Acta vet. scand. 1989, *30*, 55–62.

Epidemiological Studies of Piglet Diarrhoea in Intensively Managed Danish Sow Herds

II. Post-weaning diarrhoea

By *Birgitta Svensmark, Knud Nielsen, Preben Willeberg* and *Sven Erik Jorsal*

Departments of Internal Medicine and Forensic and State Veterinary Medicine,
Royal Veterinary and Agricultural University, Copenhagen, Denmark.

Svensmark, B., K. Nielsen, P. Willeberg and S. E. Jorsal: Epidemiological studies of piglet diarrhoea in intensively managed Danish sow herds. II. Post-weaning diarrhoea. Acta vet. scand. 1989, 30, 55–62. – This study comprised 48,931 litters in 89 sow herds. During the study (1976–82) weaning age decreased from approx. 42 days to approx. 30 days. The mean incidence of post-weaning diarrhoea was 6.0 % of litters weaned, with little variation by year but with considerable variation among herds. Within the individual herd increased incidence occurred over limited periods, probably associated with specific infections.

Litters with diarrhoea during the suckling period had increased risk of post-weaning diarrhoea. The incidence of post-weaning diarrhoea increased with litter size at weaning. Thus, a litter of 11–12 piglets at weaning had 1.2 times higher risk than litters with 8–10 piglets. In contrast to pre-weaning diarrhoea, there was no association between parity of the sow and diarrhoea in the litter after weaning.

Litters weaned below 2 weeks of age had a 2-fold risk of developing diarrhoea after weaning and a 2.4-fold higher mortality rate than did litters weaned at 6–7 weeks. Similarly, litters weaned at an individual piglet weight below 3 kg bodyweight had a 3-fold higher risk of developing diarrhoea after weaning and a 5-fold higher mortality rate than did pigs from litters weaned at a bodyweight of 7–8 kg.

The incidence of post-weaning diarrhoea decreased with increasing herd size. Piglets from litters with post-weaning diarrhoea had reduced weight gains after weaning and were 2.3 days older at 25 kg bodyweight than piglets from non-diarrhoeic litters. Likewise, diarrhoea after weaning was associated with an increased incidence of diseases of the skin and respiratory tract. Thus the risk of contracting respiratory disease was 4 times greater in diarrhoeic litters.

morbidity; mortality; risk factors; swine; scours.

Introduction

Weaning age has decreased steadily in Danish sow herds over the last decade. Whereas, earlier, piglets were weaned at 7–10 weeks, it is usual to-day to wean at 3–4 weeks. Most studies on diarrhoea in weaners have dealt with the situation in traditional herds with weaning at 6–8 weeks. Accordingly, there is a need to examine the situation in intensively managed herds.

In a previous paper (*Svensmark et al.* 1989a) on pre-weaning diarrhoea a litter incidence rate of 6.8 % was found in 104 sow herds participating in the "Field Tests" under the "National Committee for Pig Breeding".

Post-weaning diarrhoea was also studied in the herds and the results will be presented in the following.

Material and methods

The data were collected in 1976–1982, during which period the weaning age decreased

from approx. 42 days to approx. 30 days, with a mean of 34 days in the sample of herds under study. Accordingly, weaning procedures changed during the period covered by the study. Weaning at 5–6 weeks was usually performed by removing the sow and leaving the piglets in the farrowing pen for 8–10 days before they were transferred to a unit for weaned piglets. Piglets weaned at 3–4 weeks were transferred from the farrowing unit to piglet units with automated climate control which adjusted temperature and humidity according to the need of the piglets, i. e. the temperature was lowered gradually from approx. 28 C. to approx. 21 C. during the 3–4 weeks that the piglets spent in the piglet unit. Most herds with weaning at 3–4 weeks had synchronized farrowing and weaning, and at the transfer to the piglet unit the piglets were distributed in flat deck pens according to size, which infers that the litters were divided after weaning. Usually, a pen housed 10–14 piglets. The pigs were transferred to the fattening unit or marketed at a weight of approx. 20 kg. In some herds, a unit for young pigs (10–20 kg) was inserted between the piglet and fattening units.

The study comprised the post-weaning periods of 48,931 litters in 89 herds participating in the Field Tests. As described in the first paper of this series (*Svensmark et al.* 1989a), herd owners kept records of diseases and symptoms appearing in the litters before and after weaning. A litter was scored for diarrhoea if more than 25 % of the piglets had diarrhoea or if the litter was medically treated for diarrhoea. Data were collected by a technician, stored and computer-processed using *SAS (Statistical Analysis System)* (1982). For more details on the parameters recorded and on the statistical analyses employed, reference is made to *Svensmark et al.* (1989a).

Results

Temporal variations

Of the 48,931 litters studied, diarrhoea was observed in 2,949 litters, i. e. an incidence rate of 6.0 %. There was little variation during the period examined (Fig. 1), except for the high incidence rate in 1976 (12.8 %), which, however, concerns a relatively small material, i. e. 235 litters from 13 herds. Among these, 3 herds which had high incidence rates (11–24 %), account for 80 % of the recorded cases of post-weaning diarrhoea.

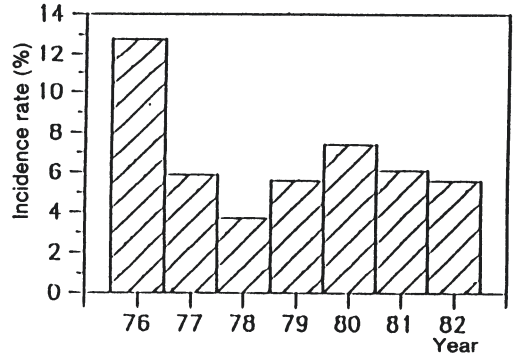

Figure 1. Incidence rate of post-weaning diarrhoea by year.

The incidence rates varied considerably, not only among herds but also within the individual herd over the observation period. As shown in Fig. 2, yearly incidence rates were below 10 % in the majority of herds, while higher incidence rates were observed in some herds. Often, these incidents appeared over a limited period of 1–3 months and were probably associated with specific infections, mainly *E. coli.*

Sow/litter factors

Parity of sow. No association was found, since litters from older sows had similar risk as litters from gilts.

Breed. Breed combinations between Danish

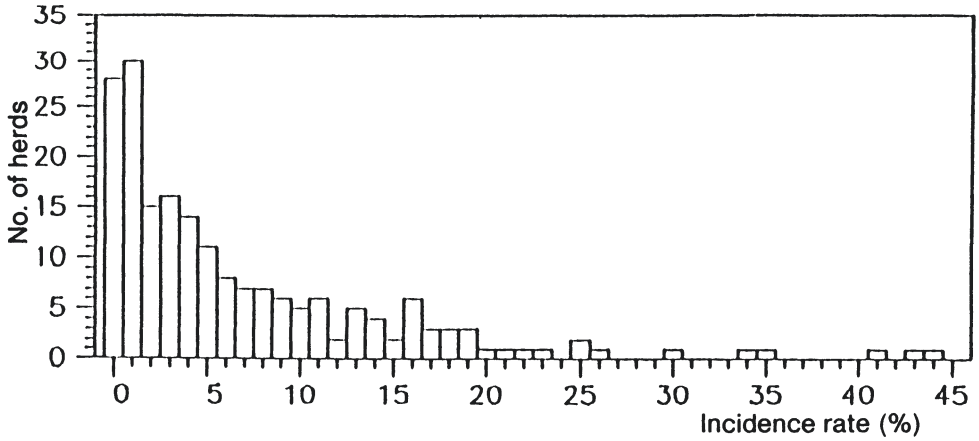

Figure 2. Distribution of yearly incidence rates of post-weaning diarrhoea in herds participating in the study.

Landrace and Yorkshire (LY and LYY) and between Danish Landrace, Yorkshire and Duroc (LYD) had the lowest incidence rates as compared to the breed combination Danish Landrace-Yorkshire back-crossed to Danish Landrace (LYL).

Pre-weaning diarrhoea. There was a significantly increased risk that litters suffering from diarrhoea during the suckling period would also develop post-weaning diarrhoea (Table 1).

Uneven litters at weaning. There was an increased risk that a litter with piglets of uneven size at weaning would develop diarrhoea after weaning. Since pre-weaning diarrhoea increases the risk of post-weaning diarrhoea as mentioned above, the relative risk in Table 2 has been adjusted for this effect. This decreases the relative risk from 1.8 to 1.7, which is still highly significant.

Table 1. Post-weaning diarrhoea in relation to occurrence of diarrhoea in the litter before weaning.

	Litters at risk	Incidence rate (%)	Relative risk
Pre-weaning diarrhoea	3,636	8.5	1.5***
No pre-weaning diarrhoea	45,295	5.8	1

Table 2. Post-weaning diarrhoea in relation to occurrence of uneven litters at weaning.

			Relative risk	
	Litters at risk	Incidence rate (%)	Crude	Adjusted for pre-weaning diarrhoea
Uneven litters at weaning	2,255	10.3	1.8***	1.7***
Uniform litters at weaning	46,673	5.8	1	1

Litter size at weaning. It appears from Table 3 that the incidence rate increased with litter size at weaning. When corrected for the positive correlation between pre- and post-weaning diarrhoea mentioned above, the risk of diarrhoea in the litter with 11–12 piglets at weaning was 1.2 times higher than in a litter with 8–10 piglets, and litters of 1–7 piglets had a relative risk of 0.8 compared to the reference litters of 8–10 piglets.

Table 3. Post-weaning diarrhoea in relation to litter size at weaning.

Litter size at weaning	Litters at risk	Incidence rate (%)	Relative risk	
			Crude	Adjusted for pre-weaning diarrhoea
1– 7	9,516	5.3	0.9***	0.8***
8–10	29,854	6.0	1	1
11–12	8,322	7.4	1.2***	1.2***
12–	681	6.6	1.1 NS	1.1 NS

Herd factors

Weaning age and weight. Piglet weaned at a very young age, viz. 2 weeks or younger, had nearly twice the risk of developing post-weaning diarrhoea than piglets weaned at 29–35 days (Table 4). Weight at weaning was equally important. Thus, piglets that weighed less than 3 kg at weaning had 3 times the risk of developing diarrhoea compared to that in the reference group of piglets weighing 7–8 kg (Table 5).

Table 4. Post-weaning diarrhoea in relation to weaning age and adjusted for weaning weight and herd level of diarrhoea.

Weaning age, days	Litters at risk	Incidence rate (%)	Relative risk	
			Crude	Adjusted for weight at weaning and herd level
–14	359	10.0	1.6***	1.9***
15–21	2,196	4.2	0.7***	1.0 NS
22–28	7,863	5.6	0.9 NS	1.1 NS
29–35	18,182	6.2	1	1
36–42	13,103	6.5	1.1 NS	0.9 NS
43–49	5,121	6.1	1.0 NS	0.8***
50–	1,549	5.3	0.9 NS	0.7*

Table 5. Post-weaning diarrhoea in relation to weaning weight and adjusted for weaning weight and herd level of diarrhoea.

Weight at weaning (kg)	Litters at risk	Incidence rate (%)	Relative risk	
			Crude	Adjusted for age at weaning and herd level
–3	61	18.0	2.8***	3.1***
3–4	532	10.9	1.7***	1,9***
4–5	1,488	6.0	0.9 NS	1.1 NS
5–6	4,196	7.0	1.1 NS	1.1 NS
6–7	7,992	6.7	1.0 NS	1.1 NS
7–8	10,280	6.5	1	1
8–9	8,659	5,7	0.9 NS	0.8**
9–10	6,229	5.6	0.9 NS	0.8***
10–11	3,671	5.4	0.8 NS	0.7***
11–12	2.273	5.4	0.8 NS	0.6***
12–	2,992	4.1	0.6***	0.5***

Herd size. The incidence rate of post-weaning diarrhoea decreased with increasing herd size. It was also found that large herds practiced earlier weaning than small herds. Adjustment for weaning age did, however, not change the overall picture (Table 6).

Consequences of post-weaning diarrhoea

Mortality. A total of 10,295 piglets died between weaning and marketing or transfer to fattening units, i. e. a loss of 0.2 piglets per litter. Since an average of 8.9 piglets were weaned per litter, the total mortality rate was 2.4 %. Around this average figure, however, there was considerable variation. Age and weight at weaning had considerable influence. Thus, weaning below 2 weeks increased the mortality rate 2.4 times as com-

Table 6. Post-weaning diarrhoea in relation to herd size and adjusted for weaning age.

Farrowings per year	Number of herd-years	Litters at risk	Incidence rate (%)	Relative risk: Crude	Relative risk: Adjusted for weaning age	Mean weaning age
100–199	22	3,737	10.9	1.1 NS	1.1 NS	40
200–299	38	9,060	9.5	1	1	36
300–399	23	8.084	5.4	0.6***	0.6***	34
400–499	15	6,559	4.4	0.5***	0.6***	32
500–	6	4,251	3.0	0.3***	0.4***	33

pared to weaning at 29–35 days (Table 7), and a weaning weight below 3 kg was associated with a 5-fold increase in mortality compared to weaning at 7–8 kg (Table 8).

Table 7. Influence of weaning age on post-weaning mortality, adjusted for weaning weight and herd level of diarrhoea.

Weaning age, days	Litters at risk	Mortality %	Relative risk: Crude	Relative risk: Adjusted for weaning weight and herd level
0–14	359	8.7	3.8***	2.4***
15–21	2,196	3.4	1.5**	1.2 NS
22–28	7,863	2.6	1.1 NS	1.2 NS
29–35	18,182	2.3	1	1
36–42	13,103	2.2	0.9 NS	1.0 NS
43–49	5,121	2.1	0.9 NS	1.0 NS
50–	1,549	2.1	0.9 NS	1.0 NS

In litters with post-weaning diarrhoea, mortality rate was 8.5 %, compared with 1.9 % in litters without occurrence of diarrhoea after weaning (Table 9). This implies that an average of 0.6 more piglets were lost in litters with post-weaning diarrhoea than in non-diarrhoeic litters. Again, age and weight at weaning had a marked influence in that the mortality from diarrhoea was much higher in pigs weaned early and of low body-weight.

Table 8. Influence of weaning weight on post-weaning mortality, adjusted for weaning age and herd level of diarrhoea.

Weaning weight, kg	Litters at risk	Mortality %	Relative risk: Crude	Relative risk: Adjusted for weaning age and herd level
–3	61	14.9	6.3***	5.2***
3–4	532	7.3	3.1***	2.1***
4–5	1.488	4.0	1.7***	1.4 NS
5–6	4.196	3.3	1.4*	1.4**
6–7	7,992	2.8	1.2 NS	1.1 NS
7–8	10,280	2.9	1	1
8–9	8,659	2.1	0.9 NS	0.9 NS
9–10	6,229	1.9	0.8 NS	0.8 NS
10–11	3,671	1.7	0.7*	0.8 NS
11–12	2,273	1.8	0.8 NS	0.8 NS
13–	2,992	1.2	0.5***	0.7**

Table 9. Mortality in relation to post-weaning diarrhoea.

	Litters at risk	Number of dead piglets per litter	Mortality %	Relative risk
With post-weaning diarrhoea	2,946	0.8***	8.5	4.5***
Without post-weaning diarrhoea	45,427	0.2	1.9	1

Table 10. Occurrence of skin disease and respiratory disease in relation to post-weaning diarrhoea.

		Skin disease		Respiratory disease	
	Litters at risk	Incidence rate (%)	Relative risk	Incidence rate (%)	Relative risk
With post-weaning diarrhoea	2,949	2.3	1.4*	1.3	4.0***
Without post-weaning diarrhoea	45,979	1.7	1	0.3	1

Weight gain. Litters with post-weaning diarrhoea had reduced weight gain and were, on the average, 2.3 days older at 25 kg bodyweight than non-diarrhoeic litters.

Other diseases after weaning. As shown in Table 10, litters with post-weaning diarrhoea had a higher risk of skin lesions and respiratory diseases than non-diarrhoeic litters. The increase was particularly evident for respiratory diseases: A litter with diarrhoea after weaning had a 4-fold higher risk of contracting respiratory disease than a litter without diarrhoea.

Discussion

Post-weaning diarrhoea occurred in 6.0 % of the 48,931 litters studied in this report. In comparison, *Bäckström* (1973) found incidence rates of 9 % among litters weaned at 5–6 weeks and 7.3 % in litters weaned at 9–10 weeks. *Nielsen et al.* (1976) found 4–5 % incidence rate in piglets weaned at approx. 8 weeks. Recent studies by *Bækbo & Nielsen* (to be published) dealing with pigs weaned at 30 days and transferred from 6 small sow herds to 1 large, common piglet unit revealed an incidence rate of 5.2 %.

Among the factors with the most marked influence upon occurrence of post-weaning diarrhoea were age and weight at weaning. Weaning below 2 weeks of age or below 4 kg bodyweight was associated with a distinct increase in incidence rates. The same finding has been reported by other authors and is probably associated with a complex interaction between physiological and immunological faetures of the gastrointestinal tract of the young piglet and the effect of infectious agents and environmental changes associated with weaning. E. g., the synthesis of intestinal enzymes is not fully developed until the age of 6–8 weeks (*Manners & Stevens* 1972, *Stevens & Kidder* 1972). Likewise, the piglet is dependent upon the continuous uptake of IgA in sow's milk for protection against infectious agents (*Hess & Bachmann* 1981). Further, the circulating immunoglobulins absorbed from colostrum during the first 2 days after birth have declined to low levels at 3–4 weeks, and, since the capability of the piglet to actively synthesize antibodies to infectious agents is not fully developed until 6–8 weeks of age, there exists, at 3–5 weeks, an "immunological gap" that leaves the piglet vulnerable to infectious diseases. To these factors should be added the other changes occurring at weaning: moving to new pens, new feeding regimes, mixing with piglets from other litters, all of which cause considerable physical and physiological stresses that will tend to diminish the resistance of the piglet to pathogens in the environment. In a recent study (*Bækbo & Nielsen,* to be published), 96 % of

the total incidence of 5.2 % post-weaning diarrhoea occurred within 2 weeks after transfer to the piglet unit and with *E. coli type O 149* as the most frequently isolated organism, a finding that is consistent with earlier reports (*Svendsen et al.* 1974).

Post-weaning diarrhoea had a marked influence upon post-weaning mortality. Thus, litters with diarrhoea after weaning suffered a 4.5 times higher mortality than did non-diarrhoeic litters. Further, piglets with post-weaning diarrhoea had a 4-fold incidence of subsequent respiratory disease compared with non-diarrhoeic litters. Similar findings have been reported from studies with fatteners (*Aalund et al* 1976, *Willeberg et al.* 1978). Thus, the economic impact upon production results is very considerable.

Svendsen (1979) reported a low incidence of post-weaning diarrhoea in herds with a high incidence of pre-weaning (neonatal) diarrhoea due to *E. coli* enterotoxaemia. He suggested that development of immunity after previous exposure to *E coli* was the main reason for this reverse relationship. The present report has shown that litters with pre-weaning diarrhoea would also have a higher risk of contracting diarrhoea after weaning, contrary to the findings of *Svendsen* (1979). The discrepancy is probably due to differences in study design. Thus, the present study covered the whole pre-weaning period and not only the neonatal period – i. e. the first few days of life – and, likewise, bacteriological examinations were not regularly employed. Therefore, some of the recorded outbreaks may have been caused by pathogens other than *E. coli*. This will be discussed in more detail in a subsequent paper (*Svensmark et al.* 1989b).

The finding that large herds had a distinctly lower incidence of post-weaning diarrhoea than small herds is interesting and probably due to a number of factors, e. g. better management and production control, more efficient protection against infection through purchased stock and a higher level of hygiene compared to small traditional herds. Many of the herds studied here were SPF herds and nearly all practiced closed management with very little contact with other herds.

This and the previous paper (*Svensmark et al.* 1989a) justify the conclusion that modern, intensive sow herds can be managed with a high health status as regards diarrhoeal disorders. The reported data reveal that reference levels in such herds can be kept at approx. 6–7 % for pre- and post-weaning diarrhoea. Incidence rates below this level may, accordingly, be accepted, whereas higher levels should bring about intensified herd examinations as to cause and prevention.

Acknowledgement

This study was aided by grants from "Forsøgsleder R. Nørtoft Thomsens legat" and "Hans Kiers Fond".

References

Bäckström L· Environment and animal health in piglet production. A field study of incidences and correlations (thesis). Acta vet. scand. 1973, suppl. 41.

Bækbo P, Nielsen K· Health status in a communal unit for early weaned piglets. In press.

Hess RG, Bachmann PA· Distribution of antibodies to rotavirus in serum and lacteal secretions of naturally infected swine and their suckling pigs. Amer. J. vet. Res. 1981, *42, 1149–1152.*

Manners MJ, Stevens JA Changes from birth to maturity in the pattern of distribution of lactase and sucrase activity in the mucosa of the small intestine of pigs. Brit. J. Nutr. 1972, *28,* 113–127.

Nielsen NC, Bille N, Svendsen J, Rising H-J Sygdomsbekæmpelse i svinebesætninger. (Disease control in swine herds). Dept. of Internal Medicine, Royal Veterinary & Agricultural Univ., Copenhagen 1976.

Stevens JA, Kidder DE The distribution of trehalase, sucrase, a-amylase, glucoamylase and lactase (B-galactosidase) along the small intestine of five pigs. Brit. J. Nutr. 1972, *28,* 129–137.

Svendsen J· Enteric *Escherichia coli* infections in suckling pigs and in pigs at weaning. Aspects of pathogenesis, prevention and control. Thesis, Sveriges Lantbruksuniversitet 1979.

Svendsen J, Larsen JL, Bille N. Outbreaks of post weaning *Escherichia coli* diarrhoea in pigs. Nord. Vet.-Med. 1974, *27,* 85–101.

Svensmark B: Diarre hos grise. Epidemiologiske undersøgelser i intensive sobesætninger med særligt henblik på rotavirus-associeret diarre. (Diarrhoea in piglets. Epidemiological studies in intensive sow herds with special reference to rota-viral diarrhoea). Ph. D.-thesis, Copenhagen 1984.

Svensmark B, Jorsal SE, Nielsen K, Willeberg P Epidemiological studies of piglet diarrhoea in intensively managed Danish sow herds. I. Preweaning diarrhoea. Acta vet. scand. 1989a, *30,* 43–53.

Svensmark B, Nielsen K, Dalsgaard K, Willeberg P. Epidemiological studies of piglet diarrhoea in intensively managed Danish sow herds. III. Rotavirus infection. Acta vet. scand. 1989b, *30,* 63–70.

Willeberg P, Gerbola M, Madsen A, Mandrup M, Nielsen EK, Riemann HP, Aalund O. A retrospective study of respiratory disease in a cohort of bacon pigs. I. Clinico-epidemiological analysis. Nord. Vet.-Med. 1978, *30,* 513–525.

Aalund O, Willeberg P, Mandrup M, Riemann H: Lung lesions at slaughter: Associations to factors in the pig herd. Ibid., 1976, *28,* 487–495.

Sammendrag

Epidemiologiske undersøgelser af diarre hos grise i intensivt drevne sobesætninger.

II Fravænningsdiarre

Undersøgelsen blev gennemført i 1976-82 blandt 48.931 kuld i 89 besætninger. I undersøgelsens forløb faldt fravænningsalderen fra ca. 42 dage i 1976 til ca. 30 dage i 1982, med et gennemsnit på ca. 34 dage. Incidencen af fravænningsdiarre var 6,0 %, med meget ringe variation fra år til år, men med betydelig variation imellem besætningerne og inden for den enkelte besætning, hvor der undertiden optrådte perioder med øget incidens, sandsynligvis knyttet til optræden af specifikke infektioner (*E. coli* o.a.). Kuld med diarre i diegivningsperioden havde øget risiko for fravænningsdiarre. Derimod var der ikke sammenhæng mellem soens paritet (kuldnummer) og incidensen af fravænningsdiarre, modsat diarre i diegivningsperioden, der er hyppigst i gyltekuld. Fravænningsalder og -vægt havde markant betydning for incidensen. Således havde kuld fravænnet før 2 ugers alder dobbelt så høj risiko for fravænningsdiarre og 2,4 gange højere mortalitet end kuld fravænnet i 6–7 ugers alderen. I kuld hvor fravænningsvægten var under 3 kg/gris var incidensen af fravænningsdiarre 3 gange højere og mortaliteten 5 gange højere end i kuld med en fravænningsvægt på 7–8 kg. Store sobesætninger havde lavere incidens end små besætninger. Grise fra kuld med fravænningsdiarre havde nedsat tilvækst og var 2,3 dage ældre ved 25 kg legemsvægt end grise fra kuld uden fravænningsdiarre. Endvidere var der højere forekomst af hud- og luftvejslidelser i kuld med fraväningsdiarre. Risikoen for opståen af luftvejslidelse var således 4 gange større end i kuld uden fravænningsdiarre.

(Received April 20, 1988, accepted June 22, 1988)

Reprints may be requested from: Knud Nielsen, Department of Internal Medicine, Royal Veterinary and Agricultural University, 13 Bülowsvej, DK-1870 Frederiksberg C., Denmark.