided by the crated calves. In contrast, the rubber mat covered with straw, which the haltered calves used for the prolonged supporting of their head forwards, is probably a more comfortable substratum.

During haltering, when the head forwards postures were easily performed over extended periods, PS was only slightly reduced and this did not seem to interfere with physiological processes occurring during this sleep state. In the crates, however, adaptation in terms of

PS may be more difficult, since the performance of alternative lying postures seems impaired and the head is supported less than usual.

The question of how calves adapt to sleeping in narrow crates needs further attention, not only because this is relevant to calf welfare, but also because a lack of sleep may impair energy conservation and anabolic processes (Walker and Berger, 1980; Oswald, 1980) and thus reduce growth. For example, the decrease in growth rate of calves in 0,50 and 0,55 m wide crates as compared to 0,60 and 0,65 m wide crates after 16 weeks of fattening (Jongebreur and Zwakenberg, 1976) is perhaps due to impairments of sleep in the smaller crates. Further studies on this subject should focus on SWS as well as on PS and an Electroencephalogram (EEG) of calves in crates should be recorded intermittently over several months.

Pending this research, conditions in 0,65 - 0,70 m wide crates are considered as clearly unfavourable for resting and possibly also for sleeping, due to spatial restrictions which not only interfere with the support of the head during lying, but also with the lying on the side or on the brisket with both hindlegs stretched (fig. 4.2) and with comfort behaviours which are partly associated with resting, such as self licking and stretching (table 4.1).

INDIVIDUAL CRATES VS GROUP PENS

Veal calves were once characterized as "anaemic sucklings of a ruminant species, which are allowed neither to ruminate nor to suckle and which are also restricted in other ways in their species specific behaviour" (Van Putten, 1979). The latter part of this statement, which summarizes the main behavioural problems of veal calves, undoubtedly refers to social and lying behaviours which are clearly impaired in crates of 0,60 - 0,65 m in width.

The feeding methods and housing systems for veal calves have received prolonged and serious criticism in public opinion, but these practices have been defended on the grounds that they are necessary to maintain the white colour of the meat and the efficiency of its production. This defence certainly holds some truth.

If a calf has to be sufficiently fat for slaughter at about 23 weeks, it must consume a ration of high nutritional value. The process of rumen fermentation which develops in a calf on a normal ration containing considerable amounts of roughage can not maintain the required flow of energy and proteins to the gastro-intestinal tract. In order to indeed achieve this, the calves must drink high fat and protein solutions, which pass directly into the abomasum (Wise and Anderson, 1939; Hegland et al., 1957), These solutions have to be low in iron during a major part of the fattening period, in order to produce the anaemic condition responsible for the white colour of the meat. For the same reason, no roughage is provided to the calves, since this usually contains considerable amounts of iron.

It is also true that individual feeding allows the necessary control of feed intake and permits early detection of diseased calves, which drink hardly or not at all. At present, this individual feeding is most conveniently carried out by the use of open buckets. Moreover, social isolation restricts the spread of infectious diseases (Wood, 1980) and finally, the limitation of individual space reduces building costs per animal (Jongebreur and Zwakenberg, 1976).

Attempts to improve the situation of veal calves, for instance by creating interstices in the partitions at floor level to facilitate the movement of the legs during lying (Bogner, 1981a), or the use of barred fences instead of solid ones to promote social contacts, were not satisfactory, due to leg injuries and mutual contamination (Anon., 1979). More radical changes of the rearing system, such as group housing with automatic teat dispensers (ad libitum feeding) failed too, as a result of a lack of control over individual feed intake and a poor detection of diseased calves (Van Putten, 1982). These failures seem to confirm the idea that the traditional housing in individual crates with solid partitions and bucket feeding is indeed most appropriate for rearing veal calves.

In closer analysis, however, the main shortcoming of the housing systems and feeding methods previously mentioned is their failure to respect the basic principles of veal calf rearing and at the same time achieve real improvement of calf welfare. Both of these aspects were indeed regarded in the design of the group housing system presented in this study, which maintains individual feeding of an iron deficient milk replacer and in addition removes some serious behavioural restrictions, which occur in individual crates. This concerns for example the ability to lie on the side ór on the brisket with both hindlegs stretched, to support the head during lying, to groom, to interact with congeners and to explore the environment. Moreover, the provision of small amounts of straw cobs is integrated in this group housing system, which allows roughage intake and rumination. The function of all these activities and the consequences of their restriction are discussed in chapter IV. Clearly, the possibilities for performing such activities essentially contribute to the well-being of the calves.

The tethering of the animals to the feeding gate during the first 6-8 weeks after arrival, as a preventive measure against preputial sucking, again restricts the freedom of movement of the hindlegs and the head during lying and the opportunities for social contacts and exploration (chapter VII). However, this occurs to a lesser extent than in individual crates, due to the limited dimensions of the partitions (fig. 3.6, photo 3.4). It may therefore be concluded that the housing of veal calves in groups of five, which are fed by open buckets, provided with some roughage and tethered during the first 6-8 weeks after arrival is a very important step in the direction of improved calf welfare.

The practical application of this group housing system will depend on its efficiency in the production of white meat, which – for reasons of export – is the ultimate purpose of veal calf rearing in the Netherlands. Preliminary data (chapter III) indicate that growth, feed conversion, slaughter quality and health may be comparable in group pens and individual crates, when disregarding the relatively high losses in the group pens. A solution to these losses may be the use of a self-yoking feeding gate, which facilitates individual care. Meat colour was satisfactory, in spite of the provision of straw cobs which contain small amounts of iron.

These results suggest that group housing may be economically competitive to the traditional housing in individual crates. The economic feasibility of this group housing system on farms, however, depends in major part on the competence and attitude of the individual farmers. This is an excellent opportunity for veal calf farmers to demonstrate that they realize and accept their responsibility for the welfare of the calves subjected to their influence!

Summary

The traditional housing of veal calves in individual crates without roughage has received prolonged and serious criticism, since it denies the animals various social activities, freedom of movement and the possibility to consume roughage and to ruminate. In order to develop an economically acceptable alternative to this housing system, which would provide a significant improvement in calf welfare, the housing of calves in groups of five was evaluated with regards to husbandry, health and ethological aspects. The present study focussed mainly on the behaviour of the calves in individual crates and group pens (chapter IV) and it was only casually concerned with the production and health of the animals (chapter III).

A major problem in the group pens was the occurrence of preputial sucking and urine drinking, which had a negative influence on production, health and behaviour. The development of these activities was described (chapter V) and several experiments concerning their prevention were presented (chapter VI). The influence on lying behaviour of the tethering of the calves during the first 6-8 weeks after arrival – as a preventive measure against preputial sucking and urine drinking – was studied in chapter VII. Finally, restrictions to particular lying postures in the crates were investigated with respect to their effect on sleep (chapter VIII).

In five consecutive experiments, a total of 94 calves were housed in individual crates (1,65 × 0,65 m) and provided with 100 g straw/calf/day, whereas 99 calves were kept in groups of five in pens (2,20 × 3,83 m) on concrete slatted floors with straw bedding and an ad libitum supply of straw in baskets. The group housed calves were not tethered during the first weeks after arrival.

In four other experiments, a total of 47 calves were housed in individual crates (1,70 × 0,70 m) and given 200 g straw cobs/calf/day from week 7 or 9 onwards, whereas 139 calves were kept in groups of five in pens (2,40 × 3,05 m) on wooden (and in some pens partly concrete) slatted floors. 1 kg straw cobs was supplied daily from week 7 or 9 onwards in one trough per group pen. During the first 6 weeks after arrival, the calves were tethered to the feeding gate, separated individually by partitions.

All calves were male and predominantly black and white (FH × HF). In three out of the nine experiments, male red and white (MRY) calves were used. The influence of this breed difference was not discussed. The calves were fed a milk replacer in open buckets twice daily at approximately 8.00 and 16.00 h.

In chapter III, limited data on production, health and labour requirements of the calves in these housing systems are reported, which provide a first impression on how individual crates and group pens compare. Growth rate (about 1200 g /day) and feed conversion (about 1,5) of the calves slaughtered at a normal weight in group pens with and without straw bedding on the one hand and individual crates on the other were comparable and quite favourable. Slaughter quality, which was satisfactory in general, was also similar in these different housing systems. Haemoglobin levels at slaughter were fairly high (8-10 g/100 ml), but meat colour was still acceptable.

A relatively large number of group housed calves, however, died or had to be culled or eliminated. The total of these losses amounted to 10,1% in the group pens with straw bedding, against 4,3% in the corresponding crates; in the group pens with slatted floors the total losses were 9,4% against 2,2% in the crates. These high losses in the group pens mainly occurred because in this housing system it was difficult to treat diseased calves individually (for example by supplying a medicinated milk replacer) since they were often pushed away by penmates. When disregarding these losses, the health status of the calves, as measured by the frequency and duration of the different medical treatments imposed,

seemed no worse in the group pens than in the individual crates.

In the group pens, the provision of 23,3 kg straw/calf for feeding and 106,3 kg straw/calf for bedding took 138,7 min/calf in total during the entire fattening period, against 32,6 min/calf for supplying 7,1 kg straw/calf in the individual crates. In the group pens with bare slatted floors and the corresponding crates, the total amount of straw cobs provided from week 9 onwards (13-14 kg/calf) and the time required to do this (15-17 min/calf) were about equal.

In the first series of experiments, when the calves were tethered for the first 6 weeks after arrival, preputial sucking did not occur. The muzzling of preputial suckers was not satisfactory, since it obstructed smelling, licking and the intake of straw and moreover, it did not stop the ingestion of urine. Abomasal lesions (erosions, ulcers, scars), which were mainly located in the pyloric region, were observed in calves housed in individual crates and group pens alike. In only 14-37% of the animals, the abomasums were not affected by lesions.

It was concluded that group housing with or without straw bedding is not incompatible with fast growth, favourable feed conversion and adequate slaughter quality. The high losses in the group pens may perhaps be reduced by restraining the calves at feeding with a self-yoking feeding gate, which facilitates not only the treatment of illnesses but also their detection. The latter seems particularly valuable on practical farms, when health inspection is not as intensive as in the present study. The supply and removal of straw as a bedding is extremely labour intensive and therefore wooden slatted floors without straw are preferred in further research. The study of the causation and prevention of preputial sucking and urine drinking has a high priority, since preventive tethering restricts freedom of movement, social contact and exploratory behaviour.

In chapter IV, it was investigated to what extent calves in individual crates were restricted in their behaviour in comparison to calves in group pens and how they dealt with their situation. For this purpose, the behaviour of the same calves whose production characteristics were described in the previous chapter was registered.

Observations were carried out on all individual calves in both housing systems over one period of 23 hours (24 hours with exception of feeding periods) in weeks 8, 12, 16 and 20 after arrival by means of instantaneous sampling in 10 minute intervals. Subsequently, an analysis of variance was executed to calculate the average frequency and trend for each behaviour and both housing systems were compared on the basis of these parameters. The percentages quoted are close approximations of average values over the second series of four experiments (with group pens on slatted floors without straw bedding and the corresponding crates).

The calves in the crates spent more time lying than those in the group pens (74 against 68%). This is probably above all the result of a greater variety of stimuli in the group pens, but occasional mounting and treading of penmates may also have contributed to this difference.

Lying on the side or on the brisket with both hindlegs stretched in the group pens amounted to 2 and 8% of total lying time respectively. Lying was severely restricted by the sidewalls of the crates and consequently, these postures only rarely occurred in the crates at the end of the fattening period. It is argued that these restrictions may interfere with the relaxation of the body. Moreover, these limitations seemed to affect behavioural thermoregulation; the crated calves regulated heat loss by stretching their forelegs forwards during lying (27% of total lying) or by bending them under the body, whereas the group housed calves increased or decreased body contact with the floor often by stretching and bending their hindlegs instead of their forelegs (hindlegs stretched: 10% of total lying; forelegs stretched: 15,5% of total lying).

Lying with the head turned backwards, which is the usual posture for supporting the head (in the group pens 20-25% of total lying) became increasingly restricted in the individual crates towards the end of the fattening period. In the crates, the duration of this lying posture as a proportion of total lying decreased from 25% in week 8 to 5% in week 20. Although the head was supported forwards on the floor more often (10% instead of 5% of total lying) or against the partitions (1-2% of total lying), the duration of lying with the head supported was clearly reduced in the crates in comparison to the group pens: 16% and 30% respectively. The latter percentage includes lying with the head on penmates in the group pens (5% of total lying). Since supporting the head is necessary for the relaxation of the neck muscles during certain states of sleep, the restriction of these lying postures in the crates may interfere with sleep as a physiological process.

Furthermore, the licking of the belly, back, thighs or hindlegs (1,7% in the crates and 3,2% in the group pens) and the scratching of the head, neck or shoulders (0,05 against 0,16%) were also hindered by the sidewalls of the crate, whereas rubbing (0,6-0,7%) was not impaired. On the other hand, the licking of the forelegs (1,0 against 0,7%) and the muzzle (1,9 against 1,1%), which are easily accessible, was more frequently performed by the crated calves than by the group housed ones. The increase of the latter activities in the individual crates may be related to conflict situations. Self stretching was reduced in the crates as compared to the group pens (0,14 against 0,25%).

In the individual crates, physical interactions between neighbouring calves were usually limited to licking and sucking at feeding times when the front was opened, whereas in the group pens mutual licking occurred regularly throughout the day (2,5%) and head butting and mounting (together 1,0%) were also performed. Preputial sucking and urine drinking were seldom in this period from 8 to 20 weeks after arrival (together less than 0,3%). Occasional licking outside feeding periods was observed in the crates as soon as the calves were able to reach over the sidewalls, which shows their desire for social contacts. Head butting against inanimate objects and jumping as an introduction to play were more frequent in the individual crates than in the group pens (together 0,4% against 0,2%), which may indicate a need for social play in the individually housed animals.

Exploration by the crated calves was confined to the licking and sniffing at the front part of the crates and the surveying of the area in front of and behind the crates. As a consequence of the limited (visual) contact with the environment, the calves in the crates were quickly alarmed, in contrast to those in the group pens, which could survey the environment even when lying.

Eating and ruminating were clearly enhanced in the group pens with straw bedding and ad libitum straw for feeding (7 and 22% respectively) as compared to the group pens with slatted floors and a limited supply of straw cobs (1,5 and 9,5% respectively) or the individual crates with small gifts of straw or straw cobs (1-2% and 8-12% respectively).

The performance of stereotypies such as the licking (4-5%) or scraping (2-3%) of objects and tongue playing (2%) was not affected by individual or group housing as such, but these activities were somewhat reduced when straw supply was ad libitum instead of restricted. Wooden slatted floors were slippery and uneven in comparison to concrete slatted floors with straw bedding although this probably did not interfere with the mobility of the calves, for instance during head butting and mounting.

As a first step in finding ways of preventing preputial sucking and urine drinking, it is described in chapter V how the orientation of sucking behaviour develops in calves which are loose housed in groups of five upon arrival.

Initially, sucking was orientated towards physical objects or body parts of congeners other than the prepuce. Most calves preferred a certain body part or (more seldom) a physical object for sucking, such as the ears, mouth, legs or scrotum of penmates, the rim of a bucket or a horizontal bar. These preferences differed among individual calves and usually changed over time. In the second and third week after arrival, many calves showed a preference for sucking at the prepuce of congeners. In reaction, the sucked calf usually started to urinate, while the sucking calf held on to the prepuce and ingested most of the urine. This preputial sucking was observed in the first 6-8 weeks after arrival; thereafter, the frequency of this behaviour and of the other sucking activities was strongly reduced in all calves. Seven out of the 30 calves in this study never sucked the prepuce and two only seldom.

In most calves, preputial sucking took up several hours per day, whereas sucking at physical objects or other body parts lasted one hour per day at most. Moreover, preputial sucking occurred during several activity periods throughout the day and night, whereas other sucking was concentrated at feeding times. Individual preferences or aversions for sucking at the prepuce of particular penmates were uncommon.

Persistent preputial sucking resulted in the loss of hair around the muzzle and cases of poor growth among the sucking calves, whereas hairloss of the prepuce and avoidance reactions occurred among the calves which were sucked. Urine drinking, the licking of the urine jet of a urinating calf, was relatively harmless and infrequent; it was performed by preputial suckers as well as non-preputial suckers.

On the basis of this information, two hypotheses were proposed. The first one implicated that the attraction of preputial sucking as compared to other sucking was connected to the intake of urine during this activity. The second one suggested that the absence of preputial sucking in some calves had to do with their early sucking experience. Both hypotheses were tested in chapter VI.

In a pilot study (chapter VI.1), several sucking and drinking devices were presented in different combinations to calves in group pens which had been fed during the first day of their life either with open buckets, with teat buckets or by the mother cow. All calves were fed a milk replacer in open buckets twice daily. The drinking and sucking behaviour of the calves was registered during one 24 hour period in weeks 2, 3 and 4 after arrival.

Teats connected to a water reservoir were sucked more than empty teats, which suggests that the release of fluid from the sucked object is an incentive in sucking. This indirectly supports the idea that the excretion of urine stimulates preputial sucking. Furthermore, 11 out of 22 open bucket reared calves and 2 out of 10 cow reared calves started preputial sucking, whereas all 8 teat bucket reared calves refrained from this activity, which tentatively shows that early sucking experience may influence the frequency of preputial sucking.

Next (chapter VI.2), it is argued that the provision of only small amounts of milk replacer during the first weeks of the fattening period (3-4 l/calf/day) may lead to a fluid deficit which may be one of the causes of preputial sucking. Therefore, the effect of extra water supply on the incidence of preputial sucking was investigated. In three replicate experiments, 3-5 l water (25-35°C) was provided two or three times per day in open buckets to a total of 60 calves in groups of five, whereas 60 other group housed calves did not receive extra water.

Total fluid intake (milk replacer + water) was on average two to three times higher in the extra water groups than in the control groups of calves (for instance in week 3: 14 l against 5 l/calf/day). Nevertheless, in extra water groups 10 calves started preputial sucking against 14 calves in the groups without extra water; there was no significant influence of an extra supply of water on the incidence of preputial sucking.

In one of the three replicates, drinking intensity of all individual calves was measured every two days by recording latency till drinking and drinking rate in separate "drinking tests". Surprisingly, the drinking intensity of calves provided with extra water was no less than that of calves without extra water. Moreover, those calves which drank the maximum of 15 l of water daily showed the highest drinking intensity. This raises some interesting questions concerning water intake regulation in these young calves.

In the last section (chapter VI.3), it was investigated if early sucking experience indeed affected the development of preputial sucking as suggested by earlier data. In the first experiment 20 bucket reared, 15 teat bucket reared and 5 cow reared calves were kept in groups of five and fed twice daily from open buckets. 13 out of 20 bucket reared calves and three out of five cow reared calves started preputial sucking, whereas again none of the 15 teat bucket reared calves engaged in this behaviour. The difference between bucket and teat bucket reared calves was significant (p(one-tailed) = 0,028).

In the second experiment, eight bucket reared and nine teat bucket reared calves were observed, but preputial sucking did not occur. In this experiment, the contacting and sucking of a teat was studied by presenting a non-nutritive teat to each calf individually for 5 minute periods, six times a day. Four out of eight bucket reared calves usually failed to suck the teat, whereas all nine teat bucket reared ones nearly always attached to the teat and sucked. The average duration of sucking of those calves which contacted the teat was similar in both groups.

The fact that in three experiments none out of a total of 32 teat bucket reared calves engaged in preputial sucking, compared to 24 out of 50 bucket reared and 5 out of 15 cow reared calves, strongly suggests that early sucking experience influences the development of preputial sucking. Furthermore, the failure of some of the bucket reared calves to attach to the teat may indicate that such calves are less likely to find the teats of an automatic feed dispenser on their own as compared to teat bucket reared calves. The practical consequences of these findings should be investigated further with a larger number of animals.

Although the previous results advanced the understanding of how preputial sucking develops and what factors are involved in its causation, they did not provide an instant method for preventing this unwanted behaviour. Since at present, tethering the calves and separating them by small partitions during the first 6-8 weeks after arrival seems the only effective and practical way to avoid preputial sucking, different tethering methods were evaluated regarding their consequences for calf behaviour (chapter VII).

Stalls (i.e. spaces where single calves were tethered between partitions) of 0,48 m and 0,58 m in width were equipped with either 0,48 m long chains with contraweights (0,2 kg) which were guided through openings in the feeding gate or fixed chains of medium length (0,40 m); in a second experiment, the long chains with contraweights were replaced by short fixed chains (0,34 m). Different lying postures and patterns of standing up and lying down were recorded, mainly from 6 to 9 weeks after arrival, just before the calves were untethered.

The tethering of calves in 0,48 m wide stalls restricted lying on the side or on the brisket with the hindlegs stretched at 6 and 8 weeks to about the same extent as housing in 0,70 m wide crates at 8 weeks; in 0,58 m wide stalls, both lying postures were hindered less. The stretching of the forelegs in these different types of stalls was not impaired.

Stalls of 0,48 m in width restricted the lying with the head turned backwards in contrast to stalls of 0,58 m in width, but these restrictions were not serious. The use of chains of 0,34 m in length and chains provided with contraweights to prevent entanglement of the forelegs was unnecessary and moreover, it hindered the turning of the head backwards during lying; these chains should not be used.

In all tethering stalls, the space in front of the calves was insufficient to swing the head forwards freely when standing up. Casual contacts with the partitions or restrictions by the chains were of minor importance, since they did not really interfere with standing up and lying down. In general, standing up and lying down occurred without great difficulty, but the calves' performance deteriorated in cold conditions.

Moreover, at temperatures below approximately 8°C, which is the lower critical value for veal calves of 4-10 weeks of age, they experienced discomfort, as appeared from the shivering of the animals and extreme postural changes including the tucking in of all legs and the burying of the head in the flank. Therefore, such low temperatures are clearly disagreeable.

The support of the head while lying, which is necessary for the relaxation of the neck muscles during paradoxical sleep (PS), was diminished in the individual crates as a result of restrictions to lying with the head turned backwards. The consequences of this impairment for the performance of PS in calves of about one week old were examined in chapter VIII.

Lying with the head turned backwards was obstructed for 24 hours by the use of a short halter and the performance of PS was measured before, during and after this obstruction. Twitches of the eyes, muzzle, mouth, legs and ears were successfully employed as indicators of ongoing PS. Ear twitches in particular were useful, since they could easily be recognized from videotapes and they represented a major part of PS.

When the turning of the head backwards was thwarted by haltering, the head was supported forwards instead. Nevertheless, PS as estimated on the basis of ear movements was somewhat reduced during haltering in comparison to before and after haltering (5,8 against 7,5% on average). This indicates that in terms of PS performance, lying with the head forwards is not an equivalent substitute for lying with the head turned backwards. Since however, this small decrease in PS during haltering was not recovered after release of the halter, physiological processes occurring during PS were probably not disturbed. In this respect, the calves seemed to deal adequately with the restrictions imposed.

In chapter IX, some points from previous chapters were discussed more comprehensively. It is argued that sucking is probably essential to establish satiety after drinking and that it may therefore constitute a reinforcing activity; this reinforcement may play an essential role in the development of individual preferences for sucking at certain body parts and objects; an individual calf may associate the reinforcement from sucking as such with some randomly chosen part of a penmate's body or a physical object on which the sucking can be performed.

Although the details of these preferences seem coincidental, some general cues for the orientation of the sucking response may exist, such as stimuli connected to the smell, shape, temperature or position of the sucked object, fluids released from it and the caloric value of these fluids. Such cues may be used to prevent preputial sucking, for instance in the feeding with automatic teat dispensers.

Teat feeding of calves was encouraged: not only because it reduces the occurrence of preputial sucking but also because it facilitates normal regulation of sucking behaviour and it promotes various digestive processes. The possible inhibitory influence of a relatively short-lasting experience with teat bucket feeding immediately after birth on the occurrence of preputial sucking was explained on the basis of imprinting processes during a sensitive period in the first days of life.

As paradoxical sleep is concerned, it was mentioned that the adaptation to restrictions to lying with the head turned backwards may be more difficult to calves in individual crates than to haltered ones, since the performance of head forwards postures seems impaired in the crates and the head is supported less than during haltering. The conditions in the crates are probably inadequate for resting and maybe also for sleeping, due to restrictions to the support of the head during lying, to the lying on the side or on the brisket with the hindlegs stretched and to comfort behaviours which are partly associated with resting, such as self licking and stretching.

Finally, it was shown that the housing of calves in groups of five, as presented in this study, respects the basic principles of veal calf rearing since it maintains individual feeding of an iron deficient milk replacer which is crucial to the efficient production of white meat. At the same time, it achieves a significant improvement in the welfare of the calves by removing some serious behavioural restrictions which occur in the crates, concerning the ability to lie on the side or on the brisket with both hindlegs stretched, to support the head during lying, to groom, to interact with congeners and to explore the environment. Furthermore, the provision of straw cobs in the group pens allows roughage intake and rumination. In spite of the fact that most of these benefits do not apply until the calves are untethered at 6-8 weeks after arrival, this group housing system marks a very important step in the direction of improved calf welfare.

The limited data on production, management and health aspects, described in the present study, suggest that the keeping of veal calves in small groups may be competitive to the traditional housing of veal calves in individual crates. The economic feasibility of group housing on farms, however, depends eventually on the competence and attitude of individual farmers, who may now demonstrate that they realize and accept the responsibility for the welfare of their calves.

Samenvatting

GEDRAG EN WELZIJN VAN VLEESKALVEREN IN RELATIE TOT HOUDERIJSYSTEMEN

De traditionele huisvesting van vleeskalveren in individuele boxen zonder ruwvoer staat reeds geruime tijd bloot aan ernstige kritiek, aangezien dit huisvestingssysteem de uitvoering van diverse sociale activiteiten en de opname van ruwvoer en herkauwen verhindert en bovendien de bewegingsvrijheid van de dieren sterk beperkt. Dit vormde de aanleiding tot een onderzoek, dat zich richtte op het ontwikkelen van een economisch aanvaardbaar alternatief voor de huisvesting in individuele boxen, dat tevens een wezenlijke verbetering van het welzijn van de kalveren zou betekenen.

Als een van de mogelijkheden werd de huisvesting in groepen van vijf kalveren vergeleken met die in individuele boxen t.a.v. produktie-, gezondheids- en ethologische aspekten. Het hier gepresenteerde onderzoek hield zich voornamelijk bezig met het gedrag *van de kalveren in beide huisvestingssystemen (hoofdstuk IV) en slechts zijdelings met hun* produktie en gezondheid (hoofdstuk III). Een belangrijk probleem in de groepshokken was het optreden van preputiaalzuigen en urinedrinken, wat een negatieve invloed had op de produktie, de gezondheid en het gedrag van de kalveren. De ontwikkeling van beide gedragingen werd beschreven (hoofdstuk V) en ook werden enige mogelijkheden ter preventie van deze aktiviteiten beproefd (hoofdstuk VI).

In de praktijk worden de dieren gewoonlijk gedurende de eerste 6-8 weken van de mestperiode met een halsketting vastgezet aan het voerhek en van elkaar gescheiden door tussenschotjes om het optreden van preputiaalzuigen en urinedrinken tegen te gaan. De invloed van verschillende vastzetmethoden op het liggedrag van de kalveren werd onderzocht in hoofdstuk VII. Bij enkele van deze methoden, maar vooral bij het houden van kalveren in individuele boxen werd het aannemen van bepaalde lighoudingen belemmerd. Het effect van deze belemmeringen op de slaap van de dieren werd in hoofdstuk VIII nagegaan.

In vijf opeenvolgende experimenten werden in totaal 94 kalveren gehuisvest in individuele boxen (1,65 × 0,65 m) en voorzien van 100 g stro/kalf/dag, terwijl 99 andere kalveren in groepen van vijf werden gehouden in hokken (2,20 × 3,83 m) met een betonnen roostervloer met daarop een laag stro en een korf gevuld met stro. De groepskalveren werden tijdens de eerste weken na aankomst niet vastgezet aan het voerhek.

In vier andere experimenten werden in totaal 47 kalveren ondergebracht in individuele boxen (1,70 × 0,70 m) en vanaf week 7 of 9 dagelijks van 200 g strobrokken/kalf voorzien, terwijl 139 kalveren werden gehuisvest in groepen van vijf in hokken (2,40 × 3,05 m) met een houten en soms gedeeltelijk betonnen roostervloer en een bak waarin vanaf week 7 of 9 dagelijks 1 kg strobrokken werd gedeponeerd. Tijdens de eerste 6 weken na aankomst werden de groepskalveren vastgezet aan het voerhek, onderling gescheiden door tussenschotjes.

Alle kalveren waren van het mannelijk geslacht en overwegend zwartbont (FH × HF); in drie van de negen proefnemingen werden roodbonte kalveren (MRY) gebruikt. De invloed van dit rasverschil werd niet beschreven. Alle dieren werden tweemaal daags gevoerd met kunstmelk die in open emmers werd verstrekt rond 8.00 uur en rond 16.00 uur.

Enige gegevens betreffende de produktie en gezondheid van de kalveren en de benodigde arbeid in deze huisvestingssystemen werden vermeld en besproken in hoofdstuk III. De groei (ongeveer 1200 g/dag) en voederconversie (ongeveer 1,5) van de kalveren was zeer goed en bovendien vergelijkbaar in de beide individuele huisvestingssystemen enerzijds en de beide vormen van groepshuisvesting anderzijds. Ook de slachtkwaliteit, die (ruim) voldoende was, liep in de verschillende systemen slechts weinig uiteen. Ondanks een vrij hoog haemoglobinegehalte (8-10 g/100 ml) was de vleeskleur in het algemeen bevredigend.

Een relatief groot aantal groepskalveren echter, ging dood of moest voortijdig worden afgeleverd of bij de berekening van groeicijfers e.d. buiten beschouwing worden gelaten vanwege een sterk verminderde groei en/of eetlust. Het totale percentage van deze kalveren bedroeg 10,1% in de groepshokken met stro op de bodem tegen 4,3% in de individuele boxen uit dezelfde experimenten; in de groepshokken met kale roostervloeren was dit percentage 9,4% tegen 2,2% in de bijbehorende boxen. Dit verschil was voornamelijk te wijten aan het feit dat in de groepshokken het behandelen van individuele ziektegevallen (bijv. door het verstrekken van medicinale kunstmelk) vrij moeilijk was doordat zieke dieren vaak werden verdrongen door hokgenoten. Wanneer echter deze "uitvallers" buiten beschouwing werden gelaten was de gezondheidstoestand van de kalveren gemeten naar de frequentie en de duur van de diverse ziektebehandelingen niet slechter in de groepshokken dan in de boxen.

In de groepshokken werd gedurende de hele mestperiode in totaal 23,3 kg stro/kalf verstrekt in de korven terwijl 106,3 kg stro/kalf als strobedding werd aangeboden; dit duurde samen 138,7 min/kalf. In de individuele boxen uit dezelfde experimenten duurde het verstrekken van in totaal 7,1 kg stro/kalf in ruifjes 32,6 min/kalf. In de groepshokken met kale roostervloeren en in de bijbehorende individuele boxen echter, was de totale hoeveelheid strobrokken die verstrekt werd vanaf week 9 (13-14 kg/kalf) en de tijd die hiervoor nodig was (15-17 min/kalf) ongeveer gelijk.

Preputiaalzuigen en urinedrinken kwamen voor bij verschillende kalveren in de eerste reeks experimenten, toen alle dieren vanaf hun aankomst in de stal losliepen, maar niet in de tweede reeks, toen ze werden vastgezet tijdens de eerste 6 weken na aankomst. Het muilkorven van individuele kalveren om deze schadelijke aktiviteiten te stoppen vormde geen bevredigende oplossing, aangezien dit het ruiken, het likken en het eten van stro belemmerde; bovendien werd hiermee het opnemen van urine niet volledig voorkomen. Beschadigingen van de lebmaagwand (erosies, zweren, littekens), die voornamelijk in het pylorusgedeelte voorkwamen, werden bij de kalveren in de boxen en in de groepshokken ongeveer even frekwent geconstateerd. Bij slechts 14-37% van de dieren waren de lebmagen niet aangetast.

Deze beperkte gegevens duiden erop dat groepshuisvesting met of zonder stro op de bodem niet onverenigbaar is met een snelle groei, een gunstige voederconversie en een redelijke slachtkwaliteit. Het relatief grote aantal "uitvallers" in de groepshokken kan wellicht worden verminderd door de kalveren tijdens het voeren vast te zetten met behulp van een zelfsluitend voerhek; dit vereenvoudigt niet alleen de behandeling van ziekten, maar ook het opsporen van zieke dieren, wat onder praktijkomstandigheden met een minder intensieve gezondheidscontrole van grote waarde is.

Het verstrekken van stro en het verwijderen van de mest is zeer arbeidsintensief en daarom worden in het verdere onderzoek houten roostervloeren zonder stro gebruikt. Het bestuderen van de oorzaken en de preventie van preputiaalzuigen en urinedrinken is van zeer groot belang, aangezien het preventieve vastzetten van de kalveren aan een halsketting hun bewegingsvrijheid belemmert en hun onderlinge contacten beperkt.

In hoofdstuk IV werd onderzocht in welke mate de kalveren in de individuele boxen werden belemmerd in hun gedrag ten opzichte van hun soortgenoten in de groepshokken en hoe zij deze beperkingen ondergingen. Met dit doel werd het gedrag bekeken van dezelfde kalveren wier produktie en gezondheid in het voorgaande hoofdstuk werden besproken.

Gedurende een periode van 23 uur (een etmaal m.u.v. de voerperioden) in week 8, 12, 16 en 20 na aankomst van de dieren in de stal werd het gedrag van ieder kalf in individuele en groepshuisvesting om de 10 minuten genoteerd. Vervolgens werd m.b.v een variantie-analyse voor elk gedrag afzonderlijk een gemiddelde frequentie en lineaire trend berekend en op deze basis werden de beide huisvestingssystemen met elkaar vergeleken. De in de tekst aangegeven percentages zijn vrij nauwkeurige benaderingen van de gemiddelde waarden over de tweede serie van vier experimenten (met groepshokken zonder stro op de bodem en de bijbehorende boxen).

De kalveren in de boxen bleken meer tijd per etmaal aan liggen te besteden dan die in de groepshokken (74% t.o.v. 68%). Dit is waarschijnlijk vooral een gevolg van de grotere gedragsmogelijkheden in de groepshokken, maar ook kunnen onderlinge verstoringen door bespringen en betrappen, die incidenteel in deze hokken voorkwamen, aan dit verschijnsel hebben bijgedragen.

Het liggen op de zij (in de groepshokken 2% van de ligduur) of op de borst met de achterpoten gestrekt (in de groepshokken 8% van de ligduur) werd ernstig belemmerd door de zijwanden van de boxen en deze lighoudingen kwamen op het einde van de mestperiode dan ook nauwelijks meer voor. Deze belemmeringen bemoeilijkten wellicht de ontspanning van het lichaam. Ook de wijze van thermoregulatie werd hierdoor beïnvloed: de boxkalveren regelden hun warmteafgifte bijv. door hun voorpoten tijdens het liggen naar voren te strekken (27% van de ligduur) dan wel onder hun lichaam te plaatsen, terwijl de groepskalveren meer de achterpoten en minder de voorpoten gebruikten om de grootte van het contactoppervlak tussen lichaam en bodem te variëren (achterpoten gestrekt: 10% van de ligduur; voorpoten gestrekt: 15,5% van de ligduur).

Het liggen met de kop omgeslagen op de schouder, buik of achterpoten, de gebruikelijke houding ter ondersteuning van de kop in de groepshokken (20-25% van de ligduur), werd in toenemende mate belemmerd in de boxen en de duur van deze lighouding als aandeel van de ligduur daalde daardoor van 25% in week 8 tot 5% in week 20. De kop werd dan weliswaar wat vaker vooruit op de bodem gelegd (10% i.p.v. 5% van de ligduur) en werd soms ook wel tegen de tussenschotjes geleund (1-2% van de ligduur), maar de totale duur van het liggen met de kop op een steunpunt was in de tweede helft van de mestperiode duidelijk geringer in de boxen dan in groepshokken: 16% t.o.v. 30% van de ligduur. Hierbij is het liggen met de kop op een soortgenoot in de groepshokken inbegrepen (5% van de ligduur). Aangezien het ondersteunen van de kop tijdens het liggen noodzakelijk is ter ontspanning van de nekspieren gedurende bepaalde fasen van de slaap kunnen belemmeringen van deze steunhoudingen het slapen van de kalveren bemoeilijken.

Verder werd het likken van de buik, rug, dijen of achterpoten (1,7% in de boxen en 3,2% in de groepshokken), evenals het krabben van de kop, nek of schouders met de achterpoten (0,05 t.o.v. 0,16%) gehinderd door de zijwanden van de boxen. Het zich schuren (0,6-0,7%) werd niet belemmerd, terwijl de voorpoten en de neus die gemakkelijk met de tong te bereiken zijn, in de boxen juist meer werden gelikt dan in de groepshokken (1,0 t.o.v. 0,7% en 1,9 t.o.v. 1,1% resp.). De toename van deze beide activiteiten bij de boxkalveren kan wijzen op een conflictsituatie. De kalveren in de boxen rekten zich wat minder vaak uit dan die in de groepshokken (0,14 t.o.v. 0,25%).

Lichamelijke contacten tussen buurkalveren in de boxen waren meestal beperkt tot onderling likken en zuigen tijdens voerperioden, wanneer het front van de boxen was geopend. In de groepshokken daarentegen, likten de kalveren elkaar (2,5%) ook op andere tijden van de dag en duwden en besprongen ze elkaar af en toe (samen 1,0%). Preputiaalzuigen en urinedrinken kwamen in deze periode (van 8 tot 20 weken na aankomst) nauwelijks voor (samen minder dan 0,3%). Activiteiten zoals het duwen met de kop tegen delen van het hok en springen, dat een inleiding tot spelen vormt, waren wat frequenter in de boxen dan in de groepshokken (samen 0,4 t.o.v. 0,2%); hieruit blijkt de behoefte van de boxkalveren aan allerlei speelse activiteiten. Ook likten de buurkalveren in de boxen elkaar zodra ze groot genoeg waren om over de zijwanden heen te reiken; dit wijst op een behoefte aan sociaal contact.

De boxkalveren konden slechts het front en het voorste deel van de zijwanden en de bodem beruiken en belikken, terwijl hun blikveld beperkt was tot het gebied voor en achter hun box. Door dit beperkte contact met de omgeving reageerden ze vaak schrikachtig op onverwachte gebeurtenissen; ze stonden meestal onmiddellijk op bij plotselinge geluiden, in tegenstelling tot hun soortgenoten in de groepshokken, die wel een goed overzicht over hun omgeving hadden.

De tijdsduur besteed aan de opname van ruwvoer en herkauwen was duidelijk langer in de groepshokken met een onbeperkte strovoorziening (7 en 22% resp.) dan in groepshokken met roostervloeren en een beperkte verstrekking van strobrokken (1,5 en 9,5% resp.) of in individuele boxen waarin de kalveren geringe hoeveelheden stro of strobrokken kregen (1-2% en 8-12% resp.).

De frekwentie van "stereotypieën" zoals het likken (4-5%) of schrapen (2-3%) van objecten of tongspelen (2%) werd niet beïnvloed door individuele of groepshuisvesting op zich, maar verminderde wel enigszins wanneer stro in onbeperkte i.p.v. in beperkte hoeveelheden werd verstrekt.

De houten roostervloeren waren niet slipvast en bovendien ongelijk in vergelijking met de betonnen roosters bedekt met stro, hoewel dit het bewegen (bijv. tijdens kopduwen en elkaar bespringen) op deze vloeren niet noemenswaardig leek te hinderen.

In hoofdstuk V werd de ontwikkeling beschreven van het zuiggedrag van mannelijke kalveren die in groepen van vijf waren gehuisvest en niet aan het voerhek werden vastgezet; doel van deze studie was het vinden van aanknopingspunten voor de preventie van preputiaalzuigen en urinedrinken.

Aanvankelijk was het zuigen gericht op delen van het hok en verschillende lichaamsdelen van soortgenoten, maar niet op het preputium. De meeste kalveren vertoonden bij dit zuigen een voorkeur voor een bepaald lichaamsdeel zoals de bek, oren, poten of het scrotum van soortgenoten of (minder vaak) voor voorwerpen, zoals de rand van de emmer. Deze preferenties verschilden tussen individuen en veranderden gewoonlijk na enige tijd. In de tweede en derde week na aankomst ontwikkelde zich bij veel dieren een voorkeur voor het zuigen aan het preputium van soortgenoten. Als reaktie op dit zuigen begon het bezogen kalf vaak te urineren; het zuigende kalf hield dan meestal het preputium in de bek en zoog de urine op. Dit preputiaalzuigen werd waargenomen in de eerste 6-8 weken na aankomst; daarna nam de frekwentie van dit gedrag en van de overige zuiggedragingen bij alle kalveren sterk af. Zeven van de 30 kalveren in dit onderzoek zogen nooit aan het preputium en twee slechts zelden.

Het preputiaalzuigen nam bij de meeste kalveren meerdere uren per dag in beslag, terwijl het bezuigen van andere lichaamsdelen of delen van het hok per dag hooguit één uur duurde. Bovendien kwam preputiaalzuigen tijdens verschillende activiteitsperioden gedurende het etmaal voor, terwijl het overige zuiggedrag direct na beide voerbeurten geconcentreerd was. Een individuele voorkeur voor of afkeer van het bezuigen van het preputium van bepáálde hokgenoten was zeldzaam.

Als gevolg van hardnekkig preputiaalzuigen vielen de haren rond de snuit vaak uit en bleef de groei van sommige zuigers sterk achter, terwijl de kalveren die bezogen werden vaak haaruitval en irritatie rond het preputium vertoonden; zij weerden langdurig zuigen op deze plaats vaak af door te trappen of weg te lopen. Urinedrinken, het likken in de urinestraal van een urinerend kalf waarbij slechts weinig urine werd opgenomen, kwam aanzienlijk minder voor dan preputiaalzuigen. Zowel preputiaalzuigers als niet-preputiaalzuigers likten af en toe in een urinestraal, soms ook bij zichzelf.

Op basis van deze gegevens werden twee hypothesen geformuleerd. De eerste hield in dat de aantrekkelijkheid van het preputiaalzuigen t.o.v. het overige zuigen was gelegen in de opname van urine tijdens het zuigen op het preputium. De tweede hypothese suggereerde dat de afwezigheid van preputiaalzuigen bij sommige kalveren verband hield met hun ervaringen met bepaalde voedermethoden (emmer, speenemmer of koe) in de eerste dagen na de geboorte. Beide hypothesen werden getoetst in hoofdstuk VI.

In een oriënterend onderzoek (hoofdstuk VI.1) werden kalveren gebruikt die gedurende de eerste levensdagen ofwel met een open emmer ofwel met een speenemmer ofwel door de moeder waren gevoed. Ze werden ondergebracht in groepen van vijf dieren en kregen tweemaal daags kunstmelk in open emmers. Bovendien hadden ze verschillende mogelijkheden om te zuigen aan spenen en om water op te nemen. In week 2, 3 en 4 na aankomst werd telkens gedurende één etmaal het zuig- en drinkgedrag van de dieren geregistreerd.

Spenen die met een waterreservoir waren verbonden werden meer bezogen dan spenen zonder water; dit duidt erop dat het vrijkomen van vloeistof het zuigen stimuleert. Dit gegeven ondersteunt indirect de veronderstelling dat urinelozingen het preputiaalzuigen bevorderen. Verder begonnen 11 van de 22 kalveren met een emmervoorgeschiedenis en twee van de tien kalveren die bij een koe hadden gezoogd met preputiaalzuigen, terwijl daarentegen alle acht kalveren met een speenemmervoorgeschiedenis zich van deze activiteit onthielden. Dit suggereert dat vroege zuigervaringen het optreden van preputiaalzuigen beïnvloeden.

Vervolgens (hoofdstuk VI.2) werd verondersteld dat door het verstrekken van de gebruikelijke geringe hoeveelheden kunstmelk in de eerste weken van de mestperiode (3-4 l/kalf/dag) er een vloeistoftekort bij de kalveren zou ontstaan, wat een van de oorzaken van het optreden van preputiaalzuigen zou kunnen zijn. Daarom werd de invloed van het aanbieden van extra water in deze periode op het vóórkomen van dit gedrag onderzocht.

In drie experimenten werd twee of drie keer per dag 3-5 l water (25-35°C) verstrekt in open emmers aan 60 kalveren, gehuisvest in 12 groepen van vijf dieren, terwijl 60 andere kalveren die ook in dergelijke groepen werden gehouden, geen extra water ontvingen. De totale vloeistofopname (kunstmelk + water) van de kalveren met extra water was gedurende de eerste 3 weken na aankomst gemiddeld twee tot drie keer zo hoog als die van de kalveren zonder extra water (bijv. in week 3: 14 l t.o.v. 5 l/kalf/dag). Desalniettemin begonnen 10 kalveren die extra water kregen met preputiaalzuigen tegenover 14 kalveren in de controlegroepen; er was geen significant effect van de verstrekking van grote hoeveelheden water op het optreden van preputiaalzuigen.

In één van de drie experimenten werd tevens eenmaal per twee dagen bij alle individuele dieren de drinksnelheid en de latentietijd vóór het drinken gemeten in aparte drinktests, enige uren na de voorgaande watergift; hieruit werd de "drinkintensiteit" afgeleid. Deze bleek tegen de verwachting in bij de kalveren die extra water kregen niet te zijn verminderd in vergelijking met de controlekalveren zonder extra water. Bovendien, kalveren die elke dag de maximale hoeveelheid van 15 l water opnamen toonden tijdens de tests de grootste drinkintensiteit. Dit geeft aanleiding tot een aantal interessante vragen t.a.v. de regulatie van de wateropname bij deze jonge kalveren.

In het laatste gedeelte van hoofdstuk VI werd onderzocht of zuigervaringen tijdens de eerste levensdagen inderdaad de ontwikkeling van het preputiaalzuigen beïnvloeden, zoals door eerdere resultaten werd gesuggereerd. 20 kalveren met een emmervoorgeschiedenis, 15 kalveren met een speenemmervoorgeschiedenis en 5 kalveren die tijdens de eerste dagen na de geboorte bij de moeder hadden gezoogd werden gehuisvest in groepen van vijf dieren en tweemaal daags met open emmers gevoerd. 13 van de 20 kalveren met een emmervoorgeschiedenis en drie van de vijf kalveren van zoogkoeien begonnen met preputiaalzuigen, terwijl opnieuw alle 15 kalveren die gedurende de eerste levensdagen met een speenemmer waren gevoerd zich van deze activiteit onthielden. Het verschil tussen de emmer- en speenemmerkalveren was significant (p(éénzijdig) = 0,028).

In een tweede experiment werden acht kalveren met een emmervoorgeschiedenis en negen kalveren met een speenemmervoorgeschiedenis geobserveerd die op dezelfde wijze werden gehouden en gevoerd als de dieren in het vorige experiment, maar preputiaalzuigen kwam niet voor. In dit experiment werd tevens de reactie van individuele kalveren op een fopspeen geregistreerd, die zes keer per dag gedurende 5 minuten beschikbaar was. Vier van de acht emmerkalveren zogen bij de meeste gelegenheden niet op de speen, terwijl alle negen speenemmerkalveren bijna altijd wèl op de speen zogen. De gemiddelde duur van het speenzuigen, wanneer de speen eenmaal in de bek was genomen, was gelijk voor beide groepen kalveren.

Het feit dat in drie experimenten geen enkel kalf uit een totaal van 32 speenemmerkalveren met preputiaalzuigen begon, in tegenstelling tot 24 van 50 emmerkalveren en 5 van 15 zoogkalveren, wijst er sterk op dat vroege zuigervaringen de ontwikkeling van preputiaalzuigen beïnvloeden. Bovendien geeft het achterwege blijven van speenzuigen bij sommige emmerkalveren aan, dat deze dieren wellicht minder gemakkelijk de speen van een voederautomaat kunnen vinden dan de speenemmerkalveren. De praktische consequenties van deze bevindingen dienen nader te worden onderzocht met een groter aantal dieren.

De voorgaande gegevens hebben tot een beter begrip van het ontstaan van preputiaalzuigen geleid, maar voorzien niet onmiddellijk in een praktische methode ter preventie van dit schadelijke gedrag. Het tijdelijk (gedurende de eerste 6-8 weken na aankomst) vastzetten van de kalveren aan het voerhek, van elkaar gescheiden door tussenschotjes, is momenteel de meeste effectieve en praktische methode om het optreden van preputiaalzuigen tegen te gaan. Daarom werden de gevolgen van de toepassing van enige varianten van deze methode voor het gedrag van de kalveren onderzocht in hoofdstuk VII.

Standen (d.w.z. de plaatsen tussen de schotjes voor het vastzetten van de kalveren) van 0,48 en 0,58 m breed werden voorzien van ofwel 0,48 m lange kettingen met een contragewicht (0,2 kg), die door een gat in het voerhek werden geleid (schuifkettingen) ofwel kettingen met een vast bevestigingspunt en een lengte van 0,40 m (vaste kettingen). In het tweede experiment werden de lange schuifkettingen vervangen door korte, vaste kettingen (0,34 m). Diverse lighoudingen en patronen van opstaan en gaan liggen werden geregistreerd, voornamelijk in de periode van 6 tot 9 weken na aankomst, vlak voordat de kalveren werden losgelaten.

In 0,48 m brede standen werd het liggen op de zij of op de borst met de achterpoten gestrekt in week 6 en 8 in ongeveer dezelfde mate gehinderd als in boxen van 0,70 m breed in week 8; in 0,58 m brede standen werd het aannemen van beide lighoudingen minder ernstig belemmerd. Het strekken van de voorpoten werd in geen van beide standen beperkt.

Standen van 0,48 m breed hinderden het liggen met de kop achterwaarts op de schouder, buik of achterpoten in tegenstelling tot 0,58 m brede standen, maar deze belemmeringen waren niet ernstig. De toepassing van 0,34 m lange kettingen en schuifkettingen om verstrikking van de voorpoten te voorkomen, bleek onnodig en bovendien werd hierdoor het achterwaarts draaien van de kop tijdens het liggen belemmerd; het gebruik van deze kettingen werd daarom afgeraden.

In alle standen was de ruimte vóór de kalveren onvoldoende om de kop voorwaarts te zwaaien tijdens het opstaan; verbeteringen op dit punt zijn zeer wenselijk. Aanrakingen van de tussenschotjes en beperkingen door de ketting waren van gering belang, aangezien ze het opstaan en gaan liggen niet noemenswaardig hinderden. In het algemeen verliep het opstaan en gaan liggen zonder grote problemen, hoewel de moeilijkheden toenamen bij lage omgevingstemperaturen. Bovendien veroorzaakte een staltemperatuur beneden 8°C (dit is de laagste kritieke temperatuur voor vleeskalveren van 4-10 weken oud) ongerief, zoals bleek uit het rillen en de ineengedoken lighoudingen van de dieren. Dergelijke lage temperaturen zijn daarom ongewenst.

In individuele boxen konden de kalveren tijdens het liggen de kop niet zo langdurig ondersteunen als hun soortgenoten in de groepshokken, omdat de hiervoor gebruikelijke lighouding met de kop achterwaarts op de schouder, buik of achterpoten werd belemmerd door de zijwanden van de boxen. Kopsteunhoudingen zijn van belang voor het uitvoeren van paradoxale slaap (PS) en daarom werden in hoofdstuk VIII de gevolgen van bovengenoemde beperkingen voor het optreden van dit slaapstadium bij kalveren van ongeveer een week oud onderzocht.

Het liggen met de kop achterwaarts werd gedurende 24 uur onmogelijk gemaakt door een kort halster en PS werd vóór, tijdens en na het halsteren gemeten. Spiertrekkingen van de ogen, de snuit, de bek, de poten en de oren werden met succes gebruikt als indicatoren voor het optreden van PS. Vooral oorbewegingen waren nuttig voor het meten van PS, daar ze gemakkelijk konden worden herkend (zelfs op video opnamen) en ze het grootste deel van dit slaapstadium vertegenwoordigden.

Wanneer het achterwaarts draaien van de kop door het halsteren werd verhinderd, werd de kop in plaats daarvan vooruit op de bodem gelegd. Desalniettemin verminderde PS geschat op basis van uitsluitend oorbewegingen enigszins tijdens het halsteren t.o.v. vóór en na het halsteren (gemiddeld 5,8 t.o.v. 7,5%). Dit duidt erop dat het liggen met de kop voorwaarts minder geschikt is voor het uitvoeren van PS dan het liggen met de kop achterwaarts. Aangezien echter deze kleine vermindering van PS niet werd ingehaald na het losmaken van de halster, mag worden aangenomen dat de fysiologische processen die samenhangen met PS niet of nauwelijks waren verstoord door het halsteren. In dit opzicht leken de kalveren de hen opgelegde beperkingen zonder grote problemen te doorstaan.

In hoofdstuk IX werden enkele gegevens uit vorige hoofdstukken nader besproken. Zo werd beredeneerd dat zuigen waarschijnlijk van belang is voor het bereiken van verzadiging na het drinken en dat het uitvoeren van zuiggedrag daarom waarschijnlijk gepaard gaat met positieve ervaringen. Dit effect speelt mogelijk een rol bij de ontwikkeling van een individuele voorkeur voor het bezuigen van bepaalde lichaamsdelen en voorwerpen: een kalf vormt wellicht een associatie tussen de positieve ervaringen bij het zuigen en een willekeurig deel van een lichaam of voorwerp waarop gezogen kan worden.

Hoewel de bijzonderheden van deze preferenties op toeval lijken te berusten, zijn er ook factoren aanwijsbaar die de richting van het zuiggedrag bepalen, zoals de reuk, vorm, temperatuur of positie van het zuigobject, de eventuele afgifte van vloeistof en de energetische waarde van deze vloeistof. Hiervan kan gebruik worden gemaakt om het preputiaalzuigen te verminderen, bijv. door het verstrekken van de kunstmelk m.b.v. voerautomaten met spenen.

Het voeren met spenen werd aangemoedigd, niet alleen vanwege de preventieve werking op preputiaalzuigen maar ook omdat speenvoedering de normale regulatie van het zuiggedrag vergemakkelijkt en de vertering bevordert. De wellicht preventieve invloed van een relatief kortdurende ervaring met speenemmervoedering direct na de geboorte op het optreden van preputiaalzuigen werd verklaard op basis van inprentingsprocessen tijdens een gevoelige periode gedurende de eerste levensdagen.

Wat betreft paradoxale slaap van kalveren in individuele boxen werd gesteld dat de aanpassing van de dieren aan belemmeringen van lighoudingen met de kop achterwaarts in dit huisvestingssysteem wel eens moeilijker zou kunnen zijn dan tijdens het halsteren; ook het liggen met de kop voorwaarts wordt namelijk bemoeilijkt in de boxen en de kop rust in de tweede helft van de mestperiode minder op een steunpunt dan gebruikelijk is. De omstandigheden in deze boxen zijn ongunstig voor het rusten en misschien ook voor het slapen van de kalveren. Dit is te wijten aan de geringe breedte van de boxen; niet alleen wordt hierdoor het ondersteunen van de kop tijdens het liggen belemmerd, maar ditzelfde geldt voor het liggen op de zij of op de borst met de achterpoten gestrekt en comfortgedragingen zoals zich likken en zich uitrekken, die ook verband houden met het rusten van de dieren.

Tenslotte werd opgemerkt dat de huisvesting van de kalveren in groepen van vijf, zoals in dit onderzoek, een van de belangrijkste principes van de vleeskalverhouderij handhaaft, namelijk de individuele voedering van ijzerarme kunstmelk; dit is essentieel voor een efficiënte produktie van wit kalfsvlees. Tevens wordt door toepassing van dit huisvestingssysteem een wezenlijke verbetering van het welzijn van de kalveren bereikt, omdat enkele gedragingen die in de boxen worden beperkt, in de groepshokken wél zonder belemmeringen mogelijk zijn. Dit betreft het liggen op de zij of op de borst met beide achterpoten gestrekt, het ondersteunen van de kop tijdens het liggen, de verzorging van de huid door likken en krabben, het onderling spelen en likken en het exploreren van de omgeving. Bovendien maakt de verstrekking van strobrokken in de groepshokken de opname van ruwvoer en herkauwen mogelijk. Ondanks het feit dat de meeste van deze voordelen pas ten volle gelden nadat de kalveren zijn losgelaten (na 6-8 weken), betekent deze vorm van huisvesting een belangrijke stap in de richting van een verbeterd welzijn van vleeskalveren.

De beperkte produktiegegevens uit dit onderzoek geven aan dat dit groepshuisvestingssysteem kan concurreren met de traditionele huisvesting van vleeskalveren in individuele boxen. De economische haalbaarheid van groepshuisvesting in de praktijk echter, hangt uiteindelijk af van de bekwaamheid en de houding van de individuele kalvermesters, die nu kunnen tonen dat ze zich bewust zijn van hun verantwoordelijkheid voor het welzijn van hun kalveren.

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Appendices

Appendix 1 The volume of liquid milk replacer provided to each calf per feeding at different days from arrival to slaughter and the amount of milk replacer powder in these quantities.

Weeks after arrival	Days after arrival	Liquid milk replacer (l)	Milk replacer powder (g)
1 and 2*	1-12	1,5	190
	13-16	2	250
3	17-18	2,5	320
	19-21	3	375
4	22-23	3,5	415
	24-25	4	460
	26-28	4	500
5	29-30	4,5	540
	31-32	4,5	585
	33-35	5	625
6	36-37	5	665
	38-39	5,5	685
	40-42	5,5	730
7	43-44	6	775
	45-46	6	815
	47-49	6,5	850
8 and 9	50-63	6,5	875
10	64-70	6,5	900
11	71-72	7	930
	73-74	7	970
	75-77	7	1000
12	78-79	7	1035
	80-81	7	1070
	82-84	7	1100
13	85-87	7	1135
	88-91	7	1160
14	92-94	7	1190
	95-98	7	1215
15	99-101	7,5	1240
	102-105	7,5	1265
16	106-108	7,5	1290
	109-112	7,5	1315
17	113-115	7,5	1340
	116-119	7,5	1370
18-slaughter	120-slaughter	7,5-8	1400

* : with 1,5 l water (20-30°C) *after the morning feeding during the first two weeks*

Appendix 2A Minimum and maximum ambient temperatures (°C) during 24 hour observation periods in different weeks during two experiments with individual crates and group pens with straw bedding (above) and during four experiments with individual crates and group pens with slatted floors (below). (Chapters III and IV)

	Exp. 4		Exp. 5	
Week	Min.	Max.	Min.	Max.
8	4	10	19	26
12	8	14	19	22
16	8	15	15	22
20	11	17	14	19

	Exp. 1		Exp. 2		Exp. 3		Exp. 4	
Week	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
8	5	10	18	27	10	14	14	19
12	−1	7	15	21	11	14	10	19
16	8	14	19	22	5	16	16	22
20	3	9	18	22	4	8	15	21

Appendix 2B Mean frequncy of different lying postures with hindlegs and/or foreleg(s) stretched as a percentage of total lying in individual crates and in group pens with slatted floors during four experiments. (Chapter IV)

	Lying on the side (hindlegs and forelegs stretched)		Lying on brisket, both hindlegs stretched		Lying on brisket, foreleg(s) stretched	
Exp.	Ind.	Group	Ind.	Group	Ind.	Group
1	0,2	0,9	1,1	6,2	20,1	9,0
2	0,9	2,1	2,6	15,4	31,0	14,4
3	1,0	2,4	0,7	3,6	17,5	10,2
4	0,4	3,2	1,2	7,0	32,5	19,2

Appendix 3A The mean daily consumption of straw cobs (g/calf) of calves in crates on a ration of 200 g straw cobs/calf/day in different weeks after arrival during two experiments. The supply started in week 7. (Chapter IV)

Period (weeks)	Experiment 3 (N = 12)	Experiment 4 (N = 11)
0- 2		
2- 7		
7-10	188	101
10-14	199	192
14-18	200	198
18-20	200	160

Appendix 3B The mean daily consumption of straw (g/calf) by calves in crates on a ration of 100 g straw/calf/day in different weeks after arrival during two experiments. (Chapter IV)

Period (weeks)	Experiment 4 (N = 18)	Experiment 5 (N = 19)
0- 2	8	8
2- 6	16	16
6-10	26	41
10-14	69	68
14-18	89	98
18-20	80	97

Appendix 3C Duration of eating straw from the baskets or from the bedding in four group pens with straw bedding in different weeks after arrival during two experiments. The values shown are percentages of the total number of observations per 24 hours (total observations/pen/24 hours = 690 (five calves per pen) or 552 (four calves per pen). (Chapter IV)

Experiment	Week 8		Week 12		Week 16		Week 20	
	Baskets	Bedding	Baskets	Bedding	Baskets	Bedding	Baskets	Bedding
4 (N = 4)	2,0	2,6	3,3	2,6	1,5	5,6	3,5	3,5
5 (N = 4)	3,0	2,3	11,6	1,3	6,4	1,5	5,9	3,0

Appendix 4 Cross-tabulation of active and passive partners (left and above respectively) in preputial sucking and urine drinking and the incidence of other sucking and of sucking as a total in individual calves in four pens in different weeks after arrival. The values shown are numbers of observations per week (1080 observations/calf/week). (Chapter V, experiment 2)

pen 1

week 2

	preputial sucking 1	2	3	4	5	tot.	urine drinking 1	2	3	4	5	tot.	other sucking	total sucking
1						0						0	100	100
2						0						0	71	71
3						0						0	22	22
4						0	3					3	20	20
5						0						0	27	27
tot.	0	0	0	0	0	0	3	0	0	0	0	3	240	240

week 3

	preputial sucking 1	2	3	4	5	tot.	urine drinking 1	2	3	4	5	tot.	other sucking	total sucking
1						0		3	3	2		8	65	65
2						0						0	117	117
3	1	4				5	2	14		5	2	23	80	80
4	1	4	10			15	8	14	3		3	28	58	73
5						0						0	77	77
tot	2	8	10	0	0	20	10	31	6	7	5	59	397	417

week 4

	preputial sucking 1	2	3	4	5	tot.	urine drinking 1	2	3	4	5	tot.	other sucking	total sucking
1		10	18		5	33		5	2	2	4	13	99	132
2			38		3	41						0	59	100
3						0	1	5				6	76	76
4	11	69	83		25	188						0	8	196
5						0						0	82	82
tot	11	79	139	0	33	262	1	10	2	2	4	19	324	586

week 5

	preputial sucking 1	2	3	4	5	tot.	urine drinking 1	2	3	4	5	tot.	other sucking	total sucking
1		10	4			14		4		3		7	103	117
2	1		135		2	138				1		1	15	153
3						0					1	1	41	41
4	1	8	22			31						0	1	32
5	3					3						0	69	72
tot.	5	18	161	0	2	186	0	4	0	4	1	9	229	415

week 7

	preputial sucking 1	2	3	4	5	tot.	urine drinking 1	2	3	4	5	tot.	other sucking	total sucking
1		2				2		2				2	11	13
2			28			28						0	3	31
3						0						0	49	49
4	5	8	73			86						0	2	88
5		1				1						0	19	20
tot	5	0	0	0	0	117	0	2	0	0	0	2	84	201

Appendix 4 (continued)

pen 3

		preputial sucking						urine drinking						other sucking	total sucking
		11	12	13	14	15	tot.	11	12	13	14	15	tot.		
week 2	11		6		296		302				2	7	9	55	357
	12	56		1	37		94	4				21	25	61	155
	13						0						0	44	44
	14						0		4				4	69	69
	15	1					1						0	39	40
	tot.	57	6	1	333	0	397	4	4	0	2	28	38	268	665
week 3	11		217		85		302		3			7	10	82	384
	12	142			81	134	357	18			20	3	41	19	376
	13						0	6					6	38	38
	14		1				1						0	49	50
	15						0						0	43	43
	tot.	142	218	0	166	134	660	24	3	0	20	10	57	231	891
week 4	11		160	3	6		169		2	8			10	17	186
	12	105		4	166	56	331	9			1	9	19	30	361
	13						0	7	9				16	82	82
	14						0	2					2	66	66
	15						0						0	21	21
	tot	105	160	7	172	56	500	18	11	8	1	9	47	216	716
week 5	11		286	4	3		293		4				4	9	302
	12	210		47	86	48	391	5		4	7		16	18	409
	13						0		5				5	114	114
	14			10		19	29	4					4	62	91
	15						0						0	88	88
	tot.	210	286	61	89	67	713	9	9	4	7	0	29	291	1004
week 7	11		20				20				1		1	8	28
	12	1			14		15	1			1		1	39	54
	13						0	1			3	2	6	7	7
	14						0		1	1			2	5	5
	15						0						0	5	5
	tot.	1	20	0	14	0	35	2	1	1	5	2	10	64	99

Appendix 4 (continued)

pen 6

		preputial sucking						urine drinking						other sucking	total sucking
		26	27	28	29	30	tot.	26	27	28	29	30	tot.		
week 2	26						0						0	28	28
	27					6	6						0	20	26
	28		13		36	45	94						0	134	228
	29			13		1	14						0	104	118
	30						(0)						(0)	(62)	(62)
	tot.	(0)	(13)	(13)	(36)	(52)	114	(0)	(0)	(0)	(0)	(0)	0	286	400
week 3	26						0		1				1	109	109
	27	69		80	84	84	317						0	7	324
	28	13	28		96	20	157						0	37	194
	29	13	61	49		90	213		2				2	17	230
	30	(30)	(178)	(62)	(87)		(357)		(2)				(2)	(1)	(358)
	tot.	(125)	(267)	(191)	(267)	(194)	687	(0)	(5)	(0)	(0)	(0)	5	170	857
week 4	26			7			7		3	2			5	51	58
	27	83		23	43	68	217	1			1		2	1	218
	28	13	2		90	37	142						0	4	146
	29	1	2	53		60	116		3				3	10	126
	30	(9)	(104)	(22)	(49)		(184)						(0)	(0)	(184)
	tot.	(106)	(108)	(105)	(182)	(165)	482	(1)	(6)	(2)	(1)	(0)	10	66	548
week 5	26		52	79			131						0	30	161
	27	63		53	64	49	229			3			3	0	229
	28	22	11		19	1	53		3				3	27	80
	29	4	10	50		2	66		1				1	16	82
	30						-						-	-	-
	tot.	89	73	182	83	52	479	0	4	3	0	0	7	73	552
week 7	26		16	145			161						0	5	166
	27	33		50	41		124						0	5	129
	28	90	11		123		224						0	5	229
	29	1	5	27			33						0	0	33
	30						-						-	-	-
	tot.	124	32	222	164	0	542	0	0	0	0	0	0	15	557

( ) eliminated

pen 8

week		preputial sucking 36	37	38	39	40	tot.	urine drinking 36	37	38	39	40	tot.	other sucking	total sucking
week 2	36						0						0	184	184
	37						0						0	32	32
	38						0						0	2	2
	39						0						0	37	37
	40						0						0	0	0
	tot.	0	0	0	0	0	0	0	0	0	0	0	0	255	255
week 3	36						0						0	276	276
	37						0						0	106	106
	38		8				8						0	120	128
	39						0						0	73	73
	40		8				8						0	45	53
	tot.	0	16	0	0	0	16	0	0	0	0	0	0	620	636
week 4	36						0						0	212	212
	37						0						0	132	132
	38		24				24						0	127	151
	39						0						0	97	97
	40	5	43		33		81						0	0	81
	tot.	5	67	0	33	0	105	0	0	0	0	0	0	568	673
week 5	36						0						0	151	151
	37						0						0	88	88
	38	14	50		37	11	112						0	43	155
	39						0						0	62	62
	40	56	9	49	23		137						0	6	143
	tot	70	59	49	60	11	249	0	0	0	0	0	0	350	599
week 7	36						0						0	80	80
	37						0						0	53	53
	38	8	26		7	3	44						0	10	54
	39						0	2					2	42	42
	40	30	13	23	18		84						0	2	86
	tot.	38	39	23	25	3	128	2	0	0	0	0	2	187	315

Appendix 5A Latency time and volume of water consumed during tests by individual calves provided with additional water in weeks 1, 2 and 3. Water supply was discontinued in weeks 4 to 7. The values shown are the means of three tests per week in weeks 1, 2 and 3 and of a total of four tests in weeks 4, 5, 6 and 7. The total daily intake of water by the same calves in weeks 1, 2 and 3 is presented as a mean of 7 days per week. (Chapter VI.2)

		Latency time (1/100 min)				Volume (l)				Intake (l)		
Pen	Calf	Wk 1	Wk 2	Wk 3	Wks 4-7	Wk 1	Wk 2	Wk 3	Wks 4-7	Wk 1	Wk 2	Wk 3
	194	5,7	3,7	4,4	2,7	0,05	0,01	0,00	0,02	0,3	0,1	0,2
	168	–	–	–	–	0,00	0,00	0,06	0,23	0,3	0,1	0,4
2	177	4,8	2,1	5,8	3,3	0,28	0,10	0,04	0,08	2,1	0,7	0,1
	156	4,2	2,2	2,1	2,4	0,11	0,28	0,56	0,70	1,0	2,9	8,9
	171	3,7	3,1	2,4	1,8	0,19	0,33	0,33	0,55	6,1	11,0	12,7
	181	6,8	6,0	3,1	4,5	0,00	0,01	0,07	0,22	1,9	3,2	3,6
	192	3,5	2,2	2,3	1,8	0,67	0,64	0,74	0,83	12,7	12,3	15,4
4	153	–	–	–	–	0,00	0,10	0,08	0,65	2,8	6,3	6,1
	188	6,4	2,8	3,8	2,8	0,31	0,60	0,59	0,61	3,4	9,3	10,8
	175	2,8	2,7	1,9	1,7	0,57	0,63	0,79	0,85	9,4	15,3	15,4
	182	6,7	4,2	4,0	2,7	0,30	0,57	0,48	0,63	2,6	8,2	9,3
	189	–	–	–	–	0,03	0,16	0,15	0,36	0,7	3,7	5,9
6	157	5,2	3,4	4,0	3,6	0,03	0,07	0,02	0,18	1,1	1,6	1,1
	160	4,8	2,2	2,4	1,6	0,55	0,76	0,71	0,64	11,7	15,4	15,4
	196	4,9	3,6	3,2	3,2	0,20	0,19	0,29	0,69	10,9	14,9	12,8
	185	3,4	2,8	2,3	2,2	0,57	0,63	0,72	0,78	7,5	15,1	14,4
	193	5,3	2,8	3,1	2,6	0,57	0,73	0,57	0,71	10,3	15,5	14,2
8	159	3,8	2,8	2,6	3,1	0,60	0,56	0,59	0,69	11,4	15,4	13,4
	198	3,4	3,4	3,3	2,9	0,83	0,78	0,64	0,69	12,8	15,5	14,9
	167	5,0	3,5	5,4	3,2	0,48	0,52	0,44	0,56	2,7	5,4	6,3

–: failed to contact the water within 15 s during one or more tests per week

Appendix 5B Latency time and volume of water consumed during tests in individual calves without additional water. The values shown are the means of three tests per week in weeks 1, 2 and 3 and of a total of four tests in weeks 4, 5, 6 and 7. (Chapter VI.2)

		Latency time (1/100 min)				Volume (l)			
Pen	Calf	Wk 1	Wk 2	Wk 3	Wks 4-7	Wk 1	Wk 2	Wk 3	Wks 4-7
1	174	–	–	–	–	0,01	0,01	0,00	0,00
	163	3,8	2,3	2,3	1,8	0,60	0,71	0,66	0,58
	176	4,7	2,3	2,8	1,9	0,73	0,77	0,70	0,79
	152	3,9	3,9	3,5	3,5	0,08	0,01	0,08	0,51
	[165]								
3	162	6,7	5,7	8,4	3,8	0,00	0,00	0,05	0,36
	183	10,2	3,6	2,9	2,8	0,31	0,58	0,61	0,44
	151	–	–	–	–	0,01	0,11	0,12	0,56
	187	5,5	4,6	2,4	1,8	0,30	0,52	0,75	0,79
	(173)								
5	180	7,9	3,1	2,9	2,0	0,16	0,40	0,52	0,53
	184	4,6	3,2	2,6	1,5	0,66	0,77	0,68	0,68
	155	10,6	3,3	2,8	2,6	0,51	0,50	0,54	0,66
	158	7,9	3,3	2,9	3,3	0,35	0,35	0,17	0,43
	161	4,4	2,2	1,8	1,7	0,74	0,80	0,78	0,60
7	154	6,1	4,3	3,5	2,9	0,16	0,23	0,32	0,26
	166	9,1	2,8	1,8	1,8	0,66	0,68	0,66	0,71
	197	4,5	2,4	2,9	2,2	0,72	0,70	0,75	0,88
	(164)								
	169	5,2	2,3	2,0	2,9	0,80	0,79	0,81	0,87

[ ]: died / ( ) b: eliminated due to illness
–: failed to contact the water within 15 s during one or more tests per week

Appendix 5C Spearman rank correlations between latency time (Lat) and volume of water consumed (Vol) in drinking tests and the total daily intake of water (Int) in experimental calves with water supply and control calves without water supply in different weeks after arrival. (Chapter VI.2)

		Experimental			Control		
		N	r_s	p	N	r_s	p
Week 1	Lat - Vol	17	−0,605	**	15	−0,288	n.s.
	Lat - Int	17	−0,599	**			
	Vol - Int	20	0,813	**			
Week 2	Lat - Vol	17	−0,396	n.s.	15	−0,843	**
	Lat - Int	17	−0,232	n.s.			
	Vol - Int	20	0,881	**			
Week 3	Lat - Vol	17	−0,712	**	15	−0,712	**
	Lat - Int	17	−0,721	**			
	Vol - Int	20	0,931	**			
Weeks 4-7	Lat - Vol	17	−0,560	*	15	−0,506	*

n.s.: not significant/ *: $0,01 < p \leq 0,05$/ **: $p \leq 0,01$

Appendix 6A Latency time of teat sucking (s) in individual calves, bucket or teat bucket reared, in six tests per day on days 3 and 6 after arrival. (Chapter VI.3)

		Tests on day 3						Tests on day 6					
	Calf	I	II	III	IV	V	VI	I	II	III	IV	V	IV
	1	1	11	1	1	7	1	17	10	–	94	3	12
	2	25	10	6	4	1	1	14	1	6	1	1	1
Bucket	3	2	5	1	1	1	1	1	40	80	1	31	18
reared	4	15	20	–	–	–	–	–	–	5	10	105	41
	5	–	–	–	–	–	–	–	–	45	50	–	–
	6	60	–	–	–	–	27	20	–	–	–	–	101
	7	5	–	30	12	70	–	–	75	1	1	1	8
	8	1	–	–	–	–	–	65	–	252	–	–	–
	9	30	25	20	25	6	1	12	4	13	3	7	15
	10	5	10	1	1	5	3	1	4	2	1	1	1
	11	1	–	1	–	4	1	1	25	–	104	57	1
Teat	12	20	55	1	1	4	3	1	1	2	1	4	1
bucket	13	1	1	5	7	2	4	9	1	1	1	19	7
reared*	14	3	1	2	1	15	1	118	1	1	1	1	16
	16	1	–	1	1	1	10	1	1	1	1	1	10
	17	16	2	1	1	10	9	1	1	20	1	8	17
	19	–	12	5	1	1	5	1	20	5	210	–	–

*: calves 15 and 18 were eliminated due to persistent illness
–: failed to suck within 300 s

Appendix 6B Duration of teat sucking (s) in individual calves, bucket or teat bucket reared, in six tests per day on days 3 and 6 after arrival. Each test lasted 300 s. (Chapter VI.3)

		Tests on day 3						Tests on day 6					
	Calf	I	II	III	IV	V	VI	I	II	III	IV	V	IV
	1	275	217	232	209	140	192	189	45	0	5	124	218
	2	31	120	92	140	192	123	112	206	31	211	271	246
Bucket	3	84	65	188	20	207	238	272	127	169	98	169	195
reared	4	142	20	0	0	0	0	0	0	103	202	54	48
	5	0	0	0	0	0	0	0	0	15	43	0	0
	6	25	0	0	0	0	13	3	0	0	0	0	4
	7	12	0	12	80	23	0	0	197	198	165	240	271
	8	6	0	0	0	0	0	12	0	2	0	0	0
	9	80	67	106	110	110	136	139	176	129	141	104	217
	10	150	150	207	198	185	83	231	255	270	279	207	255
	11	62	0	155	0	54	179	66	49	0	54	57	111
Teat	12	137	62	123	187	162	113	141	150	125	71	48	105
bucket	13	226	200	89	226	143	243	155	173	129	105	96	122
reared*	14	188	164	207	138	192	188	19	173	78	109	73	146
	16	65	0	78	48	108	124	57	132	122	189	246	159
	17	63	77	47	71	14	43	253	223	89	50	277	251
	19	0	178	70	186	202	158	119	66	72	24	0	0

*: calves 15 and 18 were eliminated due to persistent illness

Appendix 7A Patterns of standing up and lying down in individual calves in four different combinations of stall width and chain length and construction. The values shown are total numbers of sequences in weeks 6 and 8 after arrival. (Chapter VII, experiment 1)

		Standing up					Lying down				
	Calf	Total	Normal	Inter-ruption	Attempt	Abnormal	Total	Normal	Inter-ruption	Attempt	Abnormal
	2	36	36	0	0	0	36	34	2	0	0
Stall width	(3)										
48 cm	4	4	23	1	0	0	23	19	4	0	0
	22	35	34	0	0	1	36	33	3	0	0
Chain length	23	22	21	1	0	0	23	22	1	0	0
48° cm	24	30	29	1	0	0	29	26	3	0	0
	Total	147	143	3	0	1	147	134	13	0	0
	7	24	15	6	3	0	22	20	2	0	0
Stall width	8	20	19	0	0	1	20	11	9	0	0
58 cm	9	27	21	5	0	1	27	24	3	0	0
	27	24	22	0	0	2	24	24	0	0	0
Chain length	28	26	22	4	0	0	26	24	2	0	0
48° cm	29	18	18	0	0	0	18	16	2	0	0
	Total	139	117	15	3	4	137	119	18	0	0
	12	17	17	0	0	0	18	12	5	1	0
Stall width	13	23	23	0	0	0	23	21	2	0	0
48 cm	14	20	23	0	1	2	19	15	4	0	0
	32	31	26	0	1	4	32	30	2	0	0
Chain length	33	41	32	5	3	1	39	35	3	0	1
40 cm	34	28	23	5	0	0	28	23	5	0	0
	Total	160	138	10	5	7	159	136	21	1	1
	17	49	47	2	0	0	49	46	3	0	0
Stall width	18	21	19	1	1	0	22	17	3	1	1
58 cm	19	27	18	7	0	2	27	26	1	0	0
	37	28	24	2	2	0	26	20	6	0	0
Chain length	38	28	28	0	0	0	30	26	4	0	0
40 cm	39	20	20	0	0	0	22	18	4	0	0
	Total	173	156	12	3	2	176	153	21	1	1

( ): eliminated due to illness
° : gliding chains

Appendix 7B Patterns of standing up and lying down in individual calves in four different combinations of stall width and chain length. The values shown are total numbers of sequences in weeks 6, 7, 9 and 10 after arrival. (Chapter VII. experiment 2)

		Standing up					Lying down				
	Calf	Total	Normal	Inter-ruption	Attempt	Abnormal	Total	Normal	Inter-ruption	Attempt	Abnormal
	102	32	30	0	0	2	37	21	12	4	0
Stall width	103	24	20	0	1	3	25	15	9	1	0
48 cm	104	39	38	1	0	0	42	28	12	2	0
	122	33	31	1	1	0	32	27	4	1	0
Chain length	123	28	24	3	1	0	28	27	0	1	0
40 cm	124	31	19	3	1	8	31	31	0	0	0
	Total	187	162	8	4	13	195	149	37	9	0
	107	22	14	0	1	7	21	19	2	0	0
Stall width	108	34	29	3	2	0	35	27	7	1	0
58 cm	109	31	29	1	0	1	30	27	1	2	0
	127	39	14	12	7	6	32	29	2	1	0
Chain length	128	33	23	3	7	0	29	28	0	1	0
40 cm	129	33	24	1	4	4	31	29	1	1	0
	Total	192	133	20	21	18	178	159	13	6	0
	112	34	25	5	1	3	33	33	0	0	0
Stall width	113	34	32	1	0	1	34	29	3	2	0
48 cm	114	37	27	3	1	6	35	32	3	0	0
	132	22	12	0	3	7	20	18	0	2	0
Chain length	133	31	20	1	5	5	28	23	3	2	0
34 cm	134	34	30	3	1	0	35	32	1	2	0
	Total	192	146	13	11	22	185	167	10	8	0
	117	47	27	12	3	5	47	37	8	2	0
Stall width	118	33	29	1	1	2	38	29	5	4	0
58 cm	119	20	15	1	0	4	21	15	4	2	0
	137	37	11	4	8	14	27	24	3	0	0
Chain length	138	47	26	12	9	0	42	39	1	2	0
34 cm	139	42	33	1	2	6	42	38	2	2	0
	Total	226	141	31	23	31	217	182	23	12	0

Appendix 8 Total duration, frequency and average duration of lying, lying with the head turned backwards, lying with the head forwards and Ear Movement Sleep (EMS) per 24 hours on consecutive days before, during and after haltering in individual control and experimental calves in four pairs. In addition, the total duration of EMS during each of both head postures is mentioned. (Chapter VIII, experiment 2)

Pair 1	Before		During		After (1)		After (2)	
	Contr.	Exp.	Contr.	Exp.	Contr.	Exp.	Contr.	Exp.
Lying (%)	78,9	69,9	88,9	80,6	76,7	75,2	80,2	77,1
Frequency	22	17	16	20	24	20	22	17
Av. dur. (min)	51,7	58,9	80,0	58,0	46,0	54,1	52,5	65,3
Head backw. (%)	37,8	44,7	42,4		33,1	37,1	33,7	38,1
Frequency	82	111	58		99	115	73	98
Av. dur. (s)	398	348	632		289	279	399	336
Head forw. (%)	0,8	2,7	1,6	42,4	1,4	0,0	7,7	0,9
Frequency	2	12	3	93	3	0	7	2
Av. dur. (s)	353	193	450	394	417	0	954	385
EMS (%)	10,3	9,1	10,5	5,8	8,8	7,2	9,4	8,6
Frequency	25	40	25	30	21	31	23	32
Av. dur. (s)	354	197	328	166	360	201	340	231
$EMS_{head\ backw.}$ (%)	10,3	8,7	10,0		8,8	7,2	7,2	8,2
$EMS_{head\ forw.}$ (%)	0,0	0,4	0,5	5,8	0,0	0,0	2,3	0,4

(1): first day / (2): second day

Appendix 8 (continued)

Pair 2	Before		During		After (1)		After (2)	
	Contr.	Exp.	Contr.	Exp.	Contr.	Exp.	Contr.	Exp.
Lying (%)	78,0	77,9	75,2	83,6	68,0	79,2	75,4	79,6
Frequency	20	25	20	27	20	22	18	17
Av. dur. (min)	56,2	44,9	54,1	44,6	49,0	51,8	60,3	67,4
Head backw. (%)	28,4	23,0	10,0		17,8	29,5	27,1	30,0
Frequency	41	61	37		31	72	43	71
Av. dur. (s)	598	325	234		497	354	544	365
Head forw. (%)	0,6	3,2	1,3	29,9	2,5	1,3	0,0	2,2
Frequency	4	4	7	95	9	5	0	9
Av. dur. (s)	120	706	157	272	236	230	0	208
EMS (%)	5,0	4,1	4,0	4,6	6,6	7,4	7,2	7,4
Frequency	20	17	16	22	32	22	33	22
Av. dur. (s)	214	206	214	195	178	290	188	301
$EMS_{head\ backw.}$ (%)	5,0	3,7	3,3		6,2	6,7	7,2	6,8
$EMS_{head\ forw.}$ (%)	0,0	0,3	0,6	4,6	0,4	0,7	0,0	0,6

(1): first day / (2): second day

Appendix 8 (continued)

Pair 3	Before		During		After (1)		After (2)	
	Contr.	Exp.	Contr.	Exp.	Contr.	Exp.	Contr.	Exp.
Lying (%)	72,2	78,3	73,1	74,3	70,0	80,0	74,6	55,7
Frequency	16	20	20	20	20	15	26	10
Av. dur. (min)	65,0	56,4	52,6	53,5	50,4	76,8	41,3	80,2
Head backw. (%)	27,7	22,1	22,4		22,4	26,0	25,8	6,0
Frequency	70	44	34		49	46	60	17
Av. dur. (s)	341	434	570		395	488	372	306
Head forw. (%)	1,6	23,1	3,8	54,7	3,6	15,8	2,0	17,5
Frequency	22	51	34	62	19	48	17	25
Av. dur. (s)	62	391	96	762	163	285	103	606
EMS (%)	7,3	10,1	6,2	7,1	5,2	8,2	5,5	5,3
Frequency	36	33	31	27	31	20	26	18
Av. dur. (s)	176	265	172	227	168	355	183	255
$EMS_{head\ backw.}$ (%)	7,3	5,2	5,7		4,4	5,3	5,0	2,0
$EMS_{head\ forw.}$ (%)	0,0	5,0	0,5	7,1	0,8	2,9	0,5	3,3

(1): first day / (2): second day

Appendix 8 (continued)

Pair 4	Before		During (1)		During (2)		During (3)		After (1)		After (2)	
	Contr.	Exp.	Contr.	Exp.	Contr.	Exp.	Contr.	Exp.	Contr.	Exp.	Contr.	Exp.
Lying (%)	77,9	81,6	78,9	90,5	74,7	84,8	78,2	88,1	86,8	85,0	76,8	81,1
Frequency	22	15	24	12	19	17	17	13	15	12	18	15
Av. dur. (min)	51,0	78,3	47,4	108,6	56,6	71,9	66,3	97,6	83,3	102,0	61,4	77,9
Head backw. (%)	32,9	48,6	33,8		33,7		37,6		37,5	31,5	40,2	34,8
Frequency	51	101	64		63		72		84	81	79	78
Av. dur. (s)	558	415	459		462		451		386	336	440	385
Head forw. (%)	0,0	1,1	2,2	33,8	0,2	37,9	0,2	38,2	0,1	0,0	0,0	0,4
Frequency	0	5	6	82	2	92	1	112	2	0	0	4
Av. dur. (s)	0	184	408	357	75	356	181	372	59	0	0	83
EMS (%)	7,1	7,3	7,8	4,6	7,2	7,5	8,1	5,4	6,6	7,4	7,0	8,1
Frequency	25	39	28	23	20	35	21	22	25	29	24	29
Av. dur. (s)	247	163	243	175	309	185	335	212	229	224	251	242
$EMS_{head\ backw.}$ (%)	7,1	7,3	7,4		7,2		8,1		6,6	7,4	7,0	8,1
$EMS_{head\ forw.}$ (%)	0,0	0,0	0,4	4,6	0,0	7,5	0,0	5,4	0,0	0,0	0,0	0,0

(1): first day / (2): second day / (3): third day

Curriculum vitae

Op verzoek van het college van dekanen van de Landbouwhogeschool te Wageningen volgen hier enkele gegevens over mijn opleiding en werkkring.

Vanaf 1969 bezocht ik het Dr. Mollercollege te Waalwijk en behaalde daar in 1975 het diploma gymnasium β. In datzelfde jaar begon ik mijn studie aan de Landbouwhogeschool te Wageningen en studeerde daar in 1981 af met als verzwaard hoofdvak de Toegepaste Ethologie en als bijvakken de Gezondheids- en Ziekteleer der Landbouwhuisdieren en de Landbouwplantenteelt.

Vanaf april 1981 verrichtte ik het onderzoek dat geleid heeft tot dit proefschrift; tot april 1983 bij de Vakgroep Veehouderij, sectie Ethologie van de Landbouwhogeschool en daarna bij het Instituut voor Mechanisatie, Arbeid en Gebouwen te Wageningen.