THE EFFECTS OF DIET AND FEEDING ON SMALL INTESTINAL DEVELOPMENT IN PIGLETS DURING THE FIRST 24 HOURS AFTER BIRTH

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VOLUME II

FIGURES AND APPENDICES

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LIST OF ABBREVIATIONS

Abbreviation		
B	=	at birth
BrdU	=	5-bromo-2'-deoxyuridine
BSA	=	bovine serum albumin
bw	=	body weight
^oC	=	degree Celcius
CC	=	cow colostrum
CCK	=	cholecystokinin
CD	=	crypt depth
CI	=	confidence interval
CM	=	cow milk
CMR	=	cell migration rate
cm	=	centimetre
$CoCl_2$	=	cobalt chloride
conc.	=	concentration
cont.	=	content
contd.	=	continued
$CuSO_4.5H_2O$	=	copper sulfate pentahydrate
CW	=	cell width
CWP	=	percentage increase in villous width
DAB	=	diaminobenzine
DNA	=	deoxy ribonucleic acid
DUO	=	duodenum
EGF	=	epidermal growth factor
Fig(s).	=	figure(s)
g	=	gramme
g	=	gravity
GIP	=	gastric inhibitory polypeptide
hr(s)	=	hour(s)
H_2O	=	water
H_2O_2	=	hydrogen peroxide
I.D.	=	inner diameter
IF	=	infant formula
Ig	=	immunoglobulin
IGF	=	insulin-like growth factor

ILE	=	ileum
JEJ	=	jejunum
kg	=	kilogramme
KH_2PO_4	=	potassium phosphate
kJ	=	kilojoule
KOH	=	potassium hydroxide
L	=	litre
LOI	=	lower ileum
LOJ	=	lower jejunum
mg	=	milligramme
min(s)	=	minute(s)
ml	=	millilitre
mm	=	millimetre
mmol	=	millimole
mol	=	mole
mOsm	=	milliosmole
MUC	=	mucosa
MUS	=	muscle
N	=	normality
NaCl	=	sodium chloride
Na_2CO_3	=	sodium carbonate
Na_2HPO_4	=	disodium phosphate
NaOH	=	sodium hydroxide
NiCl	=	nickel chloride
nm	=	nanometre
NS	=	naturally suckled
N.S.	=	no statistically significant difference
OD	=	optical density
O.D.	=	outer diameter
OGF	=	orogastric feeding
PBS	=	phosphate buffer saline
PP	=	pancreatic polypeptide
%	=	percent
RMD	=	relative migration distance
RNA	=	ribonucleic acid
RT	=	replacement time

S	=	sucking
SC	=	sow colostrum
S.D.	=	standard deviation
S.E.	=	standard error
SI	=	small intestine
SM	=	sow milk
sq.um	=	square micrometre
TGO	=	Tris-glucose-oxidase
TPN	=	total parenteral nutrition
µg	=	microgramme
UPI	=	upper ileum
UPJ	=	upper jejunum
µm	=	micrometer
µmol	=	micromole
VH	=	villous height
VHP	=	percentage increase in villous height
vs	=	versus
W/W	=	weight by weight

CHAPTER 2

LITERATURE REVIEW

FIGURES

Figure 2.1 **Schematic diagram of the morphogenesis of the villi and crypts and the distribution of mitotic activity in the small intestine of fetal rats. A: Mitoses are randomly distributed before the formation of previllous ridges (15 days of gestation). B: Development of previllous ridges (before 18 days of gestation). C: Mitoses are more prominent in intervillous areas (before 18 days of gestation). D: Over 50% of mitoses are restricted to the lower halves of the forming crypts (at 18 days of gestation). E: Mitotic activity is confined to the forming crypts (at 1-2 days before birth) (adapted from Klein & McKenzie, 1983a).**

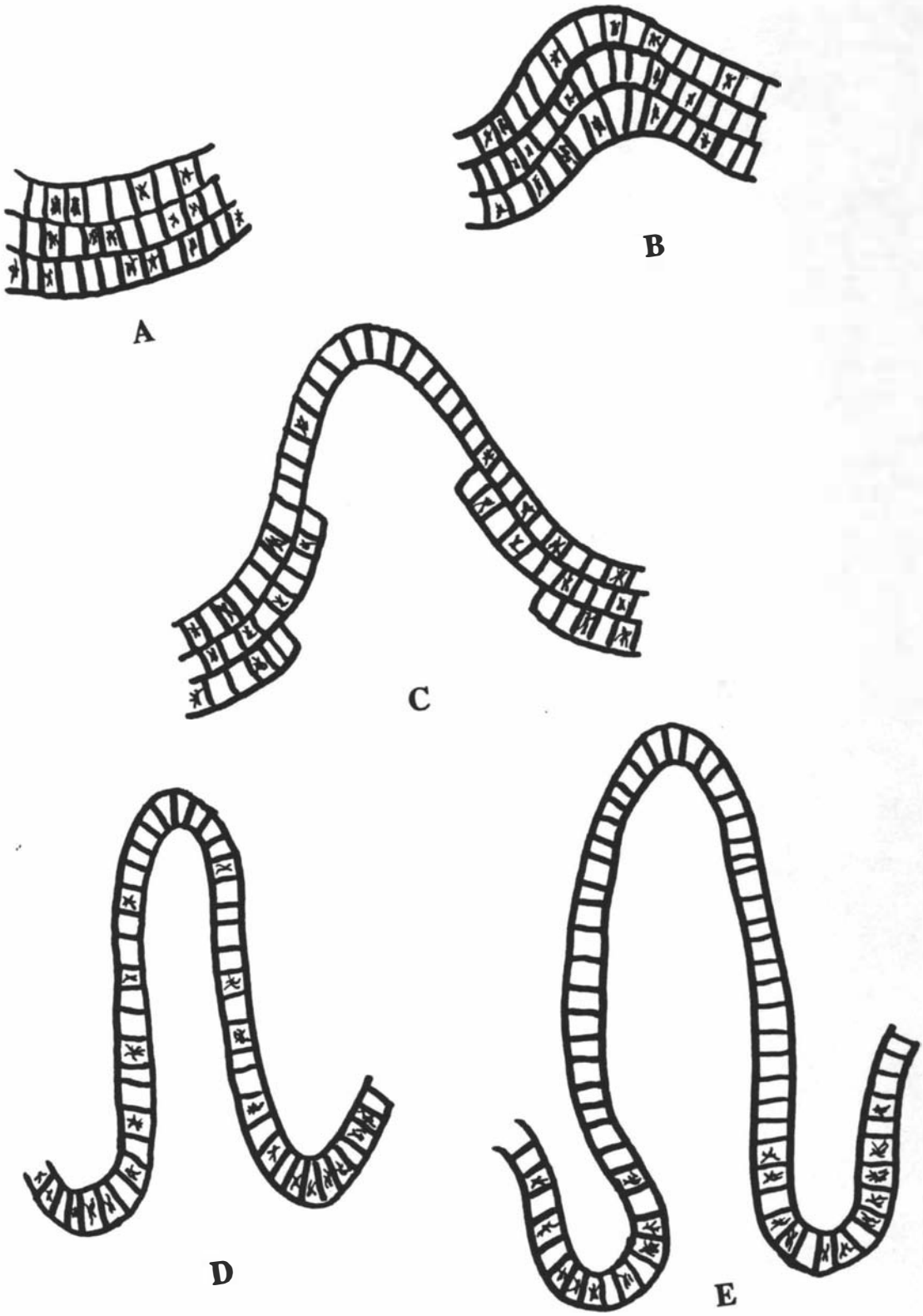
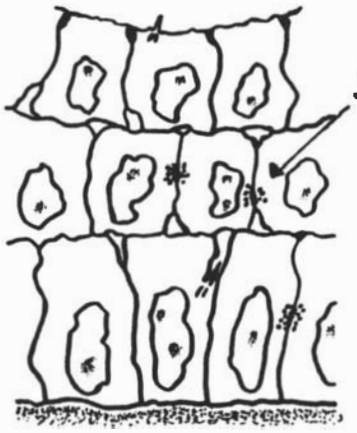
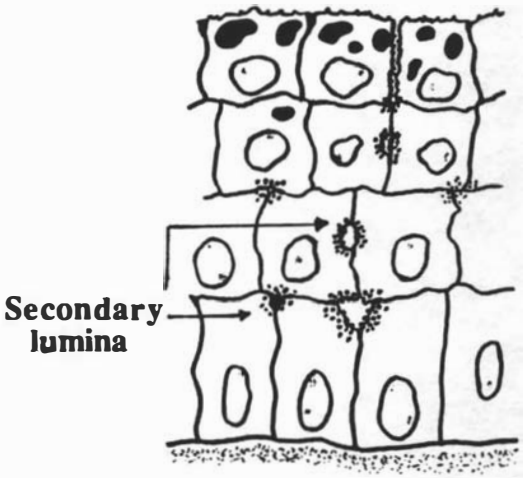

A
B
C
D
E

Figure 2.2 **Schematic diagram of the sequential changes which appear in the mucosa of the small intestine of fetal rats during the morphogenesis of the villi. Junctional complexes are apparent by 15 - 16 days gestation and develop into secondary lumina which fuse with the main lumen of the intestine (adapted from Mathan et al., 1976).**

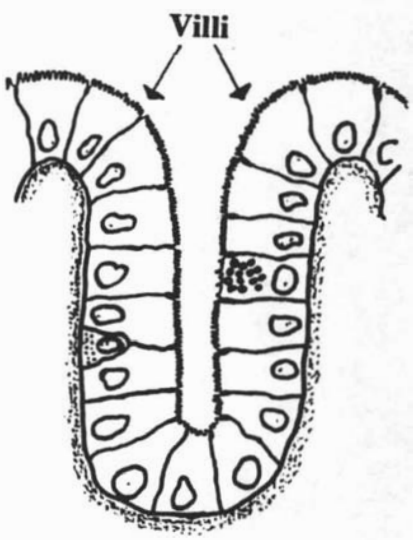


15-16 DAY



17 DAY

18 DAY



19 DAY

CHAPTER 3

EFFECTS OF COLOSTRUM AND MILK ON POSTNATAL DEVELOPMENT OF THE SMALL INTESTINE IN PIGLETS DURING THE FIRST 24 HOURS AFTER BIRTH

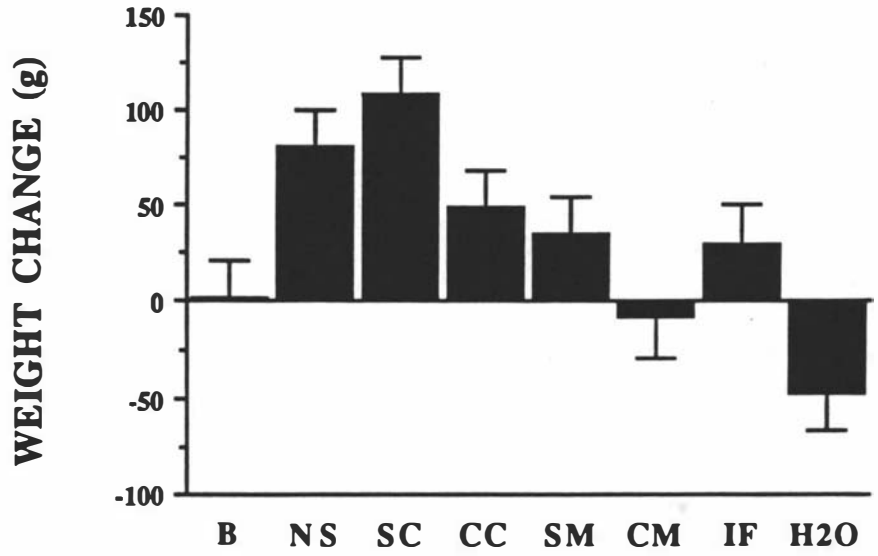
FIGURES

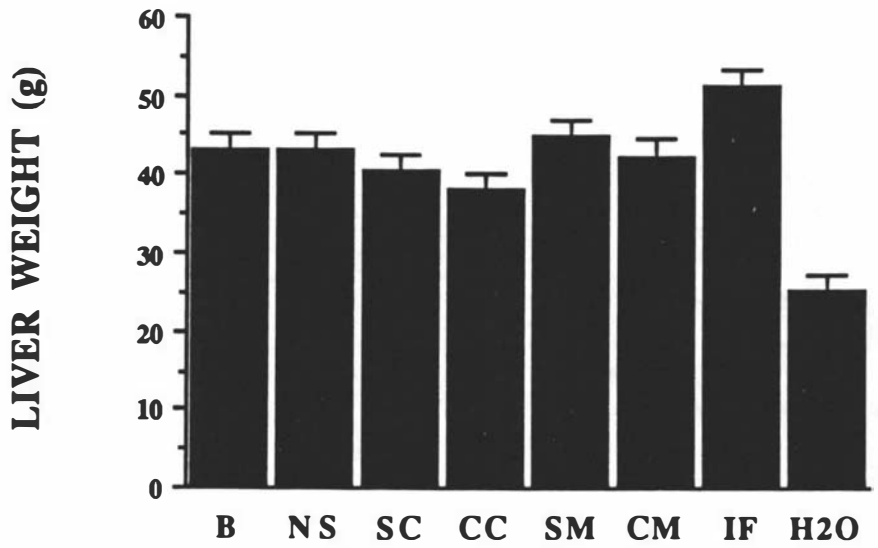
Figure 3.1 **Body weight change and liver and pancreatic weights of piglets collected at birth (B), naturally suckled (NS) or fed with either sow colostrum (SC), cow colostrum (CC), sow milk (SM), cow milk (CM), infant formula (IF) or water (H_2O) for 24 hrs (mean ± S.E.).**

BODY WEIGHT CHANGE :
SC+CC vs SM+CM **
SC vs SM *
SC+SM vs CC+CM *
SC vs CC *
SC+CC+SM+CM+IF vs H_2O ***

LIVER:
SM+CM vs IF **
SC+CC+SM+CM+IF vs H_2O ***
B vs H_2O ***

PANCREAS:
SC+CC vs SM+CM *
SC+CC+SM+CM+IF vs H_2O *
B vs NS+SC+CC+SM+CM+IF+H_2O **


WEIGHT CHANGE (g)
150
100
50
0
-50
-100
B
NS
SC
CC
SM
CM
IF
H2O


LIVER WEIGHT (g)
60
50
40
30
20
10
0
B
NS
SC
CC
SM
CM
IF
H2O

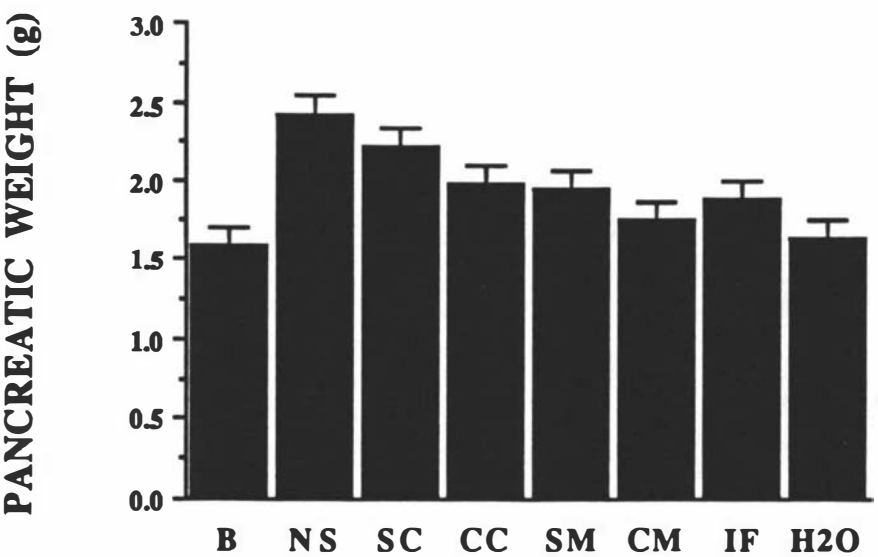

PANCREATIC WEIGHT (g)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
B
NS
SC
CC
SM
CM
IF
H2O

Figure 3.2 **Length of the total small intestine (TOTAL), duodenum (DUO), jejunum (JEJ) and ileum (ILE) of piglets collected at birth (B), naturally suckled (NS) or fed with either sow colostrum (SC), cow colostrum (CC), sow milk (SM), cow milk (CM), infant formula (IF) or water (H_2O) for 24 hrs (mean ± S.E.).**

TOTAL:
***SC vs SM* ***
***SM+CM vs IF* ***
SC+CC+SM+CM+IF vs H_2O* *
***B vs NS+SC+CC+SM+CM+IF+H_2O* ***

DUO:
***SC+CC+SM+CM+IF vs H_2O* ***
B vs NS+SC+CC+SM+CM+IF+H_2O* *

JEJ:
***SC vs SM* ***
***SM+CM vs IF* ***
SC+CC+SM+CM+IF vs H_2O* *
***B vs NS+SC+CC+SM+CM+IF+H_2O* ***

ILE:
***SC vs SM* ***
***SM+CM vs IF* ***
SC+CC+SM+CM+IF vs H_2O* *
***B vs NS+SC+CC+SM+CM+IF+H_2O* ***

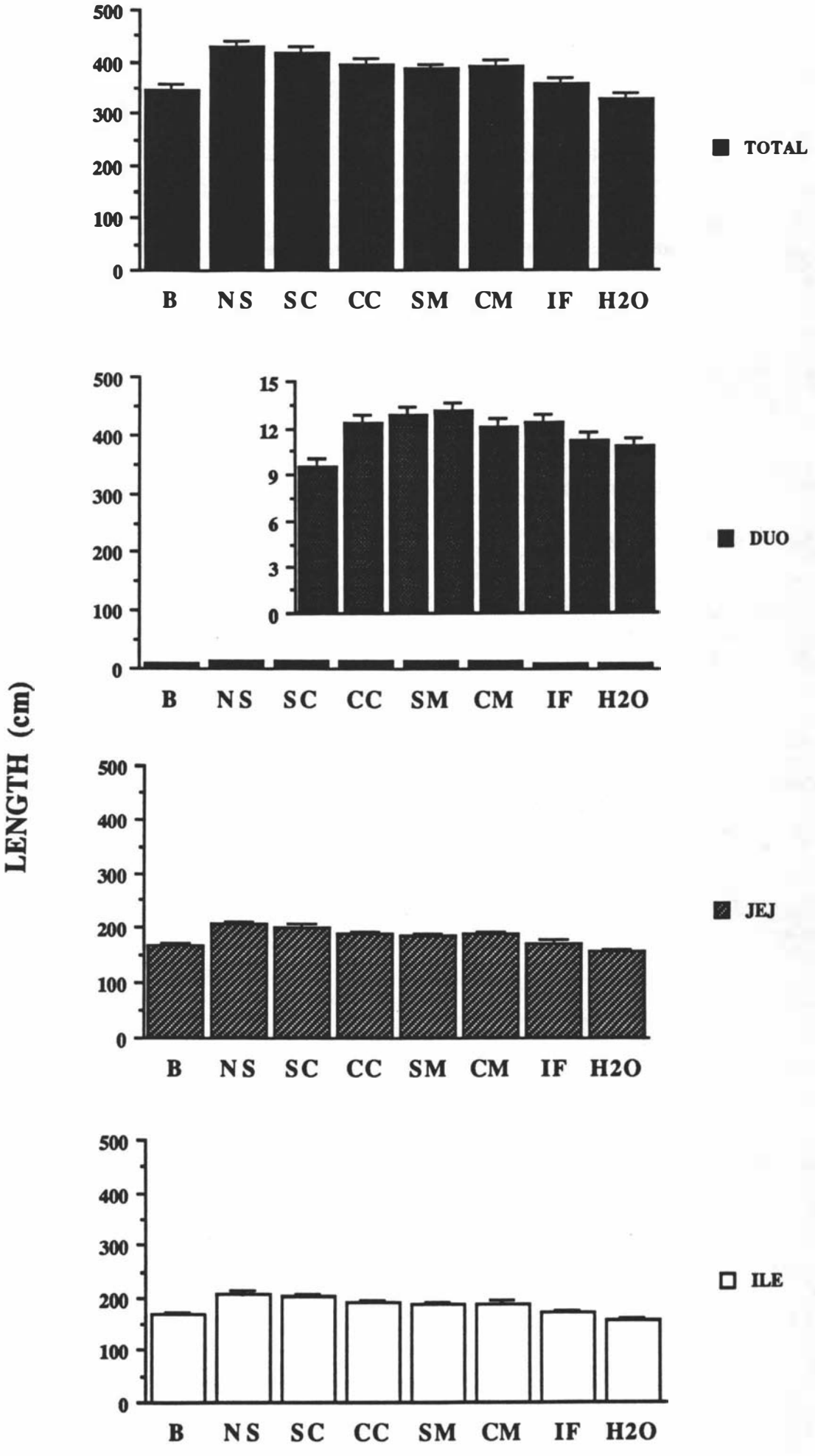

LENGTH (cm)
500
400
300
200
100
0
B NS SC CC SM CM IF H2O
TOTAL
15
12
9
6
3
0
DUO
JEJ
ILE

Figure 3.3 **Total weight of the intact small intestine (INTACT) and the intestinal mucosa (MUC) and muscle (MUS) of piglets collected at birth (B), naturally suckled (NS) or fed with either sow colostrum (SC), cow colostrum (CC), sow milk (SM), cow milk (CM), infant formula (IF) or water (H_2O) for 24 hrs (mean ± S.E.).**

INTACT:
SC+CC vs SM+CM ***
SC vs SM ***
CC vs CM **
SC+SM vs CC+CM ***
SC vs CC ***
SC+CC+SM+CM+IF vs H_2O ***
NS vs SC ***
B vs NS+SC+CC+SM+CM+IF+H_2O ***

MUC:
SC+CC vs SM+CM ***
SC vs SM ***
CC vs CM ***
SC+SM vs CC+CM ***
SC vs CC ***
SC+CC+SM+CM+IF vs H_2O ***
NS vs SC ***
B vs NS+SC+CC+SM+CM+IF+H_2O ***

MUS:
SC+CC vs SM+CM **
SC vs SM **
SC+SM vs CC+CM **
SC vs CC **
SC+CC+SM+CM+IF vs H_2O **

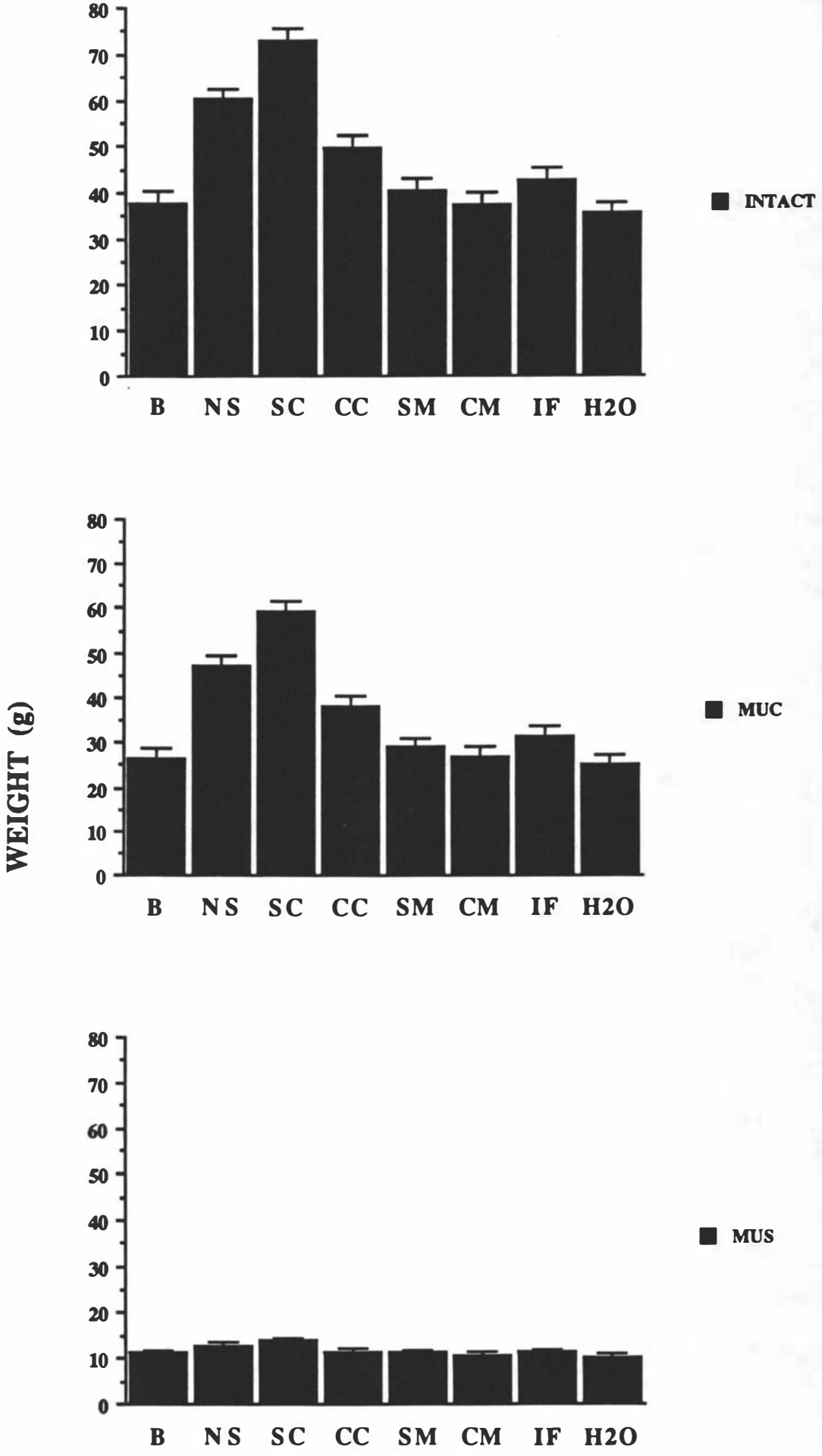

WEIGHT (g)
80
70
60
50
40
30
20
10
0
B
NS
SC
CC
SM
CM
IF
H2O
INTACT
MUC
MUS

Figure 3.4 **Intact weight of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B), naturally suckled (NS) or fed with either sow colostrum (SC), cow colostrum (CC), sow milk (SM), cow milk (CM), infant formula (IF) or water (H_2O) for 24 hrs (mean ± S.E.).**

DUO:
SC+CC vs SM+CM ***
SC vs SM **
CC vs CM *
SC+CC+SM+CM+IF vs H_2O **
B vs NS+SC+CC+SM+CM+IF+H_2O **

UPJ:
SC+CC vs SM+CM ***
SC vs SM ***
CC vs CM **
SC+SM vs CC+CM ***
SC vs CC ***
SC+CC+SM+CM+IF vs H_2O ***
B vs NS+SC+CC+SM+CM+IF+H_2O **

LOJ:
SC+CC vs SM+CM ***
SC vs SM ***
CC vs CM **
SC+SM vs CC+CM ***
SC vs CC ***
SC+CC+SM+CM+IF vs H_2O ***
NS vs SC **
B vs NS+SC+CC+SM+CM+IF+H_2O ***

UPI:
SC+CC vs SM+CM ***
SC vs SM ***
CC vs CM **
SC+SM vs CC+CM ***
SC vs CC ***
SC+CC+SM+CM+IF vs H_2O ***
NS vs SC ***
B vs NS+SC+CC+SM+CM+IF+H_2O **

LOI:
SC+CC vs SM+CM ***
SC vs SM ***
SC+SM vs CC+CM ***
SC vs CC ***
SC+CC+SM+CM+IF vs H_2O ***
NS vs SC ***
B vs NS+SC+CC+SM+CM+IF+H_2O *

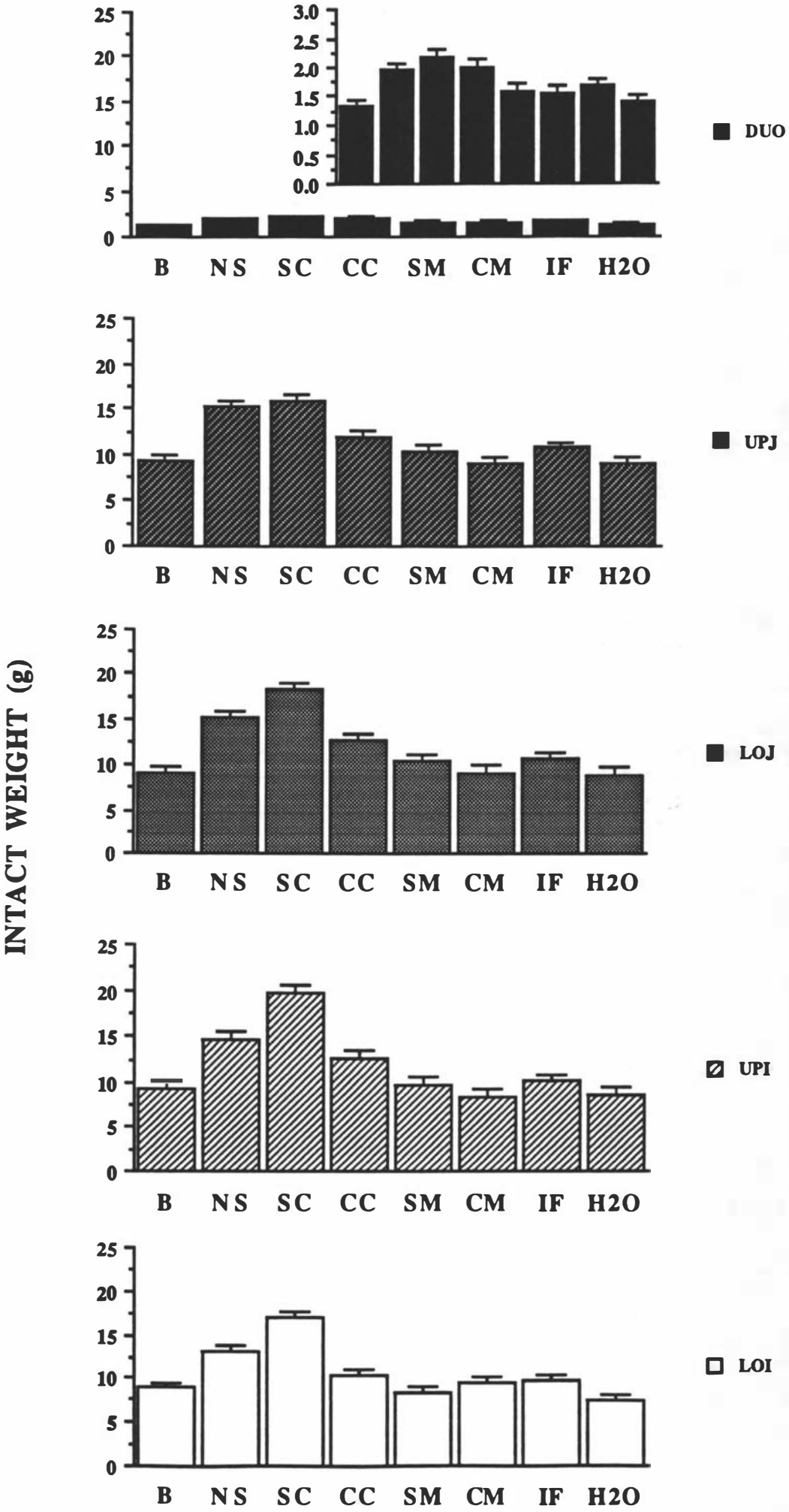

INTACT WEIGHT (g)
25
20
15
10
5
0
3.0
2.5
2.0
1.5
1.0
0.5
0.0
B NS SC CC SM CM IF H2O
DUO
UPJ
LOJ
UPI
LOI

Figure 3.5 **Mucosal weight of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B), naturally suckled (NS) or fed with either sow colostrum (SC), cow colostrum (CC), sow milk (SM), cow milk (CM), infant formula (IF) or water (H_2O) for 24 hrs (mean ± S.E.).**

DUO:
SC+CC vs SM+CM ***
SC vs SM **
SC+CC+SM+CM+IF vs H_2O ***
B vs NS+SC+CC+SM+CM+IF+H_2O ***

UPJ:
SC+CC vs SM+CM ***
SC vs SM ***
CC vs CM **
SC+SM vs CC+CM ***
SC vs CC ***
SC+CC+SM+CM+IF vs H_2O ***
B vs NS+SC+CC+SM+CM+IF+H_2O ***

LOJ:
SC+CC vs SM+CM ***
SC vs SM ***
CC vs CM **
SC+SM vs CC+CM ***
SC vs CC ***
SC+CC+SM+CM+IF vs H_2O ***
NS vs SC **
B vs NS+SC+CC+SM+CM+IF+H_2O ***

UPI:
SC+CC vs SM+CM ***
SC vs SM ***
CC vs CM ***
SC+SM vs CC+CM ***
SC vs CC ***
SC+CC+SM+CM+IF vs H_2O ***
NS vs SC ***
B vs NS+SC+CC+SM+CM+IF+H_2O **

LOI:
SC+CC vs SM+CM ***
SC vs SM ***
SC+SM vs CC+CM ***
SC vs CC ***
SC+CC+SM+CM+IF vs H_2O ***
NS vs SC ***
B vs NS+SC+CC+SM+CM+IF+H_2O *

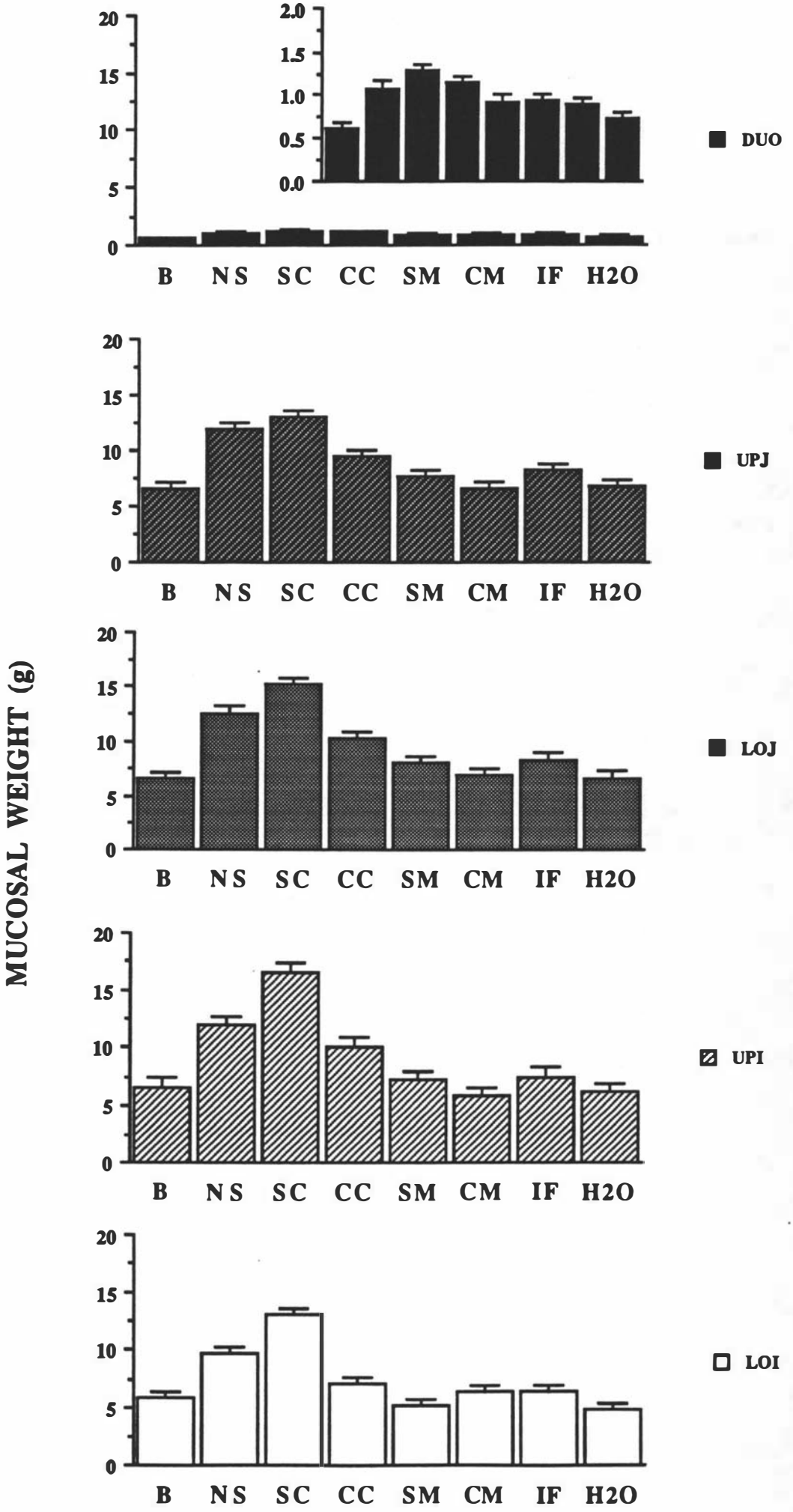

MUCOSAL WEIGHT (g)
DUO
UPJ
LOJ
UPI
LOI
B
NS
SC
CC
SM
CM
IF
H2O
0
5
10
15
20
0.0
0.5
1.0
1.5
2.0

Figure 3.6 **Muscular weight of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B), naturally suckled (NS) or fed with either sow colostrum (SC), cow colostrum (CC), sow milk (SM), cow milk (CM), infant formula (IF) or water (H_2O) for 24 hrs (mean ± S.E.).**

DUO:
SC+CC vs SM+CM **
CC vs CM *

UPJ:
N.S.

LOJ:
SC+CC vs SM+CM **
SC vs SM **
SC+SM vs CC+CM *
SC vs CC **

UPI:
SC vs SM **
SC+SM vs CC+CM *
SC vs CC **
NS vs SC *

LOI:
SC+CC vs SM+CM **
SC vs SM **
SC+SM vs CC+CM *
SC vs CC **
SC+CC+SM+CM+IF vs H_2O ***

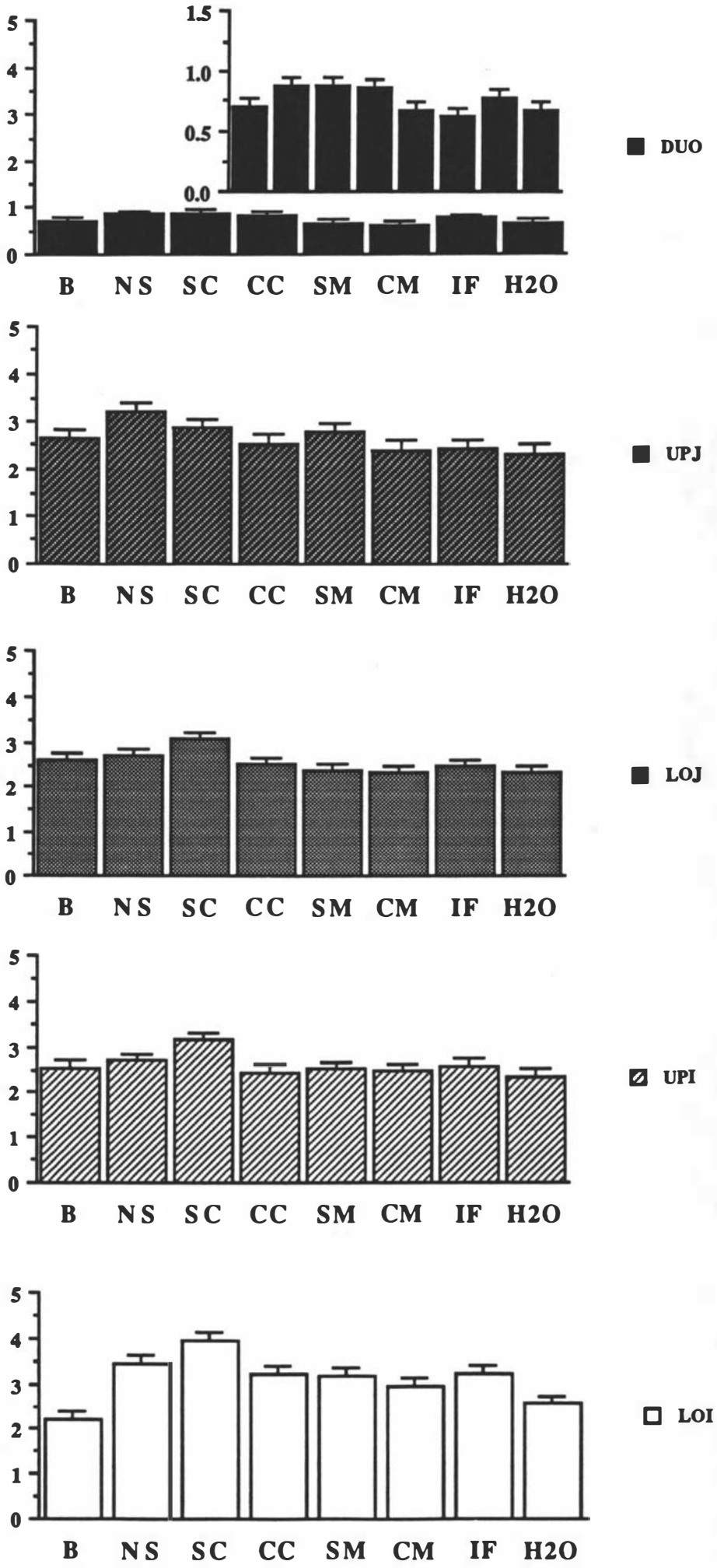

MUSCULAR WEIGHT (g)
DUO
UPJ
LOJ
UPI
LOI
B
NS
SC
CC
SM
CM
IF
H2O
0
1
2
3
4
5
0.0
0.5
1.0
1.5

Figure 3.7 **Circumference of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B), naturally suckled (NS) or fed with either sow colostrum (SC), cow colostrum (CC), sow milk (SM), cow milk (CM), infant formula (IF) or water (H_2O) for 24 hrs (mean ± S.E.).**

DUO:
SM+CM vs IF **

UPJ:
SC+CC+SM+CM+IF vs H_2O *
B vs NS+SC+CC+SM+CM+IF+H_2O ***

LOJ:
SC+CC+SM+CM+IF vs H_2O *
NS vs SC *
B vs NS+SC+CC+SM+CM+IF+H_2O *

UPI:
SC+CC vs SM+CM **
SC vs SM **
SC+CC+SM+CM+IF vs H_2O **
NS vs SC *
B vs NS+SC+CC+SM+CM+IF+H_2O **

LOI:
NS vs SC *

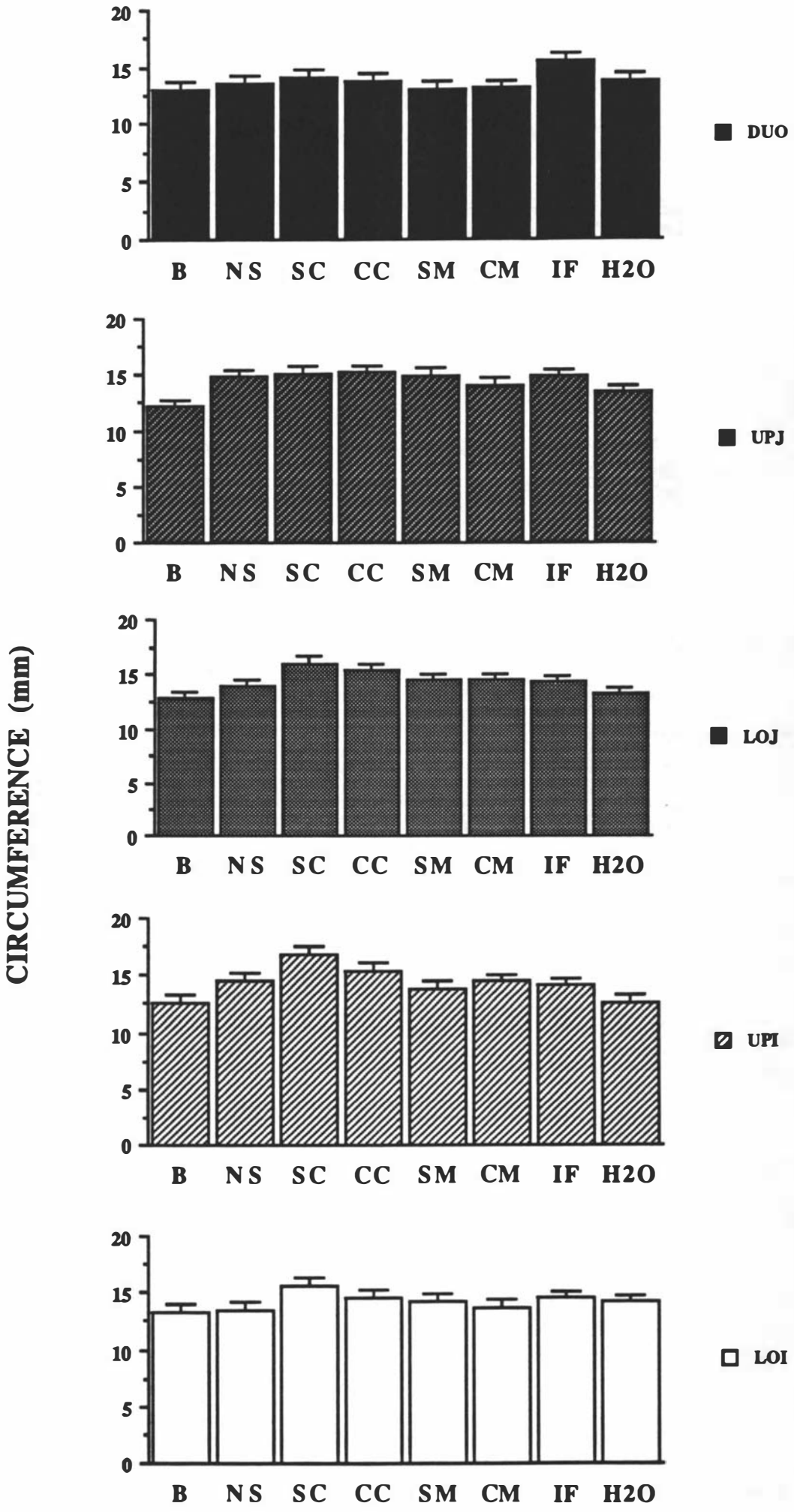

CIRCUMFERENCE (mm)
20
15
10
5
0
B NS SC CC SM CM IF H2O
DUO
UPJ
LOJ
UPI
LOI

Figure 3.8 **Wall thickness of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B), naturally suckled (NS) or fed with either sow colostrum (SC), cow colostrum (CC), sow milk (SM), cow milk (CM), infant formula (IF) or water (H_2O) for 24 hrs (mean ± S.E.).**

DUO:
N.S.

UPJ:
SC+CC vs SM+CM **
SC vs SM **
SM+CM vs IF **
SC+CC+SM+CM+IF vs H_2O **

LOJ:
SC+CC vs SM+CM **
SC vs SM **

UPI:
SC+CC vs SM+CM ***
SC vs SM **
CC vs CM **
SC+SM vs CC+CM **
SC vs CC *
SM vs CM *

LOI:
SC+CC vs SM+CM ***
SC vs SM ***
SC vs CC ***
SC+CC+SM+CM+IF vs H_2O **
B vs NS+SC+CC+SM+CM+IF+H_2O *

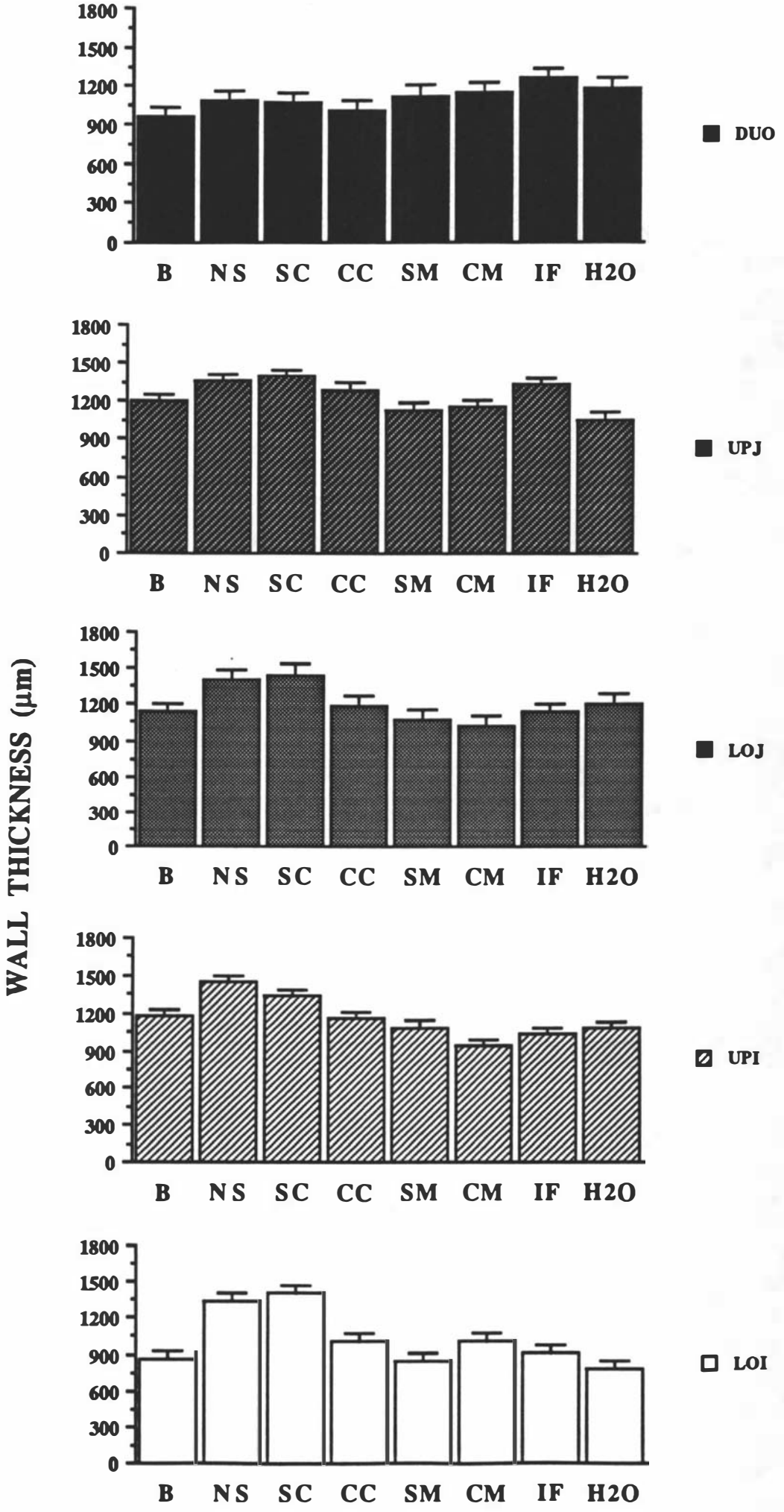

WALL THICKNESS (µm)
1800
1500
1200
900
600
300
0
B
NS
SC
CC
SM
CM
IF
H2O
DUO
UPJ
LOJ
UPI
LOI

Figure 3.9 **Submucosal thickness of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B), naturally suckled (NS) or fed with either sow colostrum (SC), cow colostrum (CC), sow milk (SM), cow milk (CM), infant formula (IF) or water (H_2O) for 24 hrs (mean ± S.E.).**

DUO:
SC+CC+SM+CM+IF vs H_2O *

UPJ:
SM+CM vs IF *
NS vs SC *

LOJ:
SC+CC+SM+CM+IF vs H_2O **

UPI:
B vs NS+SC+CC+SM+CM+IF+H_2O *

LOI:
N.S.

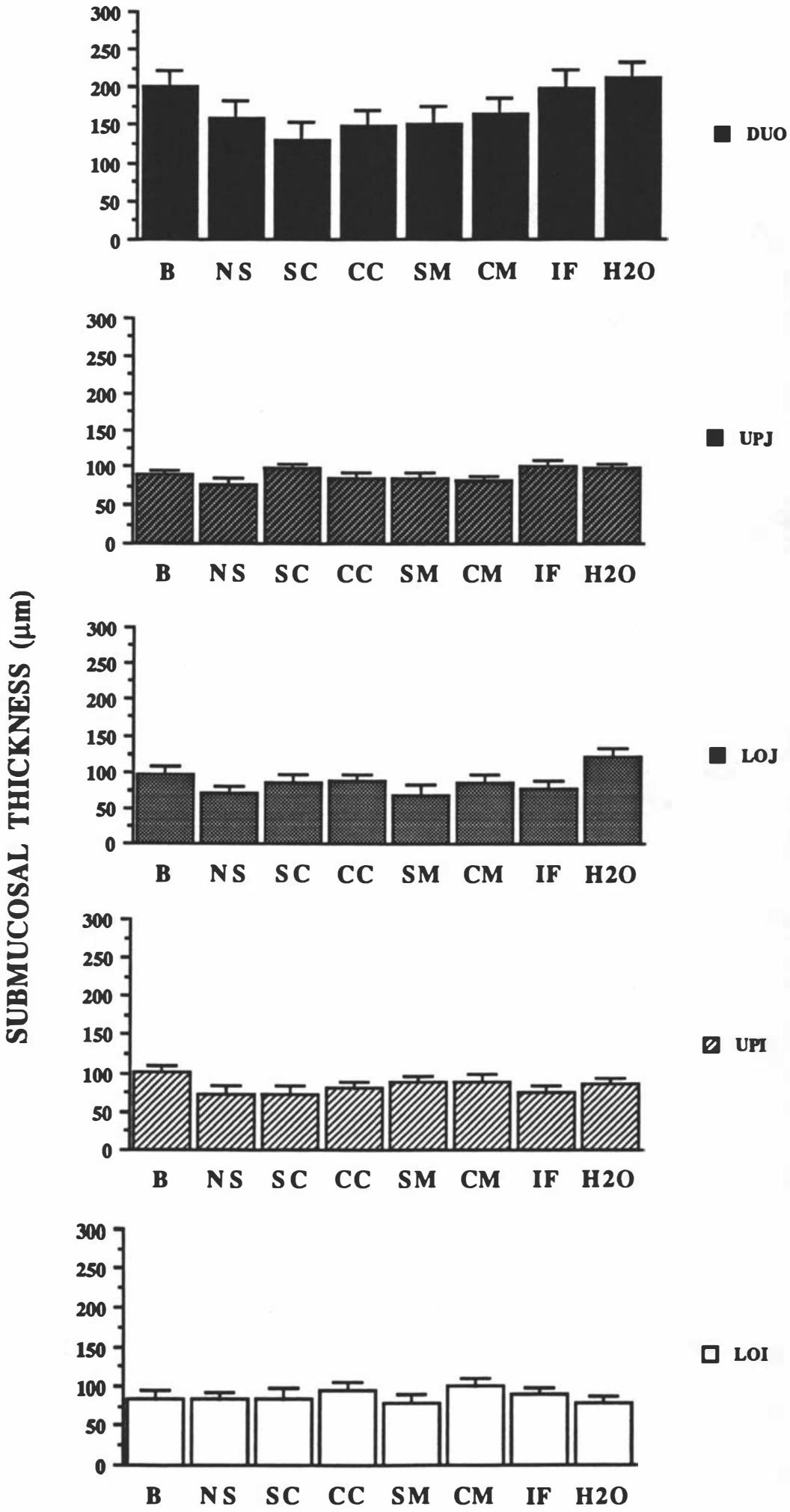

SUBMUCOSAL THICKNESS (µm)
300
250
200
150
100
50
0
B NS SC CC SM CM IF H2O
DUO
UPJ
LOJ
UPI
LOI

Figure 3.10 **Muscular thickness of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B), naturally suckled (NS) or fed with either sow colostrum (SC), cow colostrum (CC), sow milk (SM), cow milk (CM), infant formula (IF) or water (H_2O) for 24 hrs (mean ± S.E.).**

DUO:
SC+CC+SM+CM+IF vs H_2O *
B vs H_2O **

UPJ:
N.S.

LOJ:
B vs H_2O **

UPI:
SC+CC vs SM+CM **
SC vs SM *
CC vs CM *

LOI:
SC+CC vs SM+CM *
SC+SM vs CC+CM *

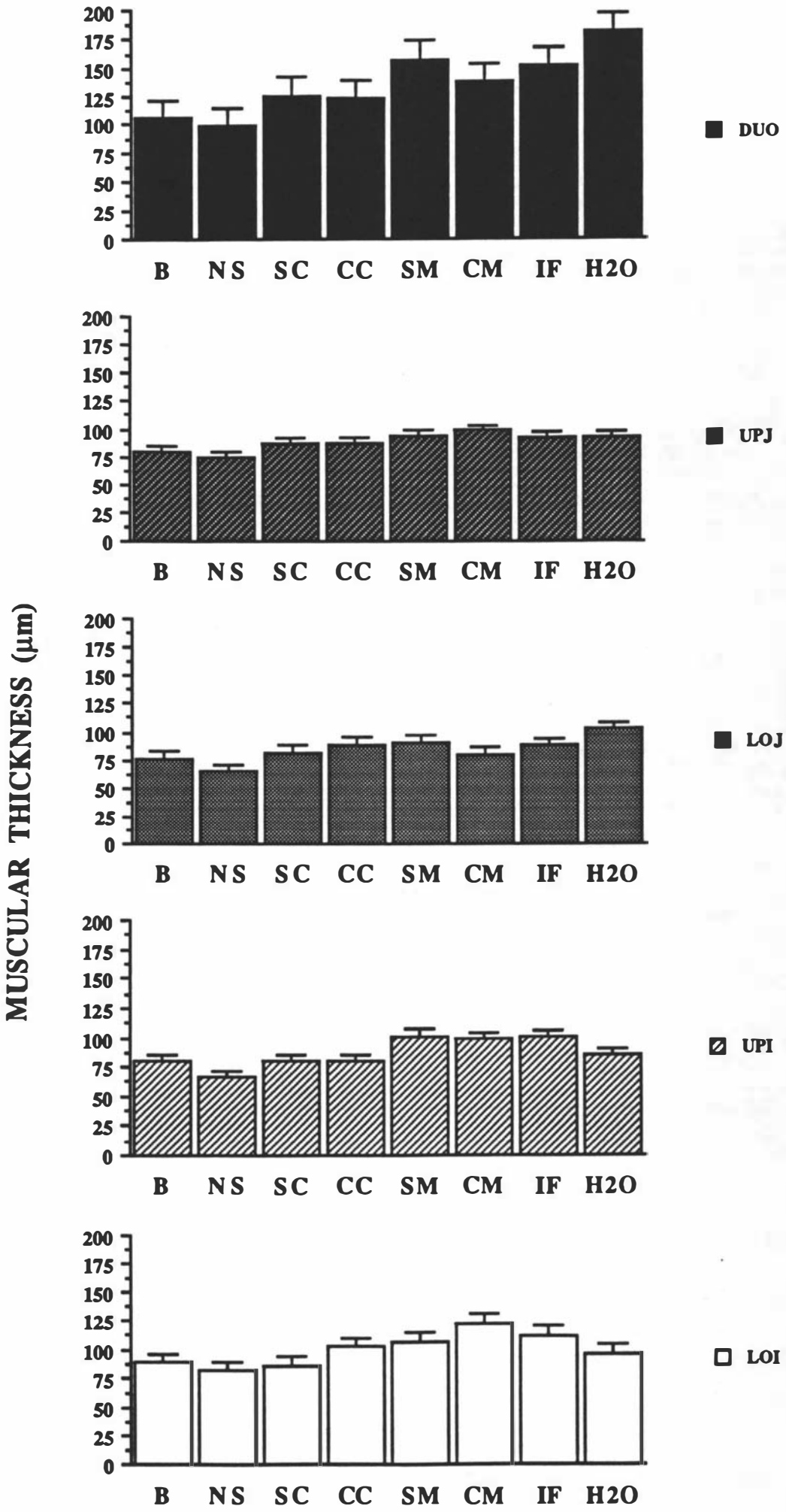

MUSCULAR THICKNESS (µm)
200
175
150
125
100
75
50
25
0
B NS SC CC SM CM IF H2O
DUO
UPJ
LOJ
UPI
LOI

Figure 3.11 **Villous height of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B), naturally suckled (NS) or fed with either sow colostrum (SC), cow colostrum (CC), sow milk (SM), cow milk (CM), infant formula (IF) or water (H_2O) for 24 hrs (mean ± S.E.).**

DUO:
B vs NS+SC+CC+SM+CM+IF+H2O *

UPJ:
SC+CC vs SM+CM ***
SC vs SM ***
SC+SM vs CC+CM *
SC vs CC **
SM+CM vs IF *
SC+CC+SM+CM+IF vs H2O ***
B vs H2O ***

LOJ:
SC+CC vs SM+CM **
SC vs SM **
CC vs CM *
SC+SM vs CC+CM *
SC vs CC *

UPI:
SC+CC vs SM+CM ***
SC vs SM ***
CC vs CM ***
SC+SM vs CC+CM **
SC vs CC **
SM vs CM *
B vs H2O *

LOI:
SC+CC vs SM+CM ***
SC vs SM ***
SC+SM vs CC+CM *
SC vs CC***
SC+CC+SM+CM+IF vs H2O **
B vs NS+SC+CC+SM+CM+IF+H2O *

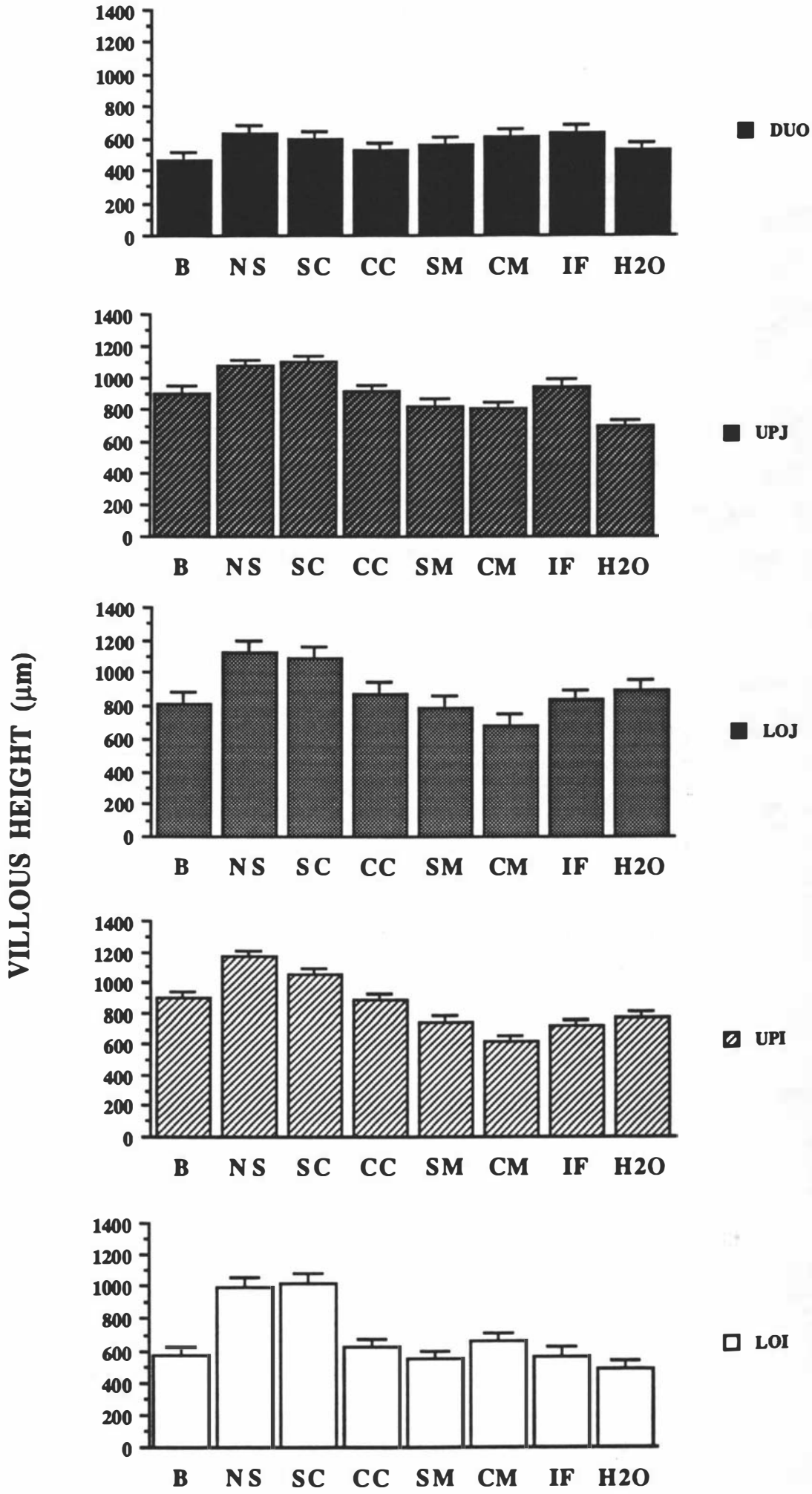

VILLOUS HEIGHT (µm)
1400
1200
1000
800
600
400
200
0
B
NS
SC
CC
SM
CM
IF
H2O
DUO
UPJ
LOJ
UPI
LOI

Figure 3.12 **Villous width of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B), naturally suckled (NS) or fed with either sow colostrum (SC), cow colostrum (CC), sow milk (SM), cow milk (CM), infant formula (IF) or water (H_2O) for 24 hrs (mean ± S.E.).**

DUO:
N.S.

UPJ:
CC vs CM *
SM vs CM *
SC+CC+SM+CM+IF vs H_2O ***
B vs NS+SC+CC+SM+CM+IF+H_2O *

LOJ:
SC+SM vs CC+CM ***
SC vs CC **
SM vs CM *
SC+CC+SM+CM+IF vs H_2O **
B vs NS+SC+CC+SM+CM+IF+H_2O **

UPI:
SC+CC vs SM+CM ***
SC vs SM ***
CC vs CM *
SC+CC+SM+CM+IF vs H_2O ***
B vs NS+SC+CC+SM+CM+IF+H_2O *

LOI:
SC+CC vs SM+CM ***
SC vs SM ***
SC vs CC **

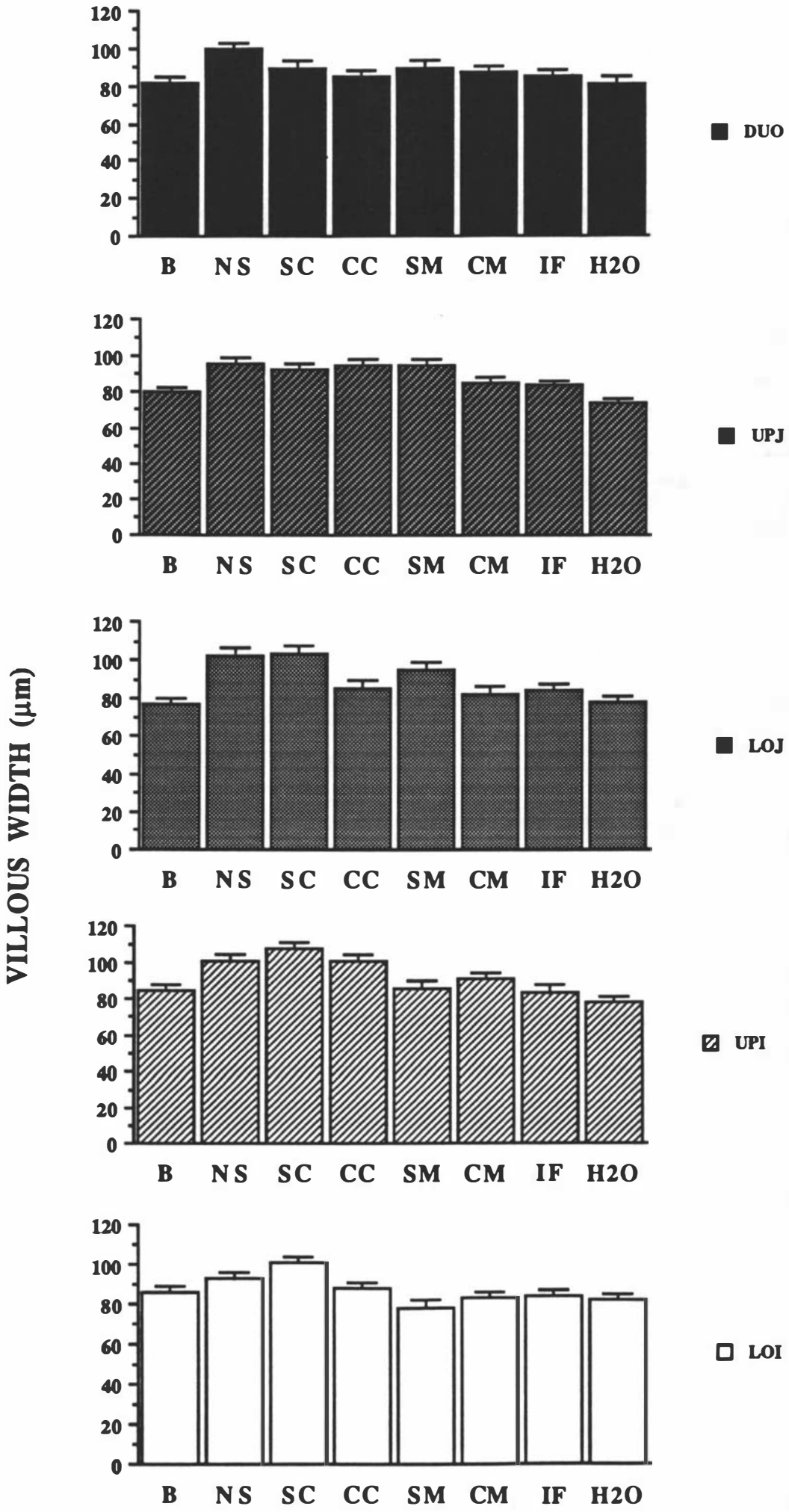

VILLOUS WIDTH (µm)
120
100
80
60
40
20
0
B
NS
SC
CC
SM
CM
IF
H2O
DUO
UPJ
LOJ
UPI
LOI

Figure 3.13 **Crypt depth of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B), naturally suckled (NS) or fed with either sow colostrum (SC), cow colostrum (CC), sow milk (SM), cow milk (CM), infant formula (IF) or water (H_2O) for 24 hrs (mean ± S.E.).**

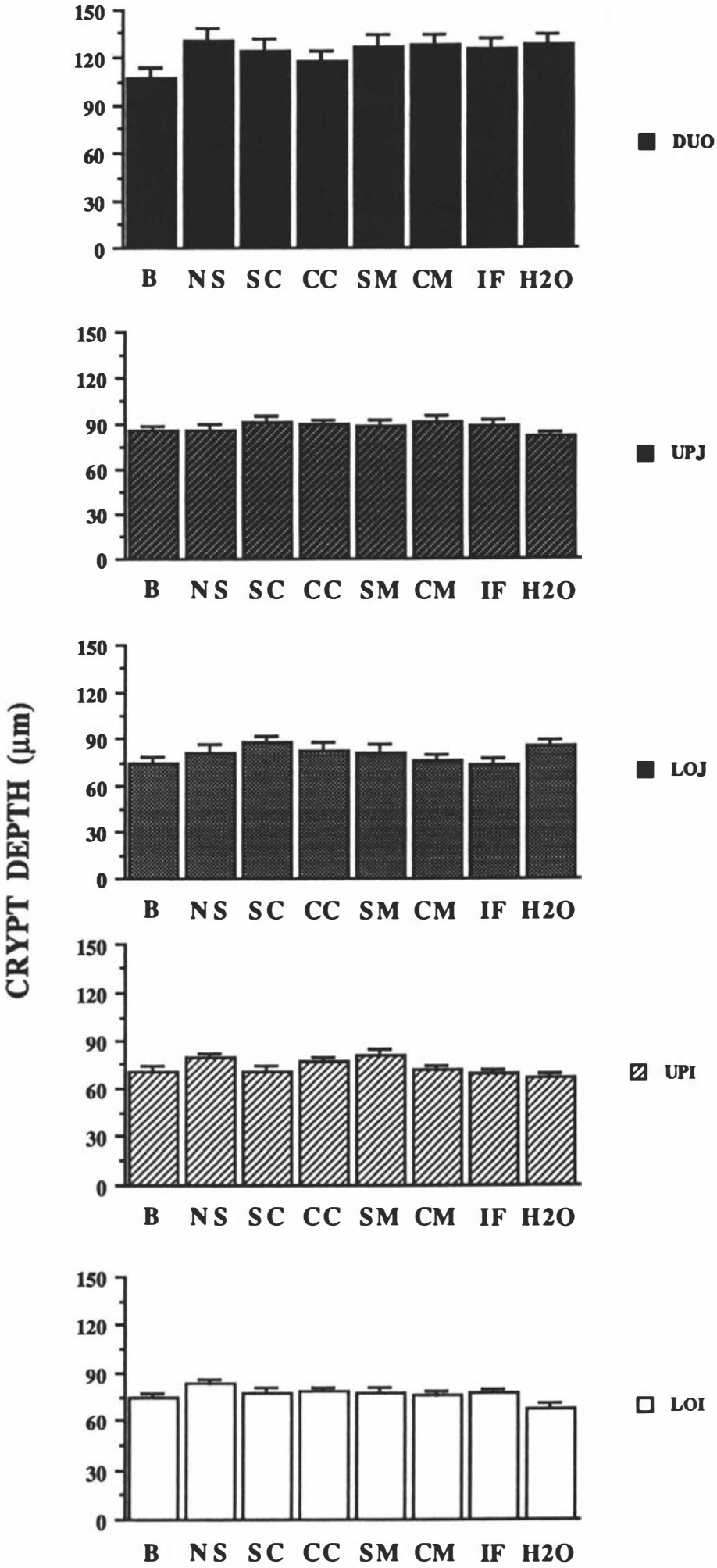
DUO:
B vs H_2O *
B vs NS+SC+CC+SM+CM+IF+H_2O *

UPJ:
SC+CC+SM+CM+IF vs H_2O *

LOJ:
N.S.

UPI:
SC vs SM *
SC+CC+SM+CM+IF vs H_2O *

LOI:
SC+CC+SM+CM+IF vs H_2O *


CRYPT DEPTH (µm)
150
120
90
60
30
0
B NS SC CC SM CM IF H2O
DUO
UPJ
LOJ
UPI
LOI

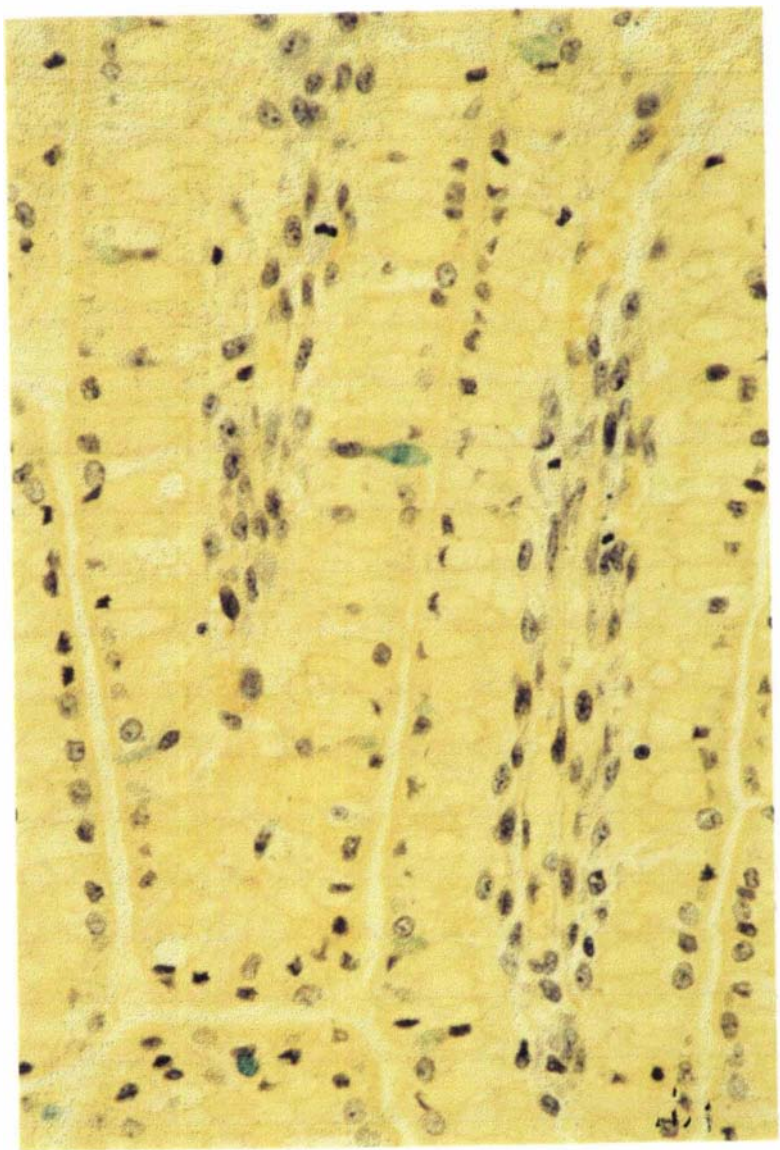


Figure 3.14A **Villi in the upper jejunum of a piglet fed sow colostrum for 24 hrs. Note the large vacuoles and the nuclei mostly located at the apex of the cells. (Alcian Blue, Hematoxylin, van Gieson; magnification x 428)**

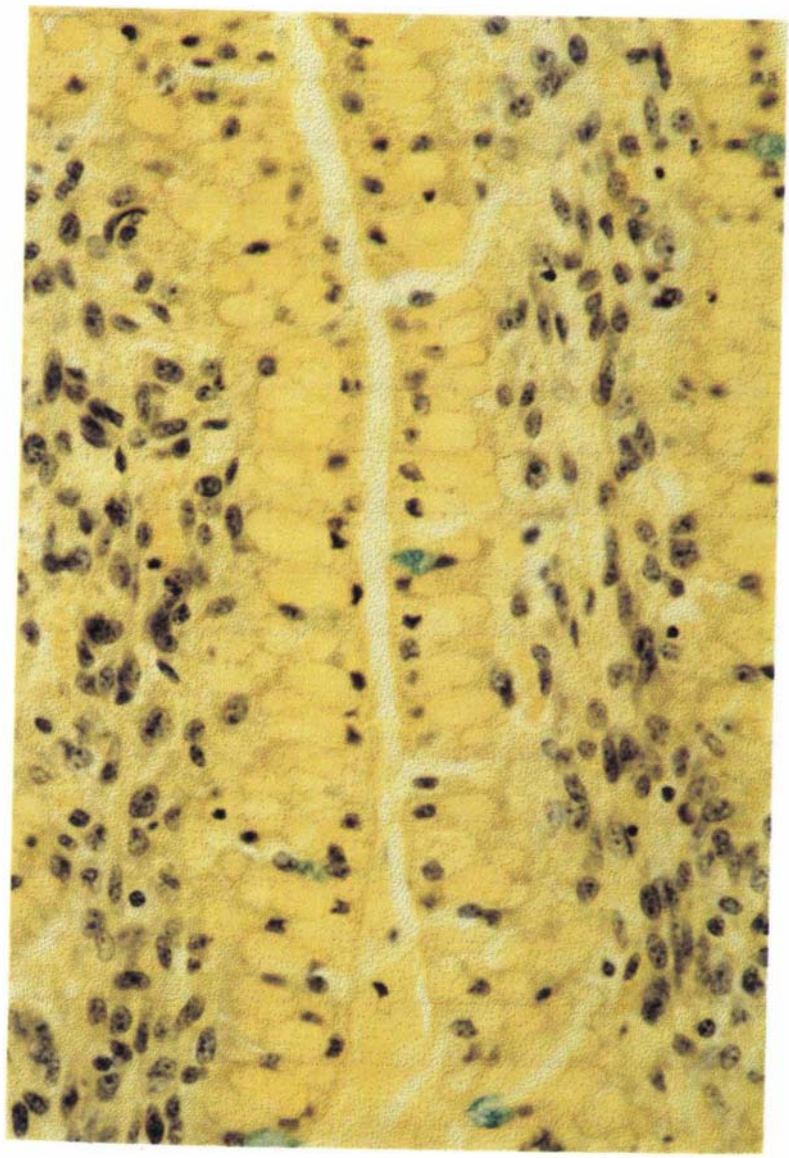


Figure 3.14B Villi in the upper ileum of a piglet fed sow colostrum for 24 hrs. Note the large vacuoles and the nuclei mostly located at the apex of the cells. (Alcian Blue, Hematoxylin, van Gieson; magnification x 428)

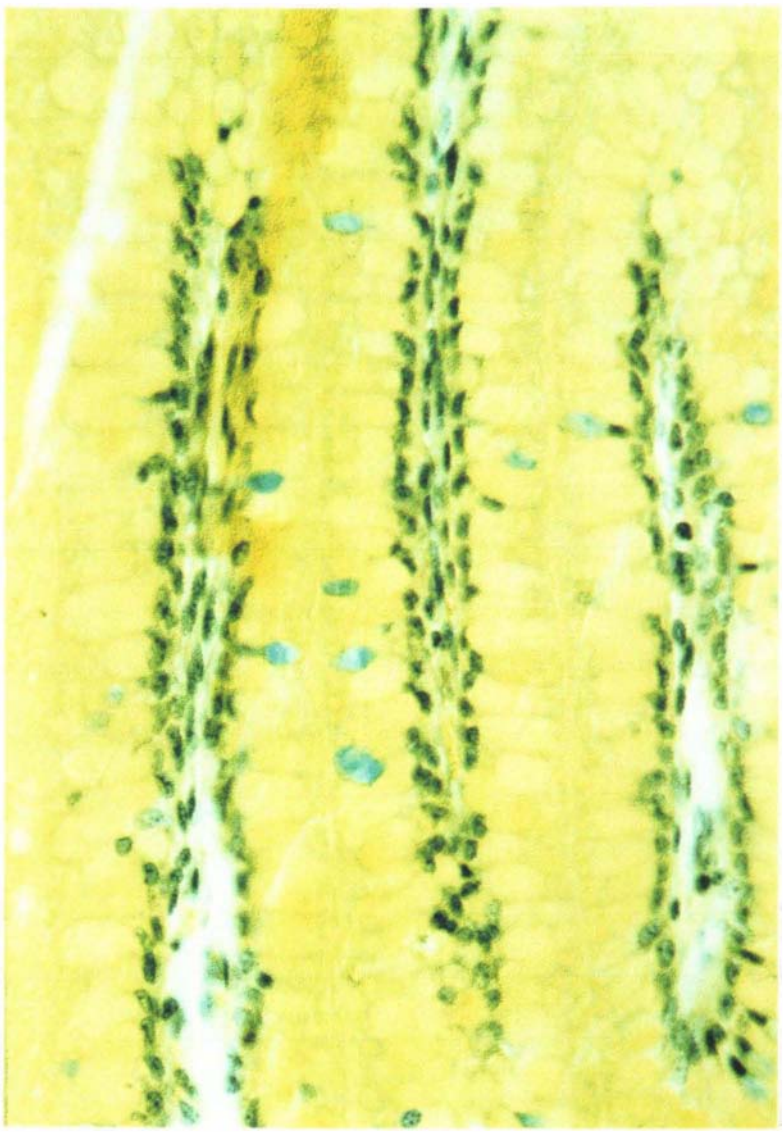


Figure 3.14C Villi in the lower ileum of a piglet fed sow colostrum for 24 hrs. Note the large vacuoles and the nuclei mostly located at the base of the cells. (Alcian Blue, Hematoxylin, van Gieson; magnification x 428)

Figure 3.14D Villi in the lower ileum of a piglet fed cow colostrum for 24 hrs. Note the large vacuoles and the nuclei mostly located at the base of the cells. (Alcian Blue, Hematoxylin, van Gieson; magnification x 428)

Figure 3.15A Villi in the upper ileum of a piglet fed sow milk for 24 hrs. Note the small vacuoles and the location of the cell nucleus at either the base or the apex of the cells. (Alcian Blue, Hematoxylin, van Gieson; magnification x 428)

Figure 3.15B **Villi in the upper ileum of a piglet fed cow milk for 24 hrs. Note the small vacuoles and the location of the cell nucleus at either the base or the apex of the cells. (Alcian Blue, Hematoxylin, van Gieson; magnification x 428)**

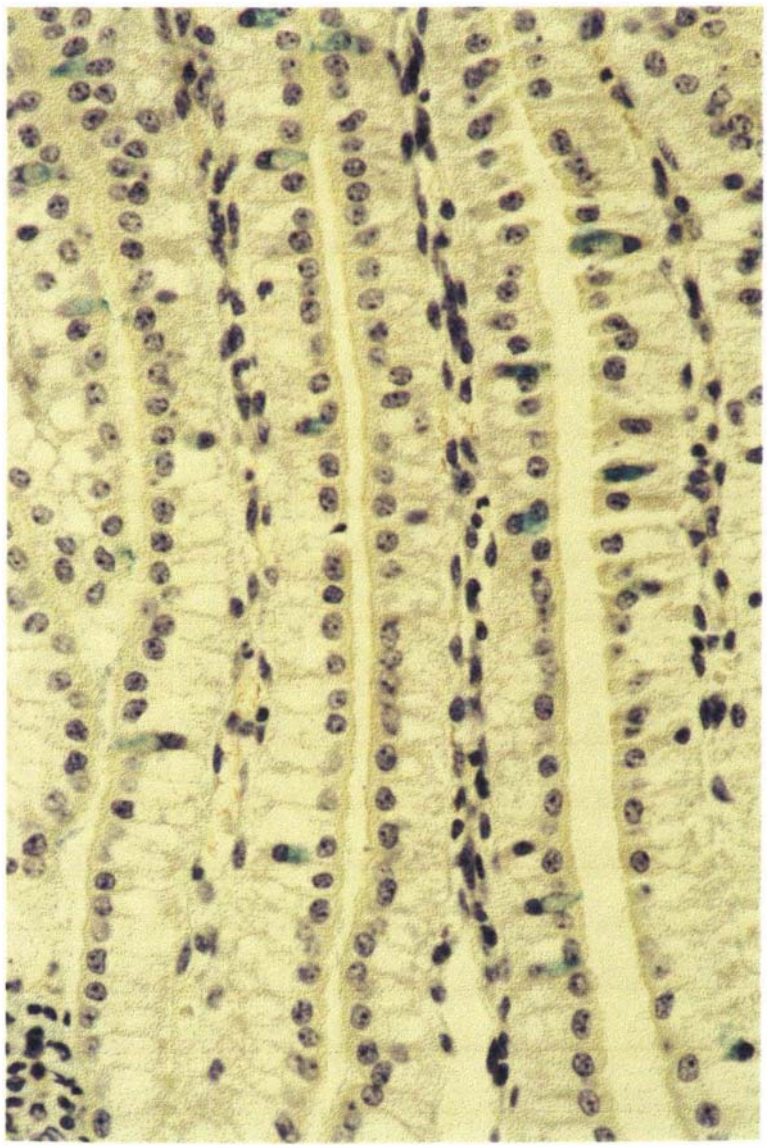


Figure 3.15C **Villi in the upper ileum of a piglet fed infant formula for 24 hrs. Note the small vacuoles and the location of the cell nucleus at either the base or the apex of the cells. (Alcian Blue, Hematoxylin, van Gieson; magnification x 428)**

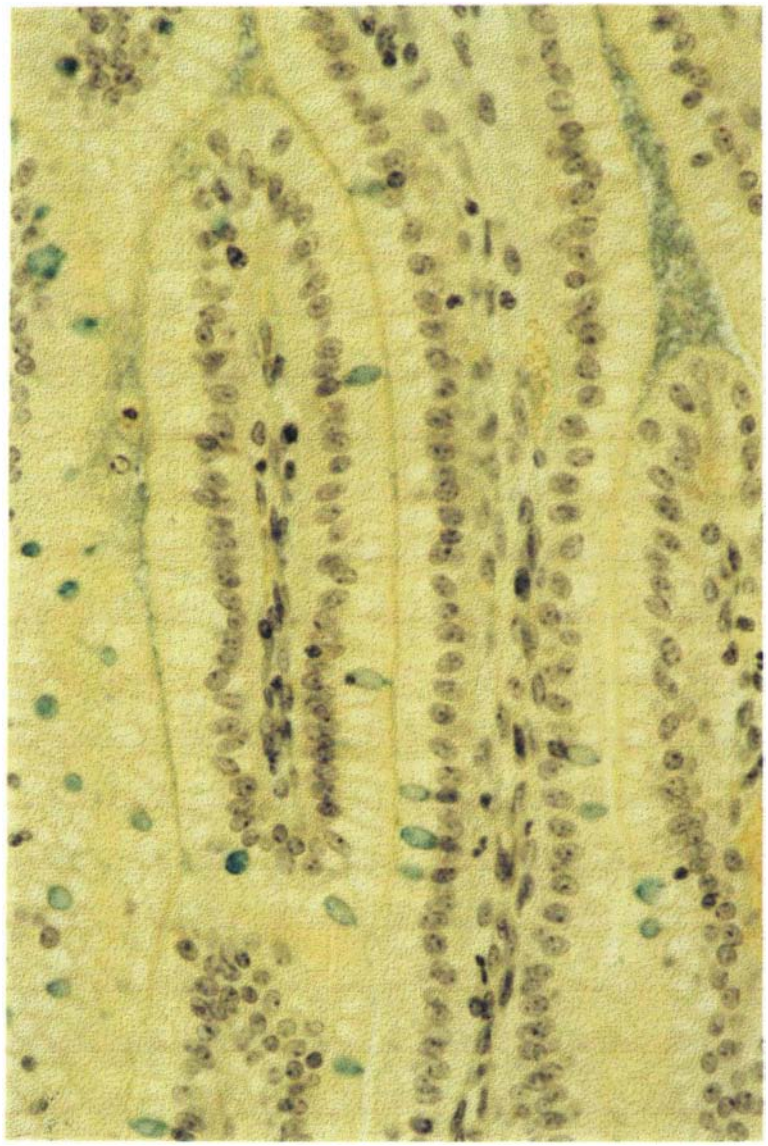


Figure 3.16A Villi in the lower ileum of a piglet fed sow milk for 24 hrs. Note the small vacuoles and the nuclei mostly located at the base of the cells. (Alcian Blue, Hematoxylin, van Gieson; magnification x 428)

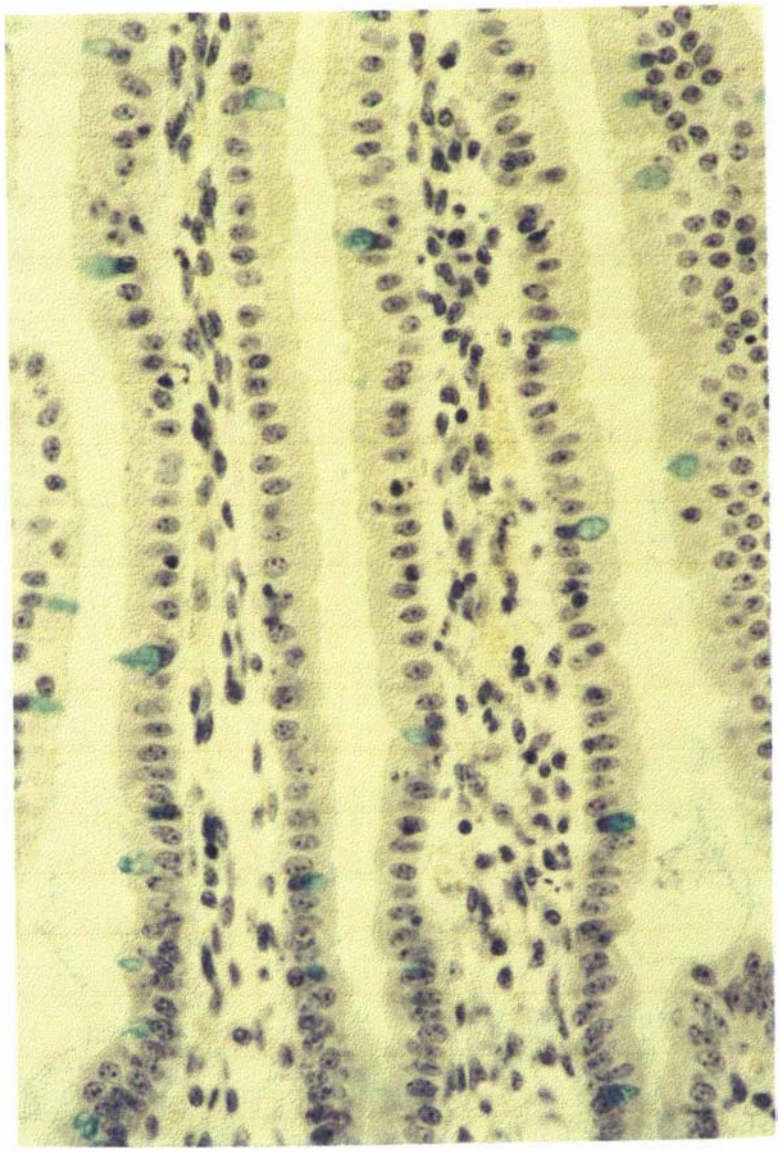


Figure 3.16B **Villi in the lower ileum of a piglet fed cow milk for 24 hrs. Note the small vacuoles and the nuclei mostly located at the base of the cells. (Alcian Blue, Hematoxylin, van Gieson; magnification x 428)**

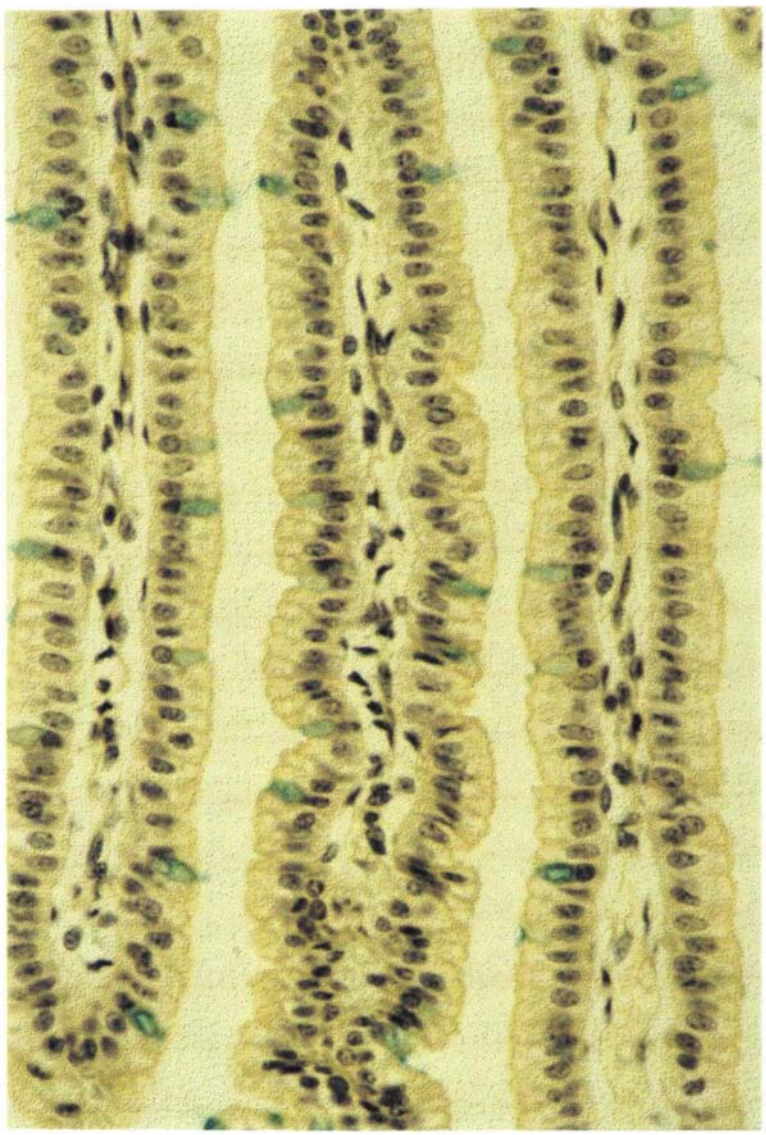


Figure 3.16C **Villi in the lower ileum of a piglet fed infant formula for 24 hrs. Note the small vacuoles and the nuclei mostly located at the base of the cells. (Alcian Blue, Hematoxylin, van Gieson; magnification x 428)**

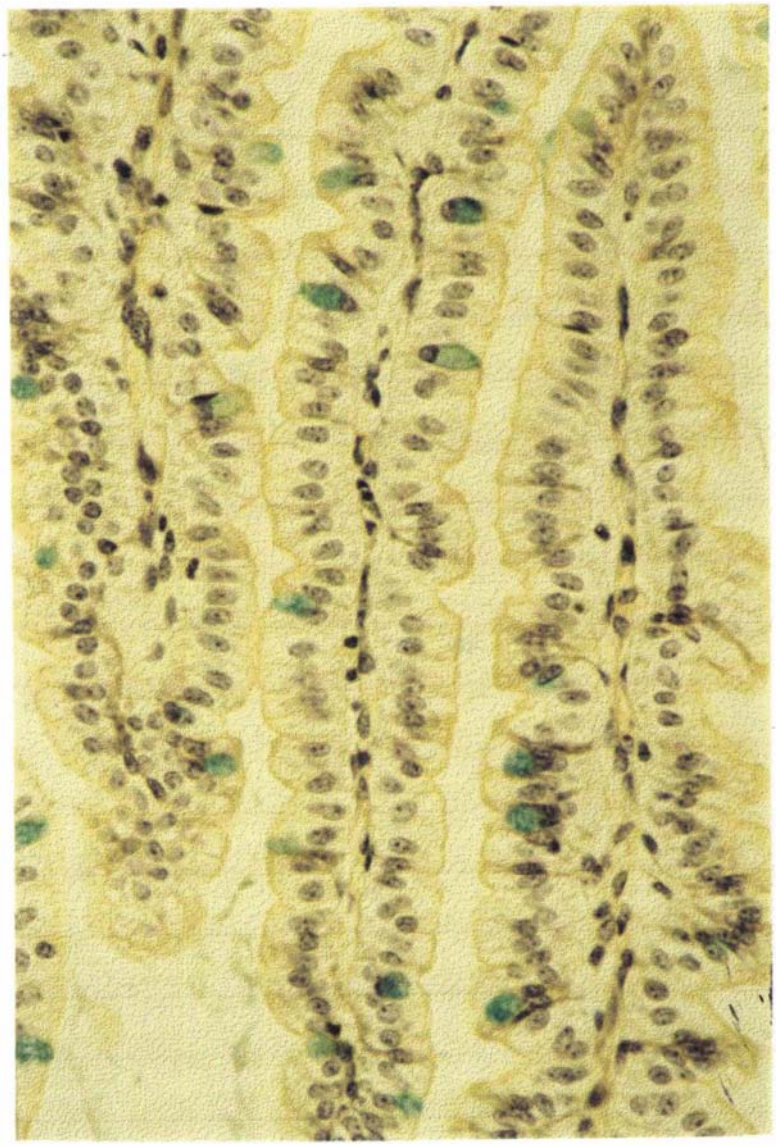


Figure 3.17A **Villi in the lower ileum of a piglet at birth. Note fewer cytoplasmic vacuoles and the nuclei mostly located at the middle of the cells. (Alcian Blue, Hematoxylin, van Gieson; magnification x 428)**

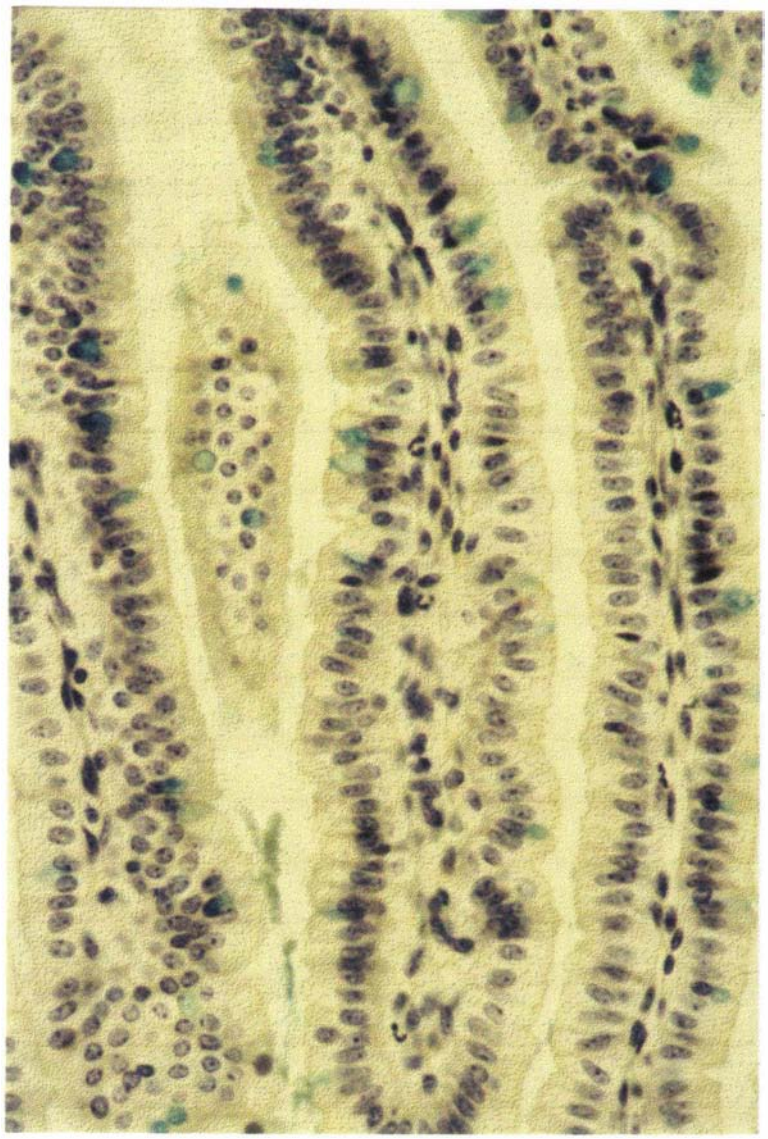


Figure 3.17B **Villi in the the lower ileum of a piglet fed water for 24 hrs. Note fewer vacuoles and the nuclei mostly located at the base of the cells. (Alcian Blue, Hematoxylin, van Gieson; magnification x 428)**

Figure 3.18 **Number of labelled dividing cells per crypt area from the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets fed with either sow colostrum (SC), cow colostrum (CC), sow milk (SM), cow milk (CM), infant formula (IF) or water (H_2O) for 24 hrs (mean ± S.E.).**

DUO:
N.S.

UPJ:
CC vs CM *
SM vs CM **

LOJ:
SM+CM vs IF *

UPI:
SC+CC+SM+CM+IF vs H_2O ***

LOI:
N.S.

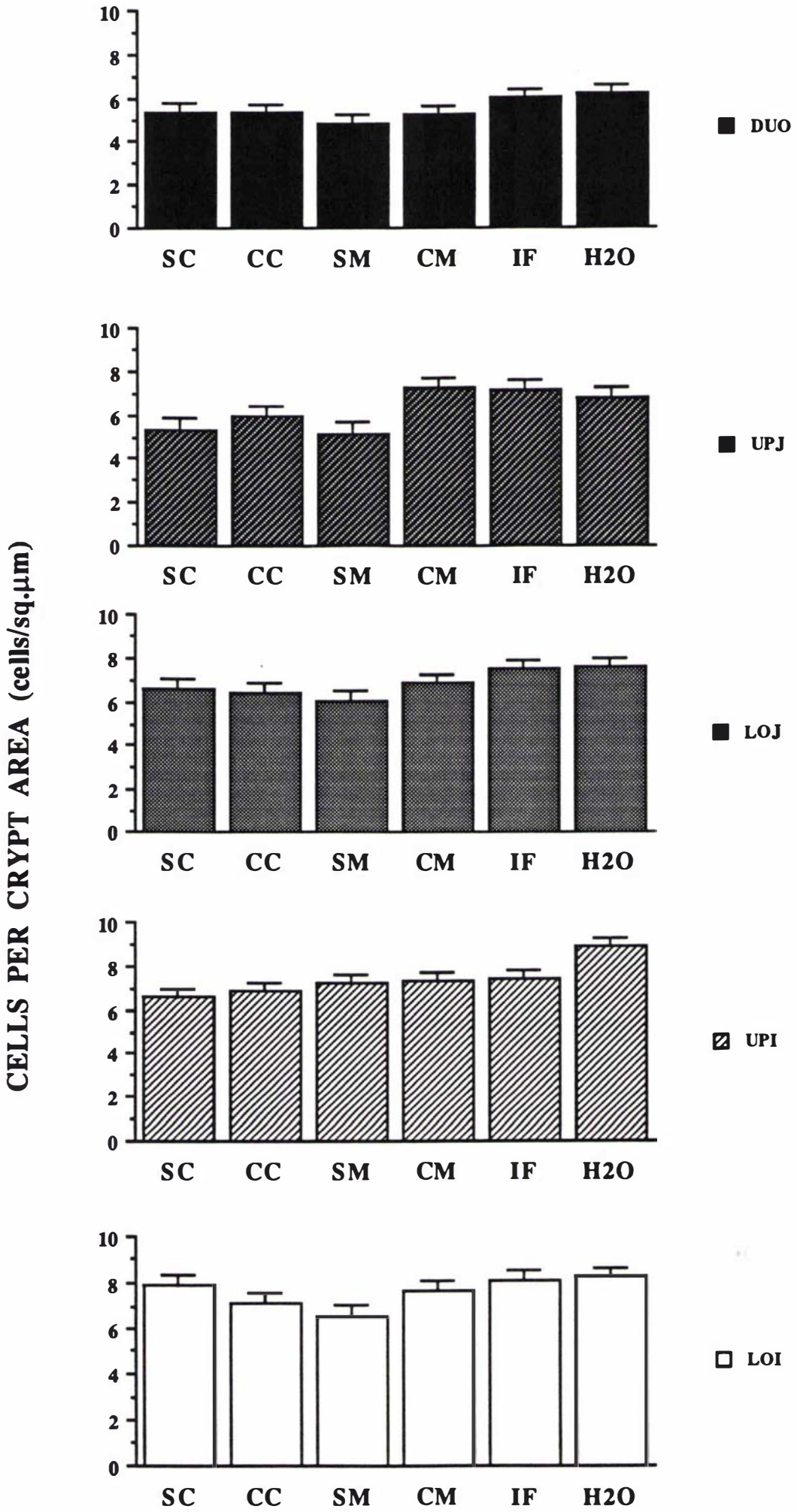

CELLS PER CRYPT AREA (cells/sq.µm)
10
8
6
4
2
0
SC
CC
SM
CM
IF
H2O
DUO
UPJ
LOJ
UPI
LOI

Figure 3.19 **The total crypt area of 12 crypts from the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets fed with either sow colostrum (SC), cow colostrum (CC), sow milk (SM), cow milk (CM), infant formula (IF) or water (H_2O) for 24 hrs (mean ± S.E.).**

DUO:
N.S.

UPJ:
SM vs CM ******
SC+CC+SM+CM+IF vs H_2O *****

LOJ:
SC+CC+SM+CM+IF vs H_2O *******

UPI:
N.S.

LOI:
SC+CC+SM+CM+IF vs H_2O *******

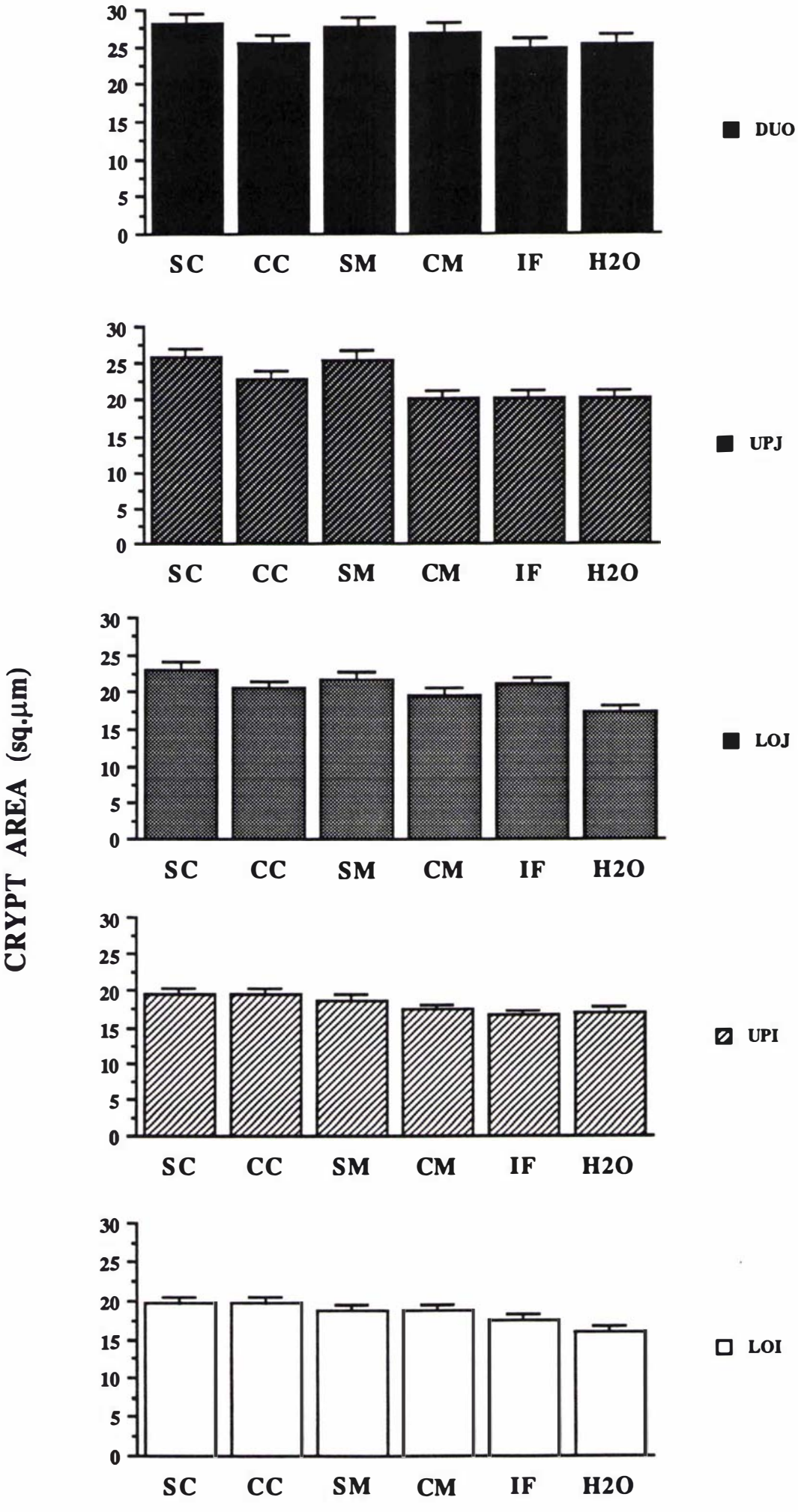

CRYPT AREA (sq.µm)
30
25
20
15
10
5
0
SC
CC
SM
CM
IF
H2O
DUO
UPJ
LOJ
UPI
LOI

Figure 3.20 **The total number of labelled dividing cells per 12 crypts from the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets fed with either sow colostrum (SC), cow colostrum (CC), sow milk (SM), cow milk (CM), infant formula (IF) or water (H_2O) for 24 hrs (mean ± S.E.).**

DUO:
N.S.

UPJ:
N.S.

LOJ:
SM+CM vs IF *

UPI:
SC+CC+SM+CM+IF vs H_2O ***

LOI:
N.S.

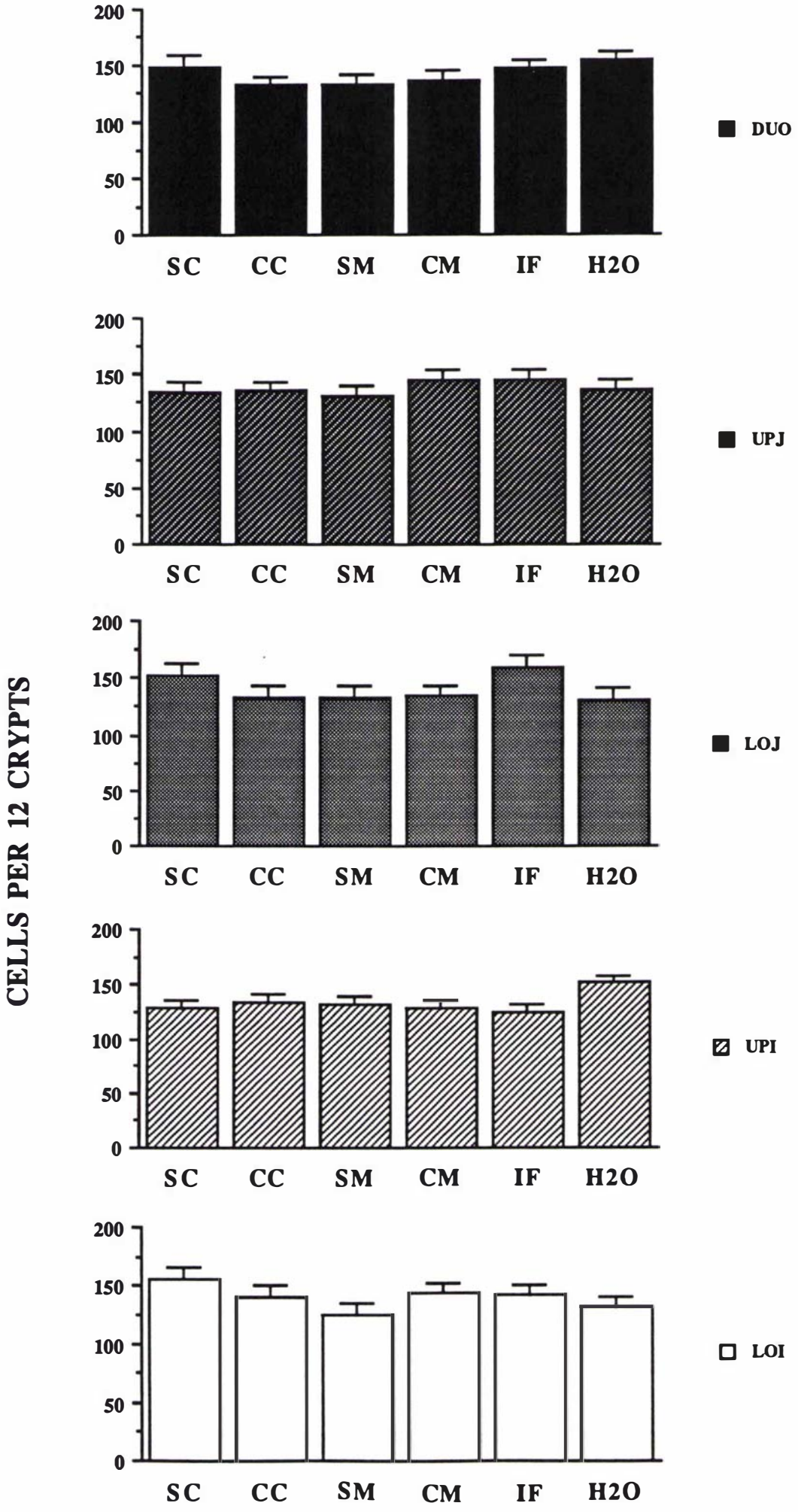

CELLS PER 12 CRYPTS
200
150
100
50
0
SC
CC
SM
CM
IF
H2O
DUO
UPJ
LOJ
UPI
LOI

Figure 3.21 **The relative migration distance of the labelled dividing cells of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets fed with either sow colostrum (SC), cow colostrum (CC), sow milk (SM), cow milk (CM), infant formula (IF) or water (H_2O) for 24 hrs (mean ± S.E.).**

DUO:
N.S.

UPJ:
SC vs CC *
SC vs CM *
SC+CC+SM+CM+IF vs H_2O *

LOJ:
SC+CC vs SM+CM *
SC vs CC **
SC vs SM **
SC vs CM **
SC+CC+SM+CM+IF vs H_2O **

UPI:
SC+CC vs SM+CM **
SC vs CC **
SC vs SM **
SC vs CM ***
SC+CC+SM+CM+IF vs H_2O *

LOI:
SC vs SM *
SC+CC+SM+CM+IF vs H_2O **

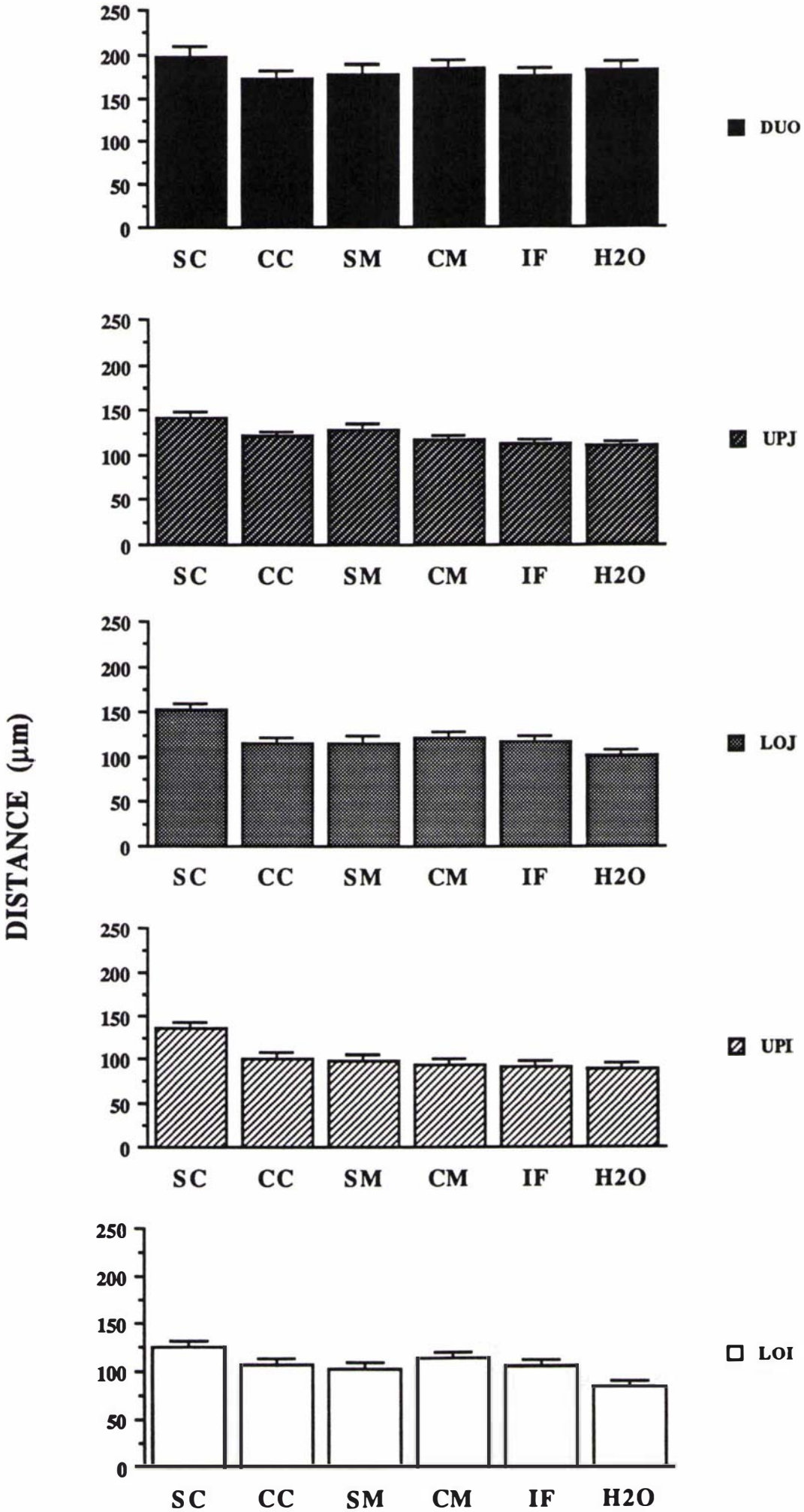

DISTANCE (µm)
250
200
150
100
50
0
SC
CC
SM
CM
IF
H2O
DUO
UPJ
LOJ
UPI
LOI

Figure 3.22 **Mucosal DNA content of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B), naturally suckled (NS) or fed with either sow colostrum (SC), cow colostrum (CC), sow milk (SM), cow milk (CM), infant formula (IF) or water (H_2O) for 24 hrs (mean ± S.E.).**

DUO:
***SC+SM vs CC+CM* ***
***B vs H_2O* ***
B vs NS+SC+CC+SM+CM+IF+H_2O* *

UPJ:
***SC vs SM* ***
***SC vs CC* ***
B vs H_2O* *
B vs NS+SC+CC+SM+CM+IF+H_2O* **

LOJ:
***SC vs SM* ***
***SM+CM vs IF* ***
B vs H_2O* *
NS vs SC* *
B vs NS+SC+CC+SM+CM+IF+H_2O* **

UPI:
***SM+CM vs IF* ***
B vs NS+SC+CC+SM+CM+IF+H_2O* *

LOI:
***B vs NS+SC+CC+SM+CM+IF+H_2O* ***

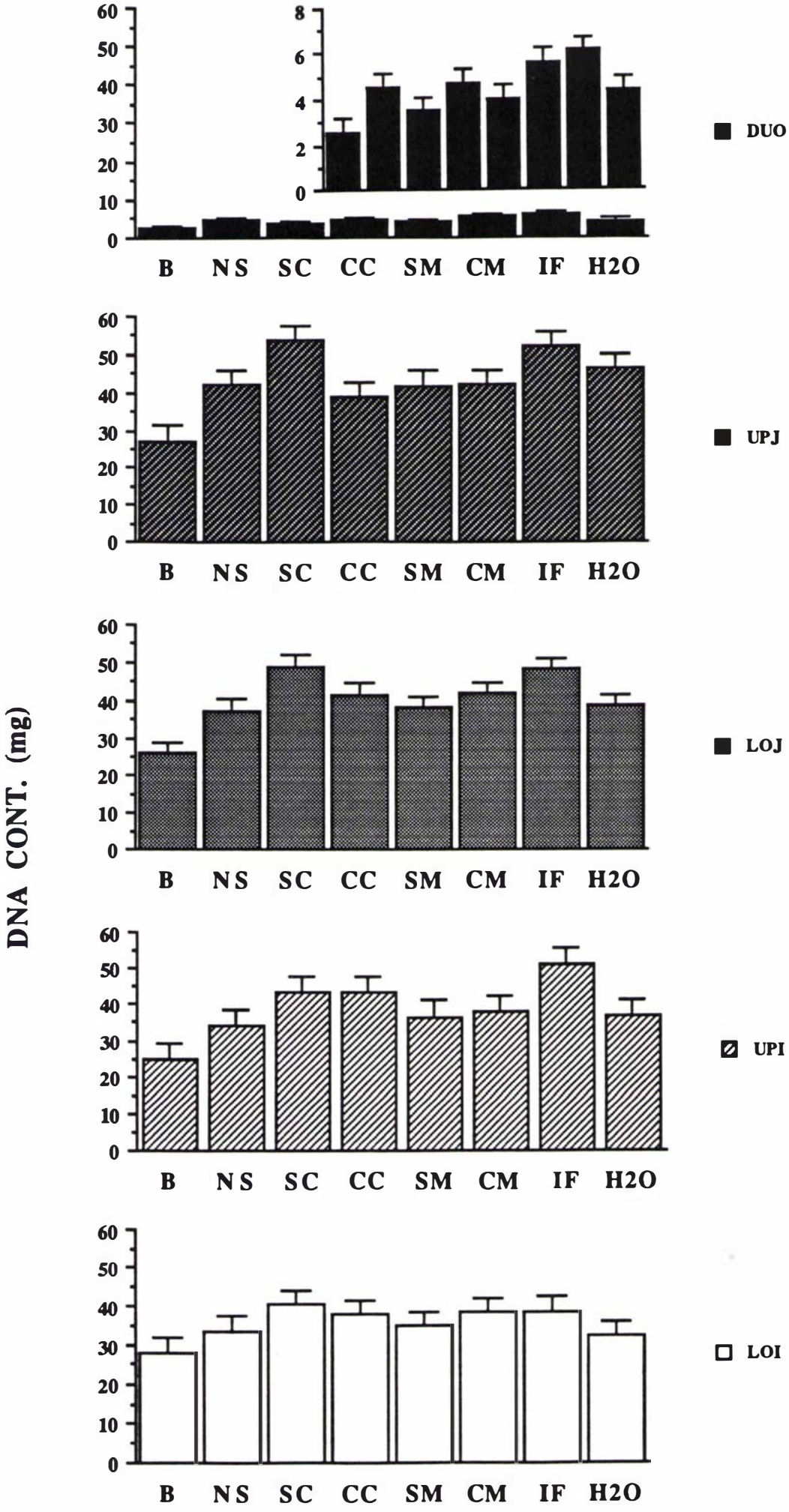

DNA CONT. (mg)
60
50
40
30
20
10
0
8
6
4
2
0
B NS SC CC SM CM IF H2O
DUO
UPJ
LOJ
UPI
LOI

Figure 3.23 **Mucosal DNA concentration of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B), naturally suckled (NS) or fed with either sow colostrum (SC), cow colostrum (CC), sow milk (SM), cow milk (CM), infant formula (IF) or water (H_2O) for 24 hrs (mean ± S.E.).**

DUO:
SC+CC vs SM+CM ***
SC vs SM *
CC vs CM *
SC+SM vs CC+CM **
SC vs CC *
SM vs CM *
SM+CM vs IF **
SC+CC+SM+CM+IF vs H_2O *
B vs H_2O **
NS vs SC *

UPJ:
SC+CC vs SM+CM **
SC vs SM *
CC vs CM *
SC+CC+SM+CM+IF vs H_2O **
B vs H_2O ***

LOJ:
SC+CC vs SM+CM ***
SC vs SM **
CC vs CM **
SC+SM vs CC+CM *
SC+CC+SM+CM+IF vs H_2O *
B vs H_2O **

UPI:
SC+CC vs SM+CM ***
SC vs SM ***
CC vs CM *
*SC vs CC**
B vs H_2O **

LOI:
SC+CC vs SM+CM ***
SC vs SM ***
SC vs CC *
B vs H_2O *

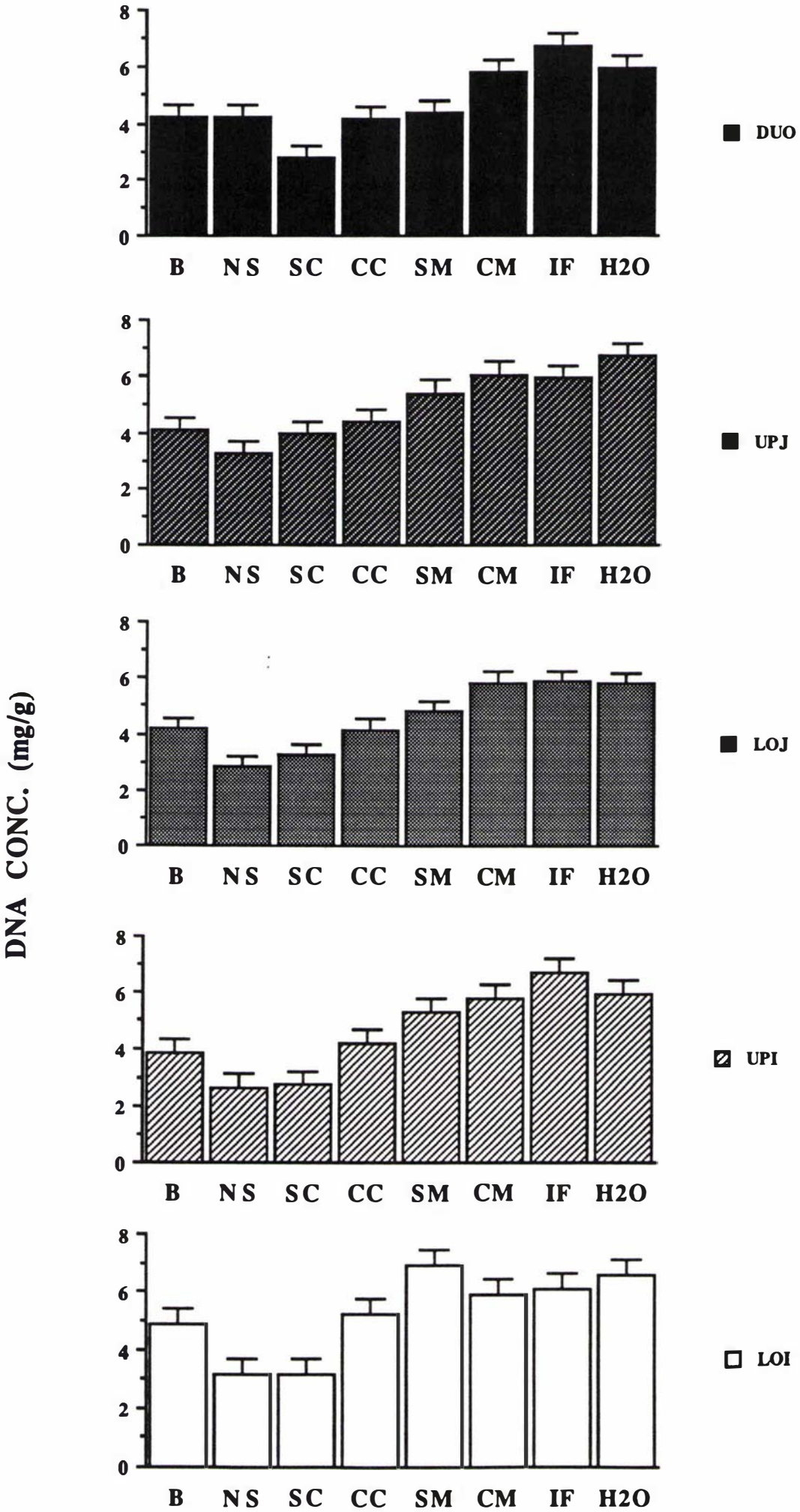

DNA CONC. (mg/g)
8
6
4
2
0
B NS SC CC SM CM IF H2O
DUO
UPJ
LOJ
UPI
LOI

Figure 3.24 **Mucosal RNA content of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B), naturally suckled (NS) or fed with either sow colostrum (SC), cow colostrum (CC), sow milk (SM), cow milk (CM), infant formula (IF) or water (H_2O) for 24 hrs (mean ± S.E.).**

DUO:
SC+CC vs SM+CM *
SC vs SM ***
SC vs CC **
SC+CC+SM+CM+IF vs H_2O *
NS vs SC *
B vs NS+SC+CC+SM+CM+IF+H_2O ***

UPJ:
SC vs SM ***
CC vs CM *
SC+SM vs CC+CM ***
SC vs CC ***
B vs NS+SC+CC+SM+CM+IF+H_2O *

LOJ:
SC vs SM *
CC vs CM ***
SC+SM vs CC+CM ***
SC vs CC ***
B vs NS+SC+CC+SM+CM+IF+H_2O **

UPI:
CC vs CM ***
SC+SM vs CC+CM *
SC vs CC ***
B vs NS+SC+CC+SM+CM+IF+H_2O *

LOI:
CC vs CM **
SC vs CC **

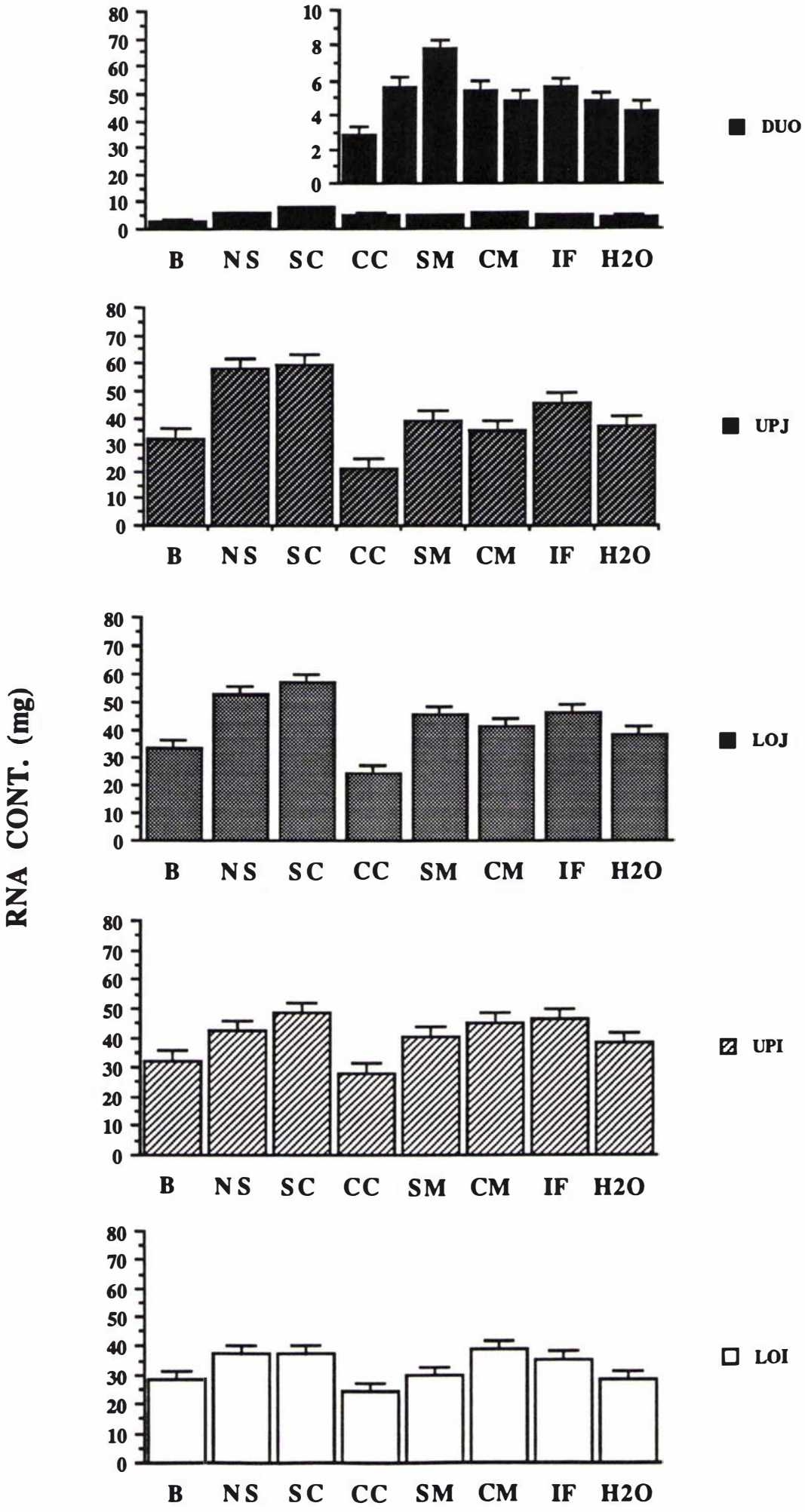

RNA CONT. (mg)
DUO
UPJ
LOJ
UPI
LOI
B
NS
SC
CC
SM
CM
IF
H2O

Figure 3.25 **Mucosal RNA concentration of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B), naturally suckled (NS) or fed with either sow colostrum (SC), cow colostrum (CC), sow milk (SM), cow milk (CM), infant formula (IF) or water (H_2O) for 24 hrs (mean ± S.E.).**

DUO:
N.S.

UPJ:
SC+CC vs SM+CM ***
CC vs CM ***
SC vs CC **

LOJ:
SC+CC vs SM+CM ***
SC vs SM ***
CC vs CM ***
SC vs CC *
SC+CC+SM+CM+IF vs H_2O **

UPI:
SC+CC vs SM+CM ***
SC vs SM ***
CC vs CM ***
SC+CC+SM+CM+IF vs H_2O **
B vs H_2O *

LOI:
SC+CC vs SM+CM ***
SC vs SM ***
CC vs CM ***

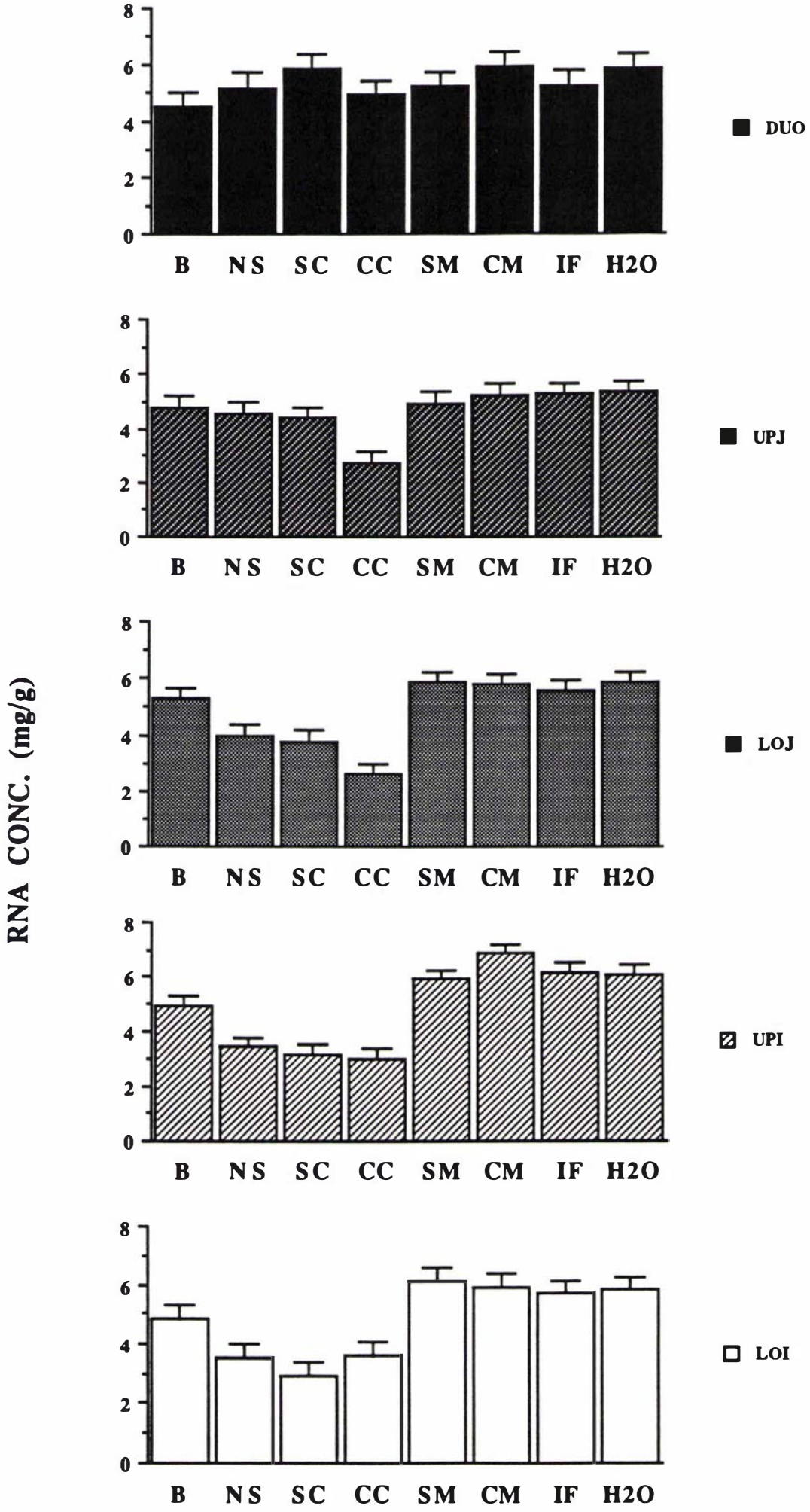

RNA CONC. (mg/g)
8
6
4
2
0
B NS SC CC SM CM IF H2O
DUO
UPJ
LOJ
UPI
LOI

Figure 3.26 **Mucosal RNA:DNA ratio of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B), naturally suckled (NS) or fed with either sow colostrum (SC), cow colostrum (CC), sow milk (SM), cow milk (CM), infant formula (IF) or water (H_2O) for 24 hrs (mean ± S.E.).**

DUO:
SC+CC vs SM+CM **
SC vs SM ***
SC+SM vs CC+CM **
SC vs CC ***
NS vs SC ***

UPJ:
SC+SM vs CC+CM *
SC vs CC **
B vs H_2O **
NS vs SC *
B vs NS+SC+CC+SM+CM+IF+H_2O **

LOJ:
CC vs CM *
SC+SM vs CC+CM **
SC vs CC **
B vs H_2O *
B vs NS+SC+CC+SM+CM+IF+H_2O **

UPI:
CC vs CM *
B vs NS+SC+CC+SM+CM+IF+H_2O *

LOI:
CC vs CM *

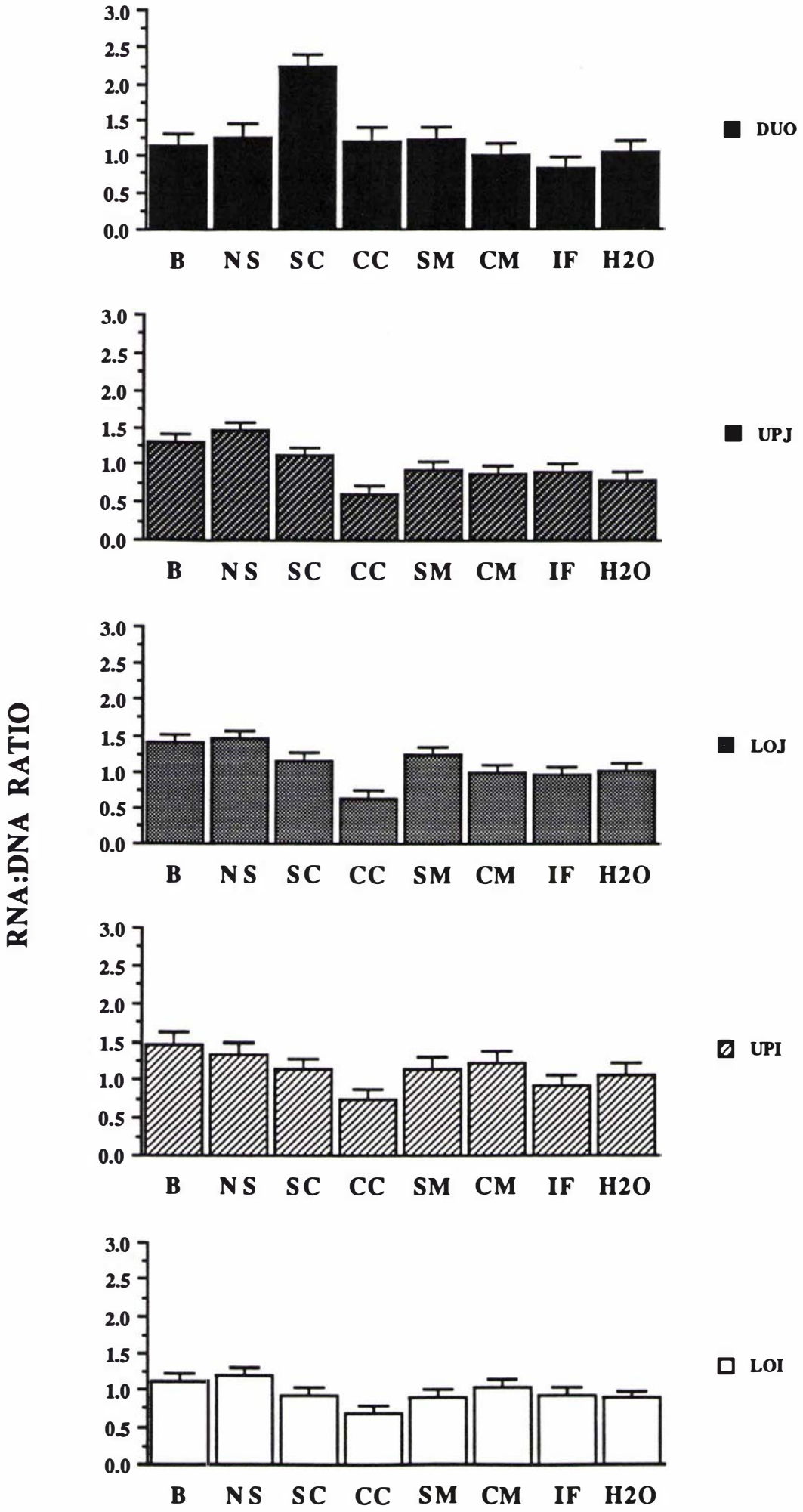

RNA:DNA RATIO
3.0
2.5
2.0
1.5
1.0
0.5
0.0
B
NS
SC
CC
SM
CM
IF
H2O
DUO
UPJ
LOJ
UPI
LOI

Figure 3.27 **Mucosal protein concentration of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B), naturally suckled (NS) or fed with either sow colostrum (SC), cow colostrum, sow milk (SM), cow milk (CM), infant formula (IF) or water (H2O) for 24 hrs (mean ± S.E.).**

DUO:
SC+CC vs SM+CM **
SC vs SM **

UPJ:
SC+CC vs SM+CM ***
SC vs SM ***
CC vs CM ***
SC+CC+SM+CM+IF vs H_2O **
B vs NS+SC+CC+SM+CM+IF+H_2O *

LOJ:
SC+CC vs SM+CM ***
SC vs SM ***
CC vs CM ***
SC+SM vs CC+CM *
SC vs CC ***
SC+CC+SM+CM+IF vs H_2O **
NS vs SC ***
B vs NS+SC+CC+SM+CM+IF+H_2O ***

UPI:
SC+CC vs SM+CM ***
SC vs SM ***
CC vs CM ***
SC+SM vs CC+CM **
SC vs CC ***
SC+CC+SM+CM+IF vs H_2O ***
NS vs SC ***
B vs NS+SC+CC+SM+CM+IF+H_2O ***

LOI:
SC+CC vs SM+CM ***
SC vs SM ***
CC vs CM **
SC+SM vs CC+CM ***
SC vs CC ***
SC+CC+SM+CM+IF vs H_2O **
NS vs SC **
B vs NS+SC+CC+SM+CM+IF+H_2O ***

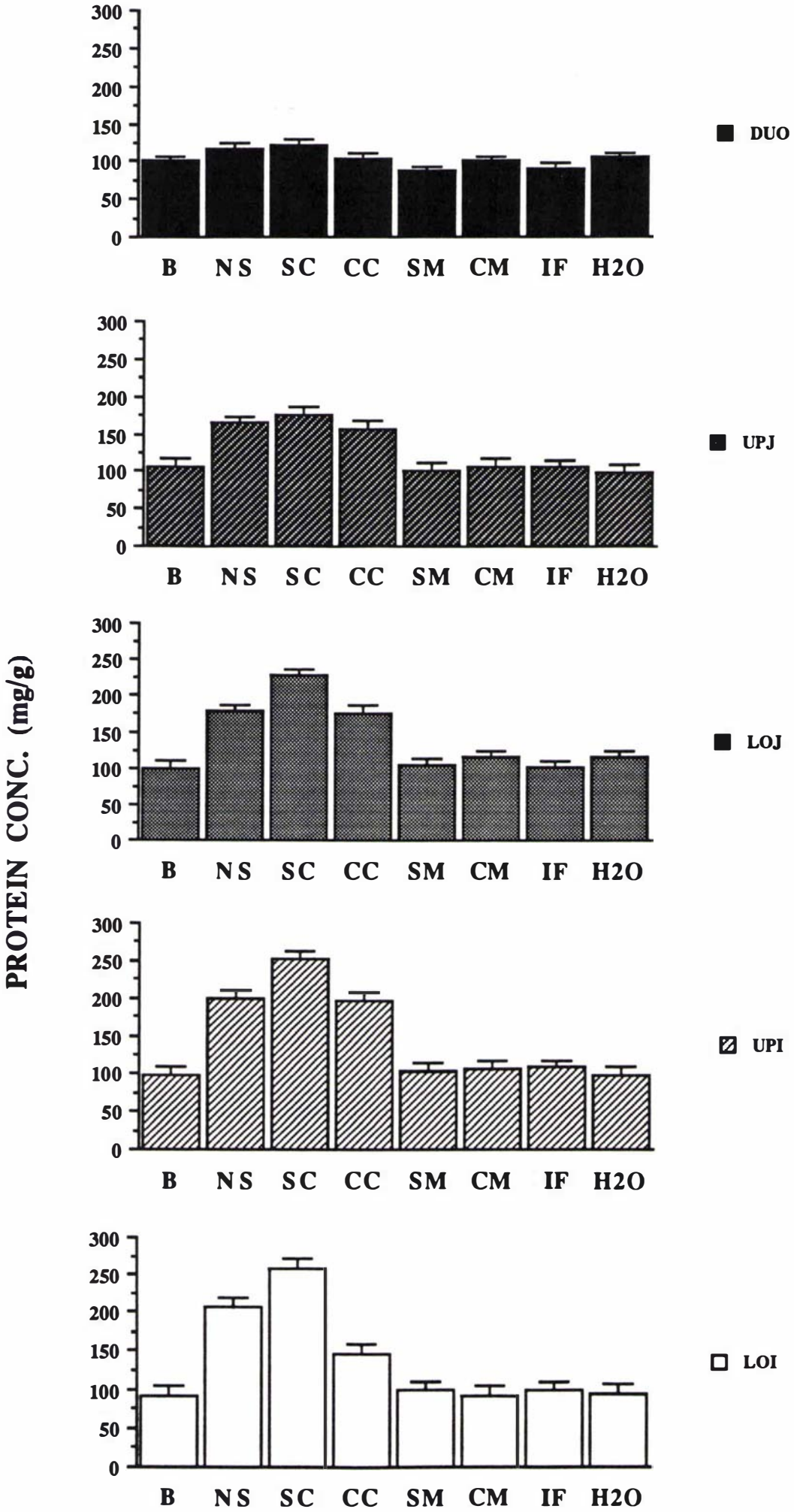

PROTEIN CONC. (mg/g)
300
250
200
150
100
50
0
B NS SC CC SM CM IF H2O
DUO
UPJ
LOJ
UPI
LOI

Figure 3.28 **Mucosal protein content of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B), naturally suckled (NS) or fed with either sow colostrum (SC), cow colostrum, sow milk (SM), cow milk (CM), infant formula (IF) or water (H2O) for 24 hrs (mean ± S.E.).**

DUO:
SC+CC vs SM+CM ***
SC vs SM ***
SC vs CC **
SC+CC+SM+CM+IF vs H_2O *
NS vs SC *
B vs NS+SC+CC+SM+CM+IF+H_2O ***

UPJ:
SC+CC vs SM+CM ***
SC vs SM ***
CC vs CM ***
SC+SM vs CC+CM *
SC vs CC **
SC+CC+SM+CM+IF vs H_2O **
B vs NS+SC+CC+SM+CM+IF+H_2O **

LOJ:
SC+CC vs SM+CM ***
SC vs SM ***
CC vs CM ***
SC+SM vs CC+CM ***
SC vs CC ***
SC+CC+SM+CM+IF vs H_2O **
NS vs SC **
B vs NS+SC+CC+SM+CM+IF+H_2O ***

UPI:
SC+CC vs SM+CM ***
SC vs SM ***
CC vs CM **
SC+SM vs CC+CM ***
SC vs CC ***
SC+CC+SM+CM+IF vs H_2O **
NS vs SC **
B vs NS+SC+CC+SM+CM+IF+H_2O **

LOI:
SC+CC vs SM+CM ***
SC vs SM ***
SC+SM vs CC+CM ***
SC vs CC ***
SC+CC+SM+CM+IF vs H_2O **
NS vs SC *
B vs NS+SC+CC+SM+CM+IF+H_2O *

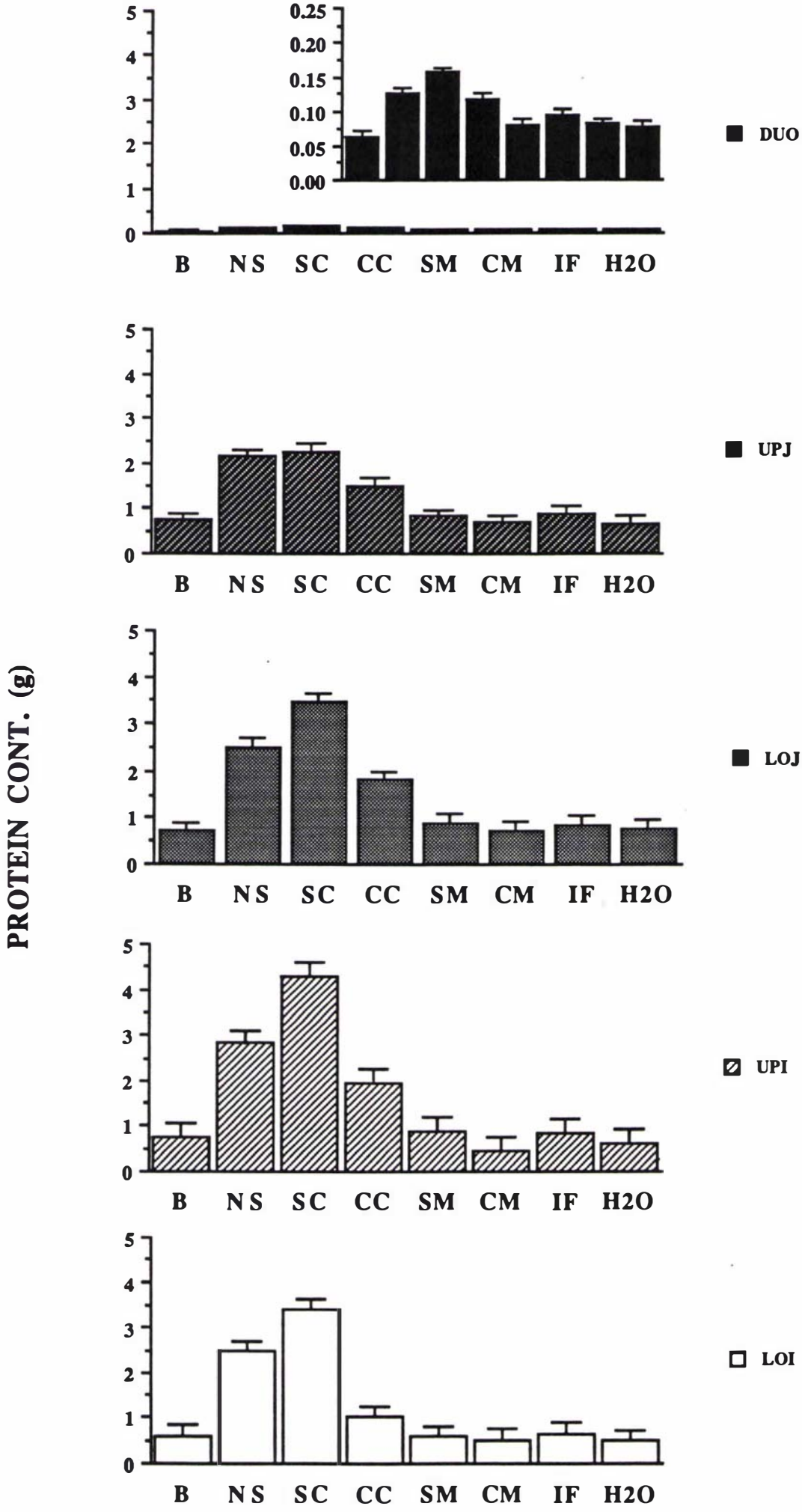

PROTEIN CONT. (g)
DUO
UPJ
LOJ
UPI
LOI
B
NS
SC
CC
SM
CM
IF
H2O

Figure 3.29 **Mucosal protein:DNA ratio of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B), naturally suckled (NS) or fed with either sow colostrum (SC), cow colostrum, sow milk (SM), cow milk (CM), infant formula (IF) or water (H_2O) for 24 hrs (mean ± S.E.).**

DUO:
SC+CC vs SM+CM ***
SC vs SM ***
CC vs CM *
SC+SM vs CC+CM ***
SC vs CC ***
SC+CC+SM+CM+IF vs H_2O *
NS vs SC ***

UPJ:
SC+CC vs SM+CM ***
SC vs SM ***
CC vs CM **
SC+CC+SM+CM+IF vs H_2O **
B vs H_2O *

LOJ:
SC+CC vs SM+CM ***
SC vs SM ***
CC vs CM ***
SC+SM vs CC+CM **
SC vs CC ***
SC+CC+SM+CM+IF vs H_2O **

UPI:
SC+CC vs SM+CM ***
SC vs SM ***
CC vs CM **
SC+SM vs CC+CM ***
SC vs CC ***
SC+CC+SM+CM+IF vs H_2O **

LOI:
SC+CC vs SM+CM ***
SC vs SM ***
SC+SM vs CC+CM **
SC vs CC ***

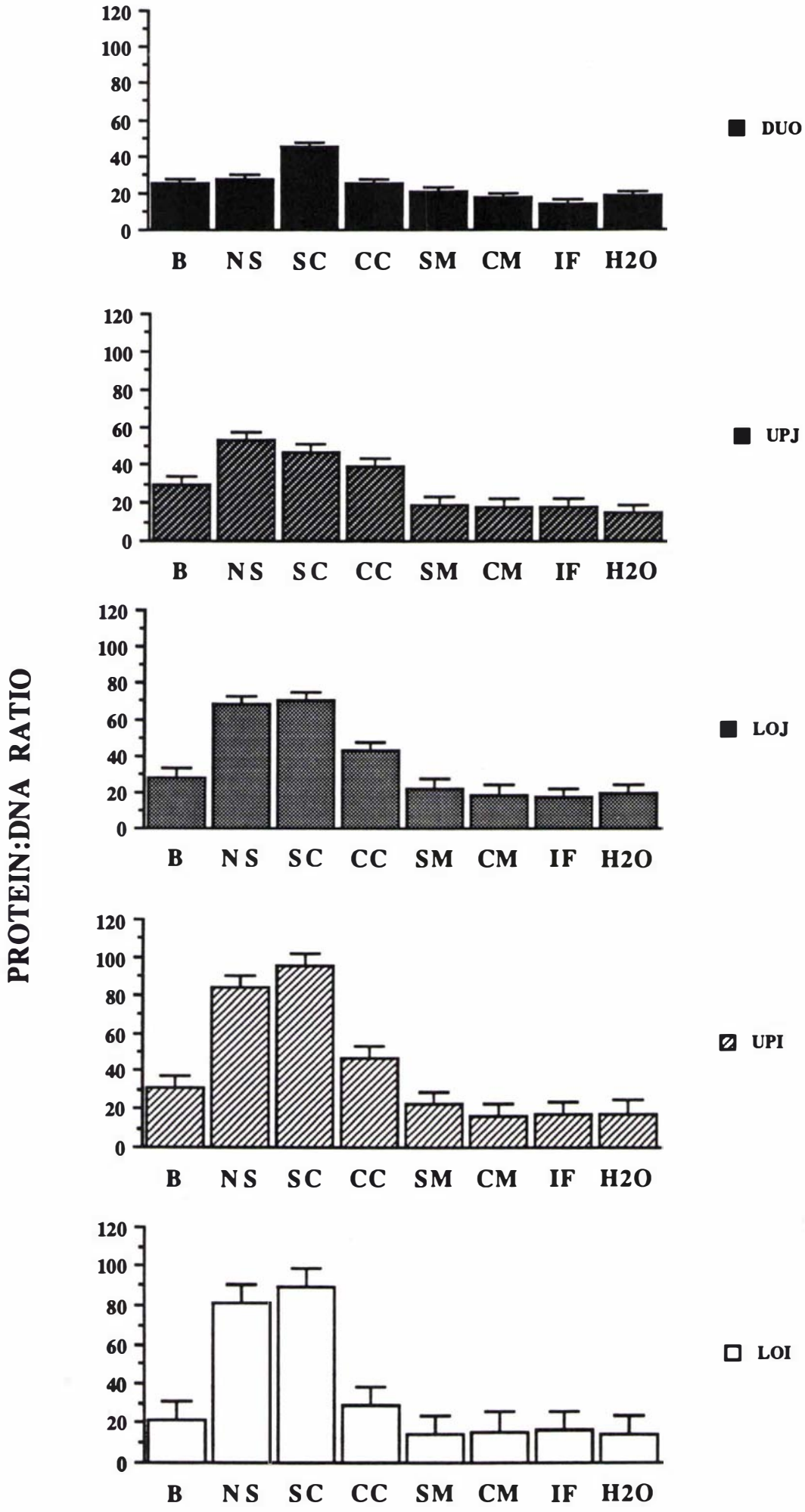

PROTEIN:DNA RATIO
120
100
80
60
40
20
0
B
NS
SC
CC
SM
CM
IF
H2O
DUO
UPJ
LOJ
UPI
LOI

Figure 3.30 **Total lactase activity of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B), naturally suckled (NS) or fed with either sow colostrum (SC), cow colostrum, sow milk (SM), cow milk (CM), infant formula (IF) or water (H_2O) for 24 hrs (mean ± S.E.).**

DUO:
SC+CC vs SM+CM ***
SC vs SM **

UPJ:
SC+CC vs SM+CM *

LOJ:
SC vs SM *
B vs NS+SC+CC+SM+CM+IF+H_2O *

UPI:
SM+CM vs IF **

LOI:
N.S.

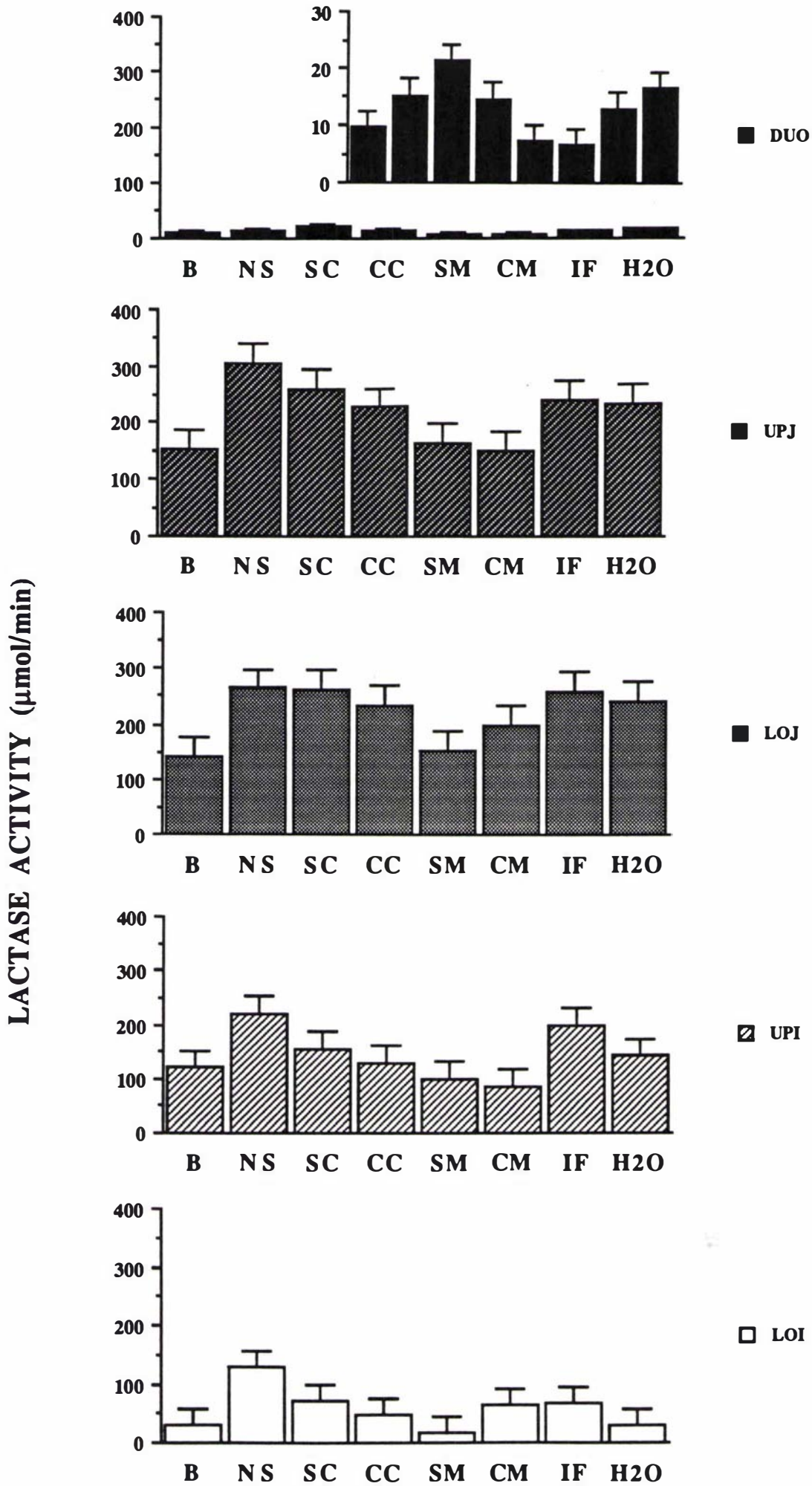

LACTASE ACTIVITY (µmol/min)
400
300
200
100
0
30
20
10
0
B
NS
SC
CC
SM
CM
IF
H2O
DUO
UPJ
LOJ
UPI
LOI

Figure 3.31 **Lactase activity per gram mucosal tissue of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B), naturally suckled (NS) or fed with either sow colostrum (SC), cow colostrum, sow milk (SM), cow milk (CM), infant formula (IF) or water (H_2O) for 24 hrs (mean ± S.E.).**

DUO:
SC+CC vs SM+CM *
SC vs SM *
SC+CC+SM+CM+IF vs H_2O **

UPJ:
SM+CM vs IF *
SC+CC+SM+CM+IF vs H_2O ***
B vs H_2O **

LOJ:
SC+SM vs CC+CM *
SM+CM vs IF *
SC+CC+SM+CM+IF vs H_2O ***
B vs H_2O **

UPI:
SM+CM vs IF **
SC+CC+SM+CM+IF vs H_2O *

LOI:
N.S.

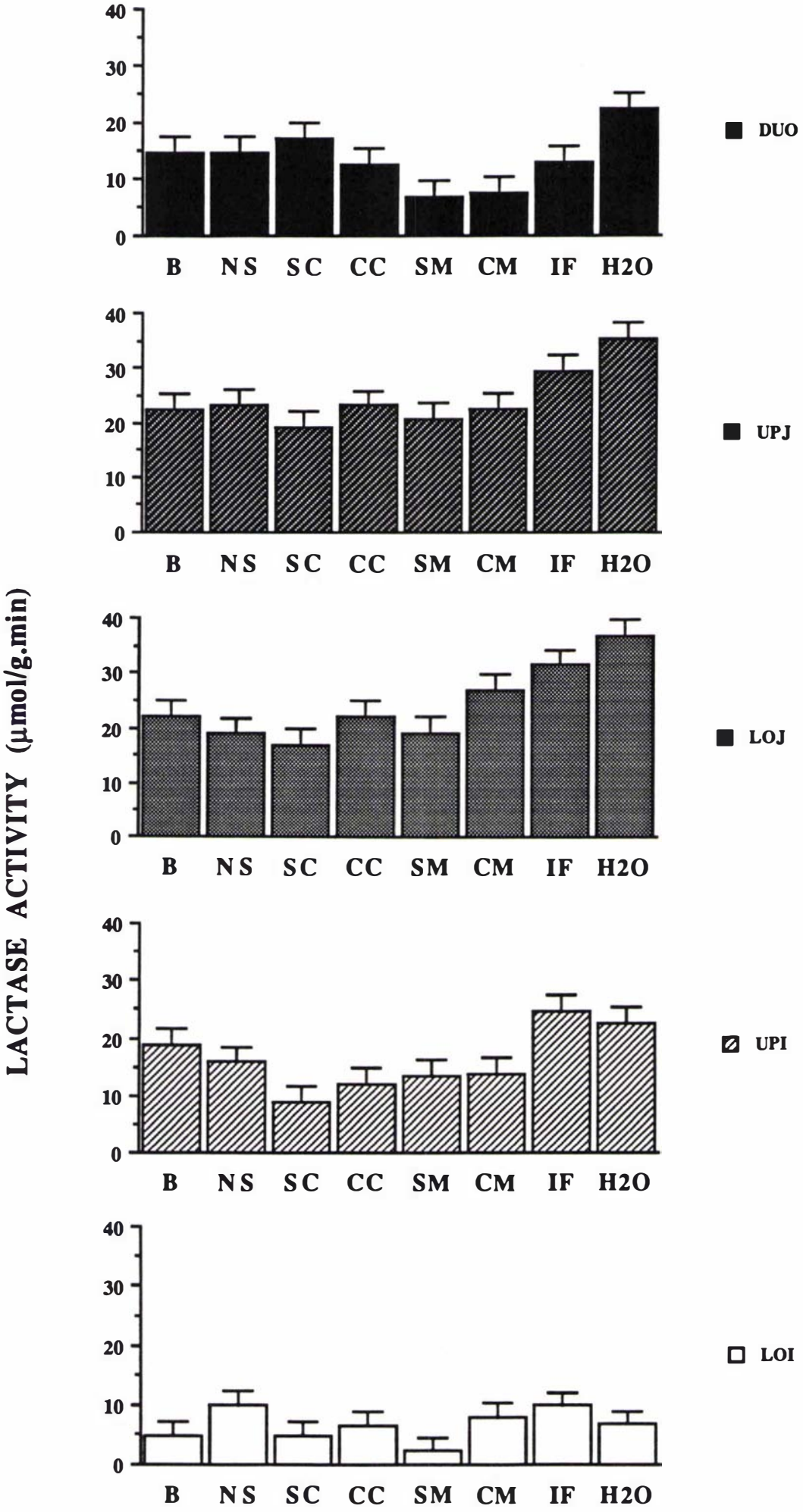

LACTASE ACTIVITY (µmol/g.min)
40
30
20
10
0
B NS SC CC SM CM IF H2O
DUO
UPJ
LOJ
UPI
LOI

Figure 3.32 **Lactase activity per milligram DNA of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B), naturally suckled (NS) or fed with either sow colostrum (SC), cow colostrum, sow milk (SM), cow milk (CM), infant formula (IF) or water (H2O) for 24 hrs (mean ± S.E.).**

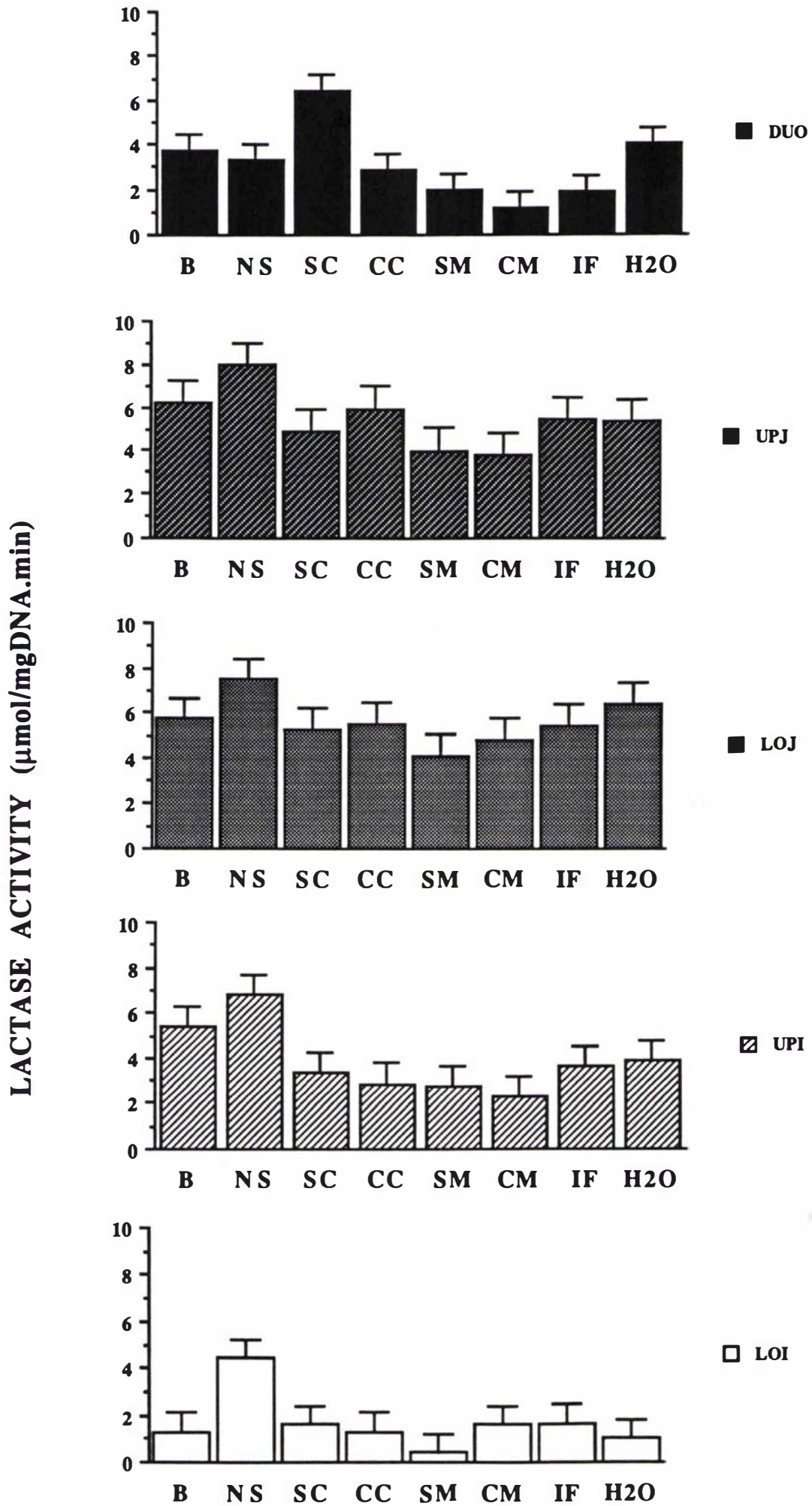
DUO:
SC+CC vs SM+CM ***
SC vs SM ***
SC+SM vs CC+CM **
SC vs CC **
NS vs SC **

UPJ:
N.S.

LOJ:
N.S.

UPI:
NS vs SC *

LOI:
NS vs SC *


LACTASE ACTIVITY (µmol/mgDNA.min)
10
8
6
4
2
0
B
NS
SC
CC
SM
CM
IF
H2O
DUO
UPJ
LOJ
UPI
LOI

CHAPTER 4

EFFECTS OF INTRALUMINAL NUTRITION AND TOTAL PARENTERAL NUTRITION ON POSTNATAL DEVELOPMENT OF THE SMALL INTESTINE IN PIGLETS DURING THE FIRST 24 HOURS AFTER BIRTH

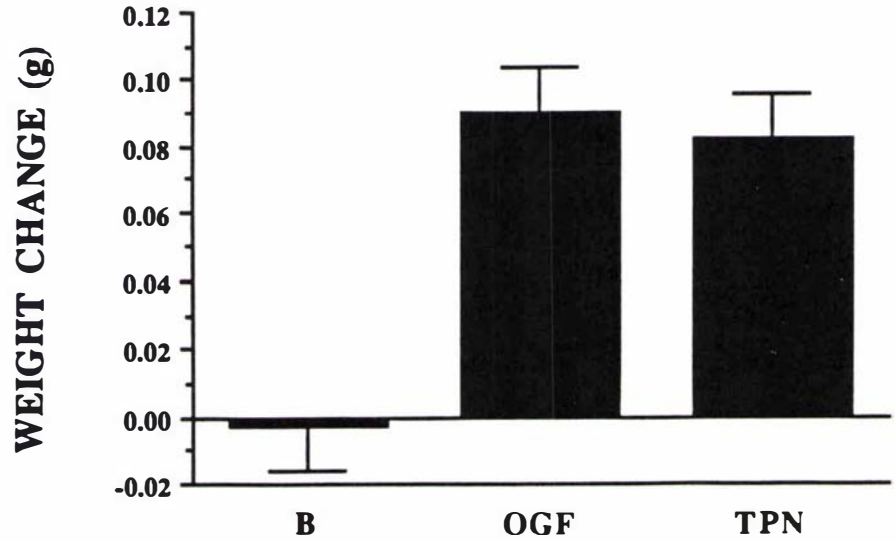
FIGURES

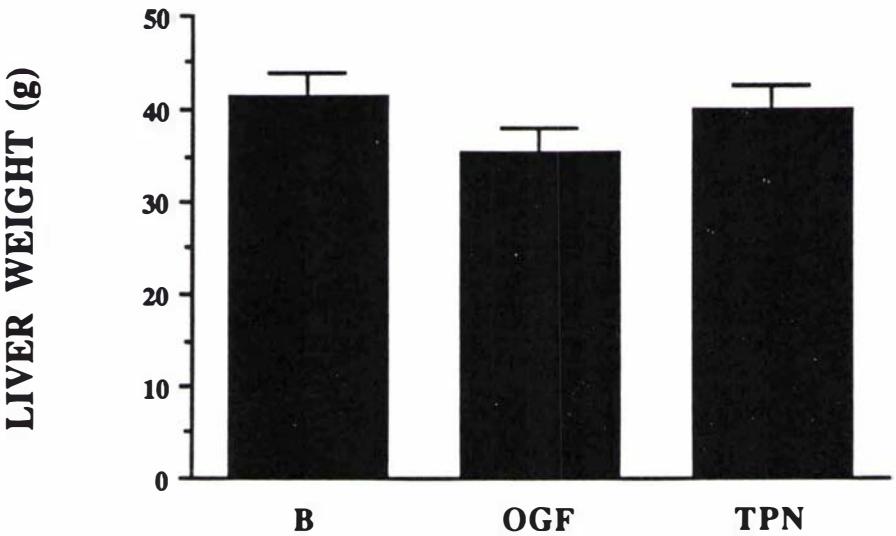
Figure 4.1 **Body weight change and liver and pancreatic weights of piglets collected at birth (B) or given nutrient solution by orogastric feeding (OGF) or total parenteral nutrition (TPN) for 24 hrs (mean ± S.E.).**

BODY WEIGHT CHANGE:
B vs OGF+TPN ***
B vs OGF ***
B vs TPN **

LIVER:
N.S.

PANCREAS:
N.S.


WEIGHT CHANGE (g)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
-0.02
B
OGF
TPN


LIVER WEIGHT (g)
50
40
30
20
10
0
B
OGF
TPN

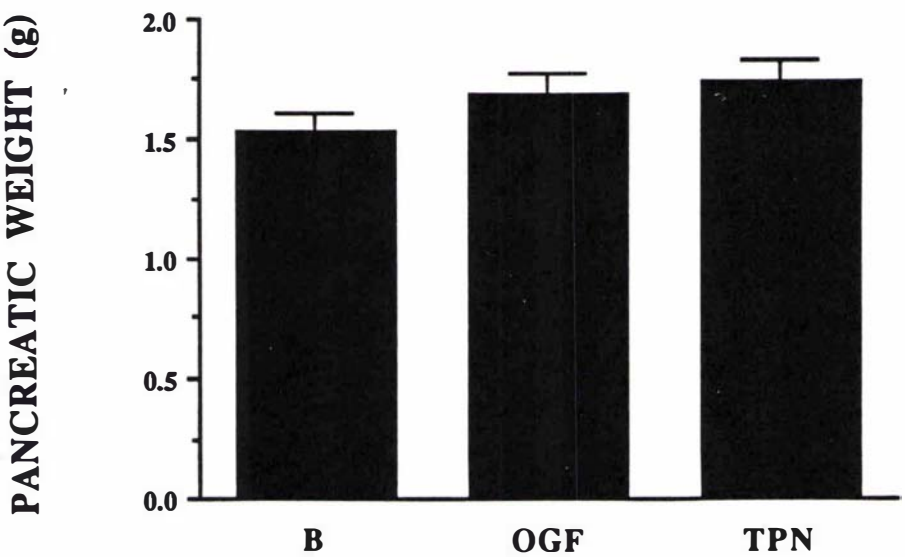

PANCREATIC WEIGHT (g)
2.0
1.5
1.0
0.5
0.0
B
OGF
TPN

Figure 4.2 **Length of the total small intestine (TOTAL), duodenum (DUO), jejunum (JEJ) and ileum (ILE) of piglets collected at birth (B) or given nutrient solution by orogastric tube feeding (OGF) or total parenteral nutrition (TPN) for 24 hrs (mean ± S.E.).**

TOTAL:
B vs OGF+TPN ***
B vs OGF ***
OGF vs TPN ***

DUO:
B vs OGF+TPN **
B vs OGF **
B vs TPN *

JEJ:
B vs OGF+TPN ***
B vs OGF ***
OGF vs TPN ***

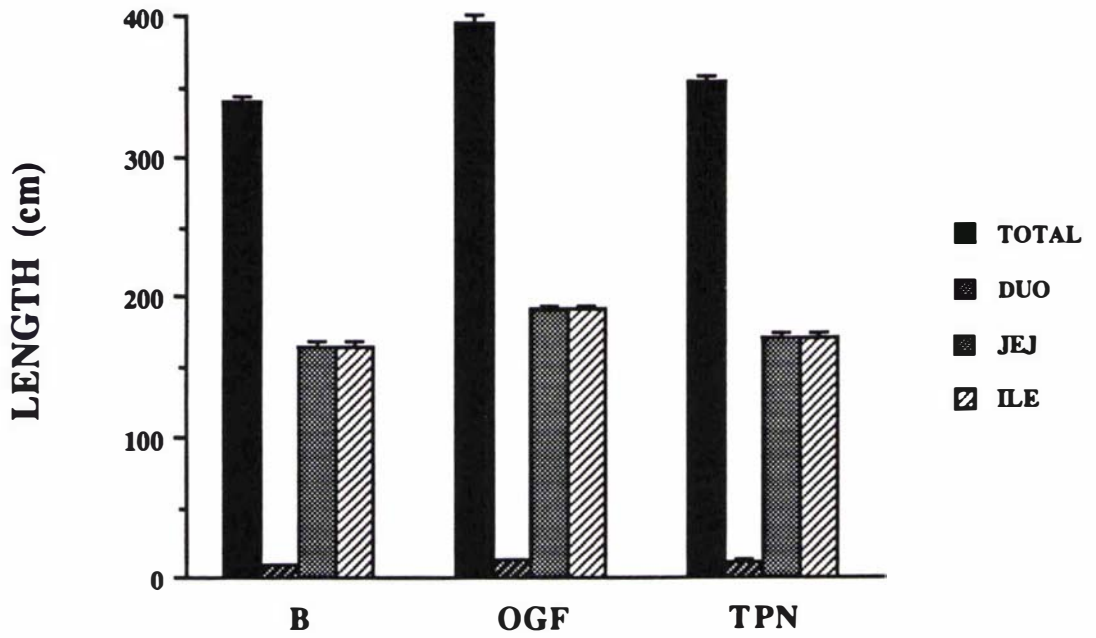
ILE:
B vs OGF+TPN ***
B vs OGF ***
OGF vs TPN ***

Figure 4.3 **Total weight of the intact small intestine (INTACT) and the intestinal mucosa (MUC) and muscle (MUS) of piglets collected at birth (B) or given nutrient solution by orogastric tube feeding (OGF) or total parenteral nutrition (TPN) for 24 hrs (mean ± S.E.).**

INTACT:
N.S.

MUC:
N.S.

MUS:
N.S.


LENGTH (cm)
400
300
200
100
0
B
OGF
TPN
TOTAL
DUO
JEJ
ILE

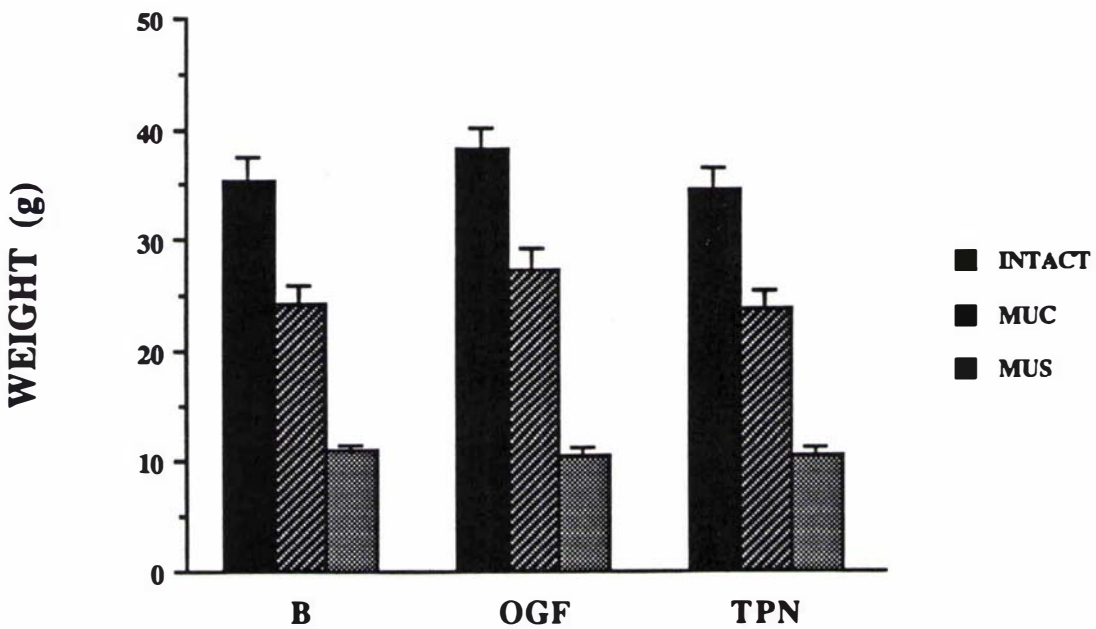

WEIGHT (g)
50
40
30
20
10
0
B
OGF
TPN
INTACT
MUC
MUS

Figure 4.4 **Intact weight of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B) or given nutrient solution by orogastric feeding (OGF) or total parenteral nutrition (TPN) for 24 hrs (mean ± S.E.).**

DUO:
B vs OGF+TPN *
B vs OGF *
B vs TPN *

UPJ:
N.S.

UPI:
N.S.

LOJ:
N.S.

LOI:
N.S.

Figure 4.5 **Mucosal weight of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B) or given nutrient solution by orogastric feeding (OGF) or total parenteral nutrition (TPN) for 24 hrs (mean ± S.E.).**

DUO:
B vs OGF+TPN **
B vs OGF **
B vs TPN **

UPJ:
N.S.

UPI:
N.S.

LOJ:
N.S.

LOI:
N.S.

Figure 4.6 **Muscular weight of the duodenum (DUO), upper jejunum UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B) or given nutrient solution by orogastric feeding (OGF) or total parenteral nutrition (TPN) for 24 hrs (mean ± S.E.).**

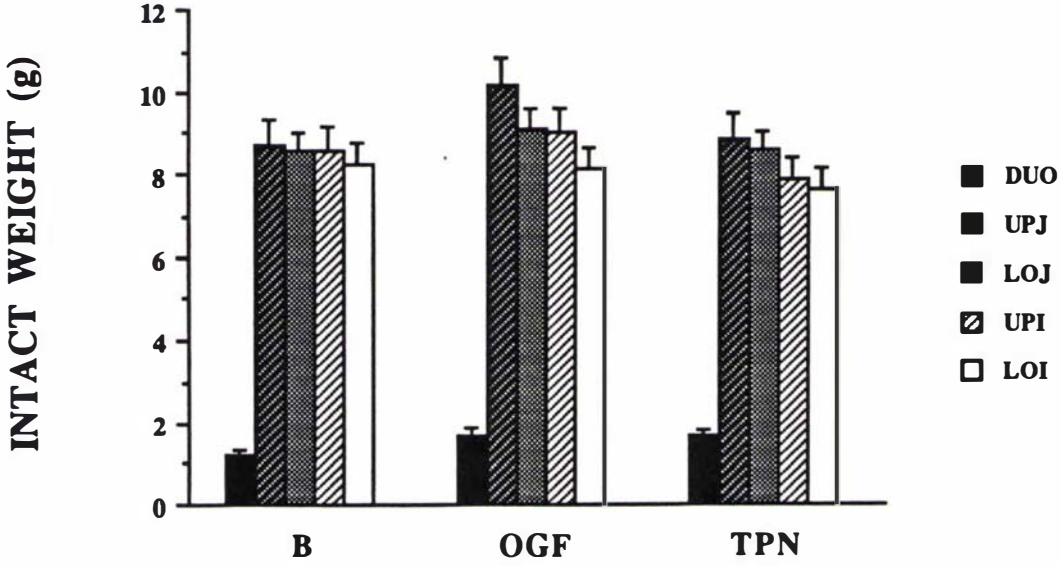
DUO:
N.S.

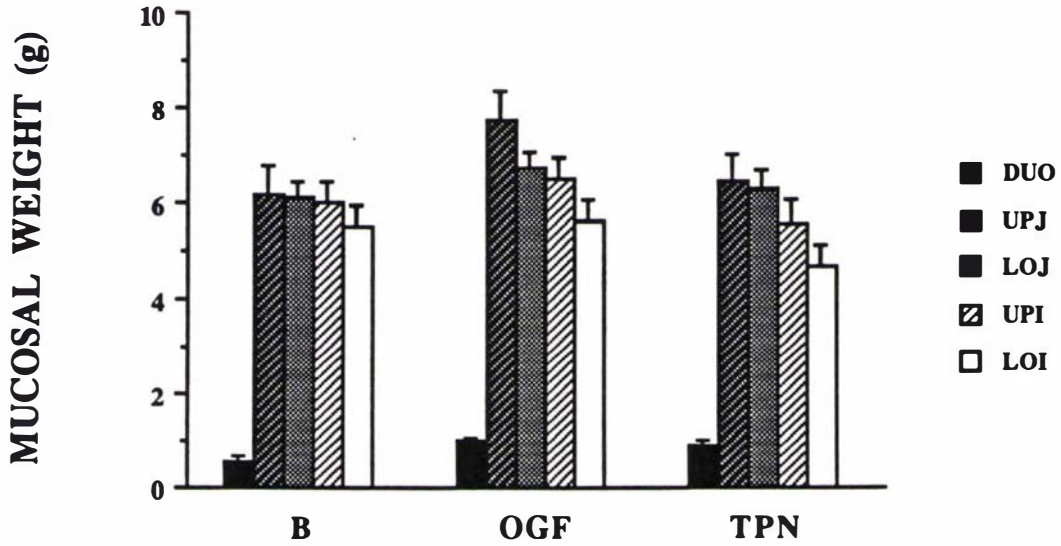
UPJ:
N.S.

UPI:
N.S.

LOJ:
N.S.

LOI:
N.S.


INTACT WEIGHT (g)
12
10
8
6
4
2
0
B
OGF
TPN
DUO
UPJ
LOJ
UPI
LOI


MUCOSAL WEIGHT (g)
10
8
6
4
2
0
B
OGF
TPN
DUO
UPJ
LOJ
UPI
LOI

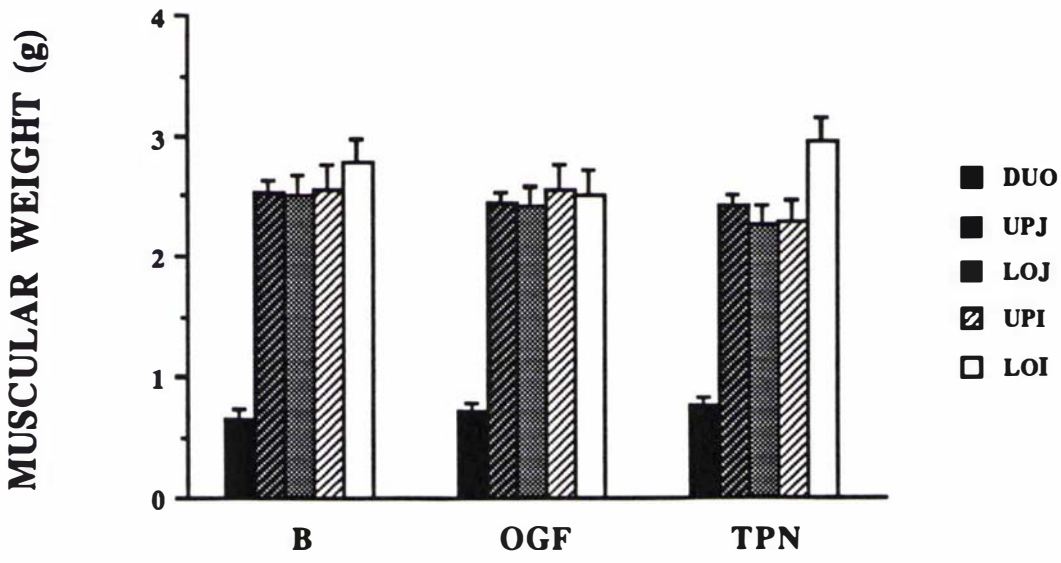

MUSCULAR WEIGHT (g)
4
3
2
1
0
B
OGF
TPN
DUO
UPJ
LOJ
UPI
LOI

Figure 4.7 **Wall thickness of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B) or given nutrient solution by orogastric feeding (OGF) or total parenteral nutrition (TPN) for 24 hrs (mean ± S.E.).**

DUO:
B vs OGF+TPN *
B vs OGF *

UPJ:
N.S.

UPI:
N.S.

LOJ:
N.S.

LOI:
B vs OGF+TPN **
B vs OGF *
B vs TPN *

Figure 4.8 **Crypt depth of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B) or given nutrient solution by orogastric feeding (OGF) or total parenteral nutrition (TPN) for 24 hrs (mean ± S.E.).**

DUO:
B vs OGF+TPN **
B vs TPN **

UPJ:
N.S.

UPI:
N.S.

LOJ:
N.S.

LOI:
N.S.

Figure 4.9 **Circumference of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B) or given nutrient solution by orogastric feeding (OGF) or total parenteral nutrition (TPN) for 24 hrs (mean ± S.E.).**

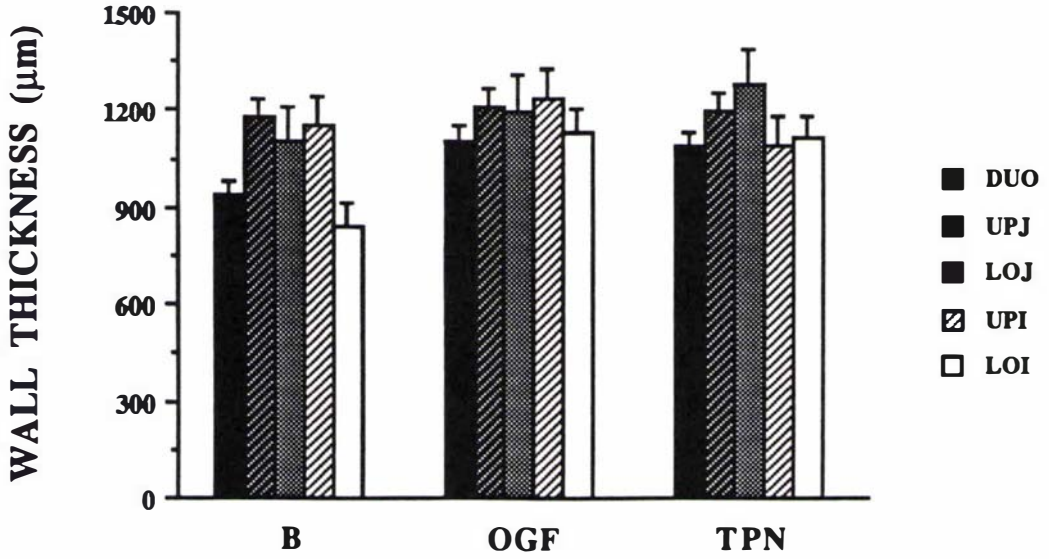
DUO:
N.S.

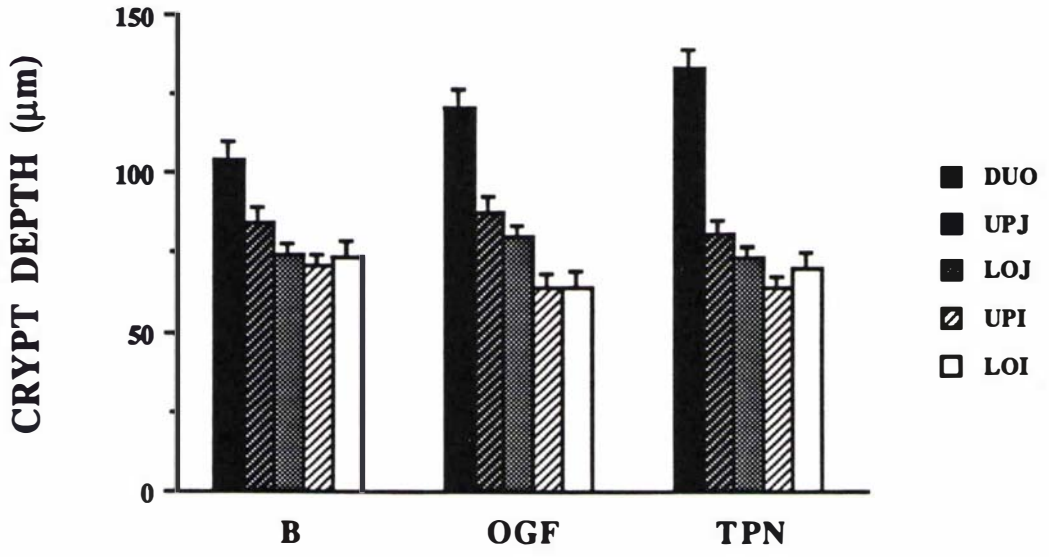
UPJ:
N.S.

UPI:
N.S.

LOJ:
N.S.

LOI:
B vs OGF+TPN *


WALL THICKNESS (µm)
1500
1200
900
600
300
0
B
OGF
TPN
DUO
UPJ
LOJ
UPI
LOI


CRYPT DEPTH (µm)
150
100
50
0
B
OGF
TPN
DUO
UPJ
LOJ
UPI
LOI

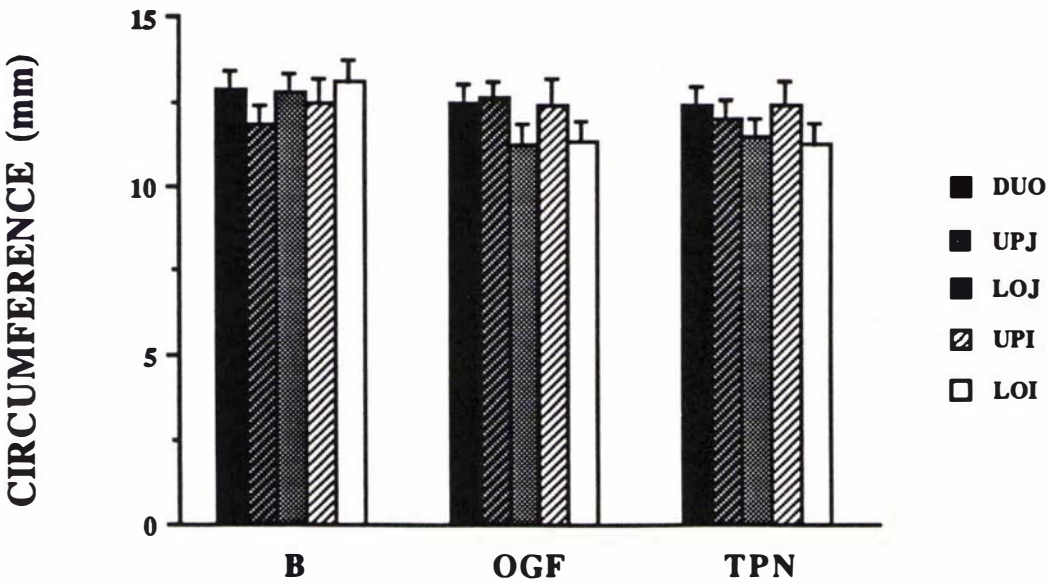

CIRCUMFERENCE (mm)
15
10
5
0
B
OGF
TPN
DUO
UPJ
LOJ
UPI
LOI

Figure 4.10 **Muscular thickness of the duodenum (DUO), upper jejunum(UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B) or given nutrient solution by orogastric feeding (OGF) or total parenteral nutrition (TPN) for 24 hrs (mean ± S.E.).**

DUO:
N.S.

UPJ:
N.S.

LOJ:
B vs TPN *

UPI:
N.S.

LOI:
B vs OGF+TPN **
B vs OGF *
B vs TPN **

Figure 4.11 **Villous height of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B) or given nutrient solution by orogastric feeding (OGF) or total parenteral nutrition (TPN) for 24 hrs (mean ± S.E.).**

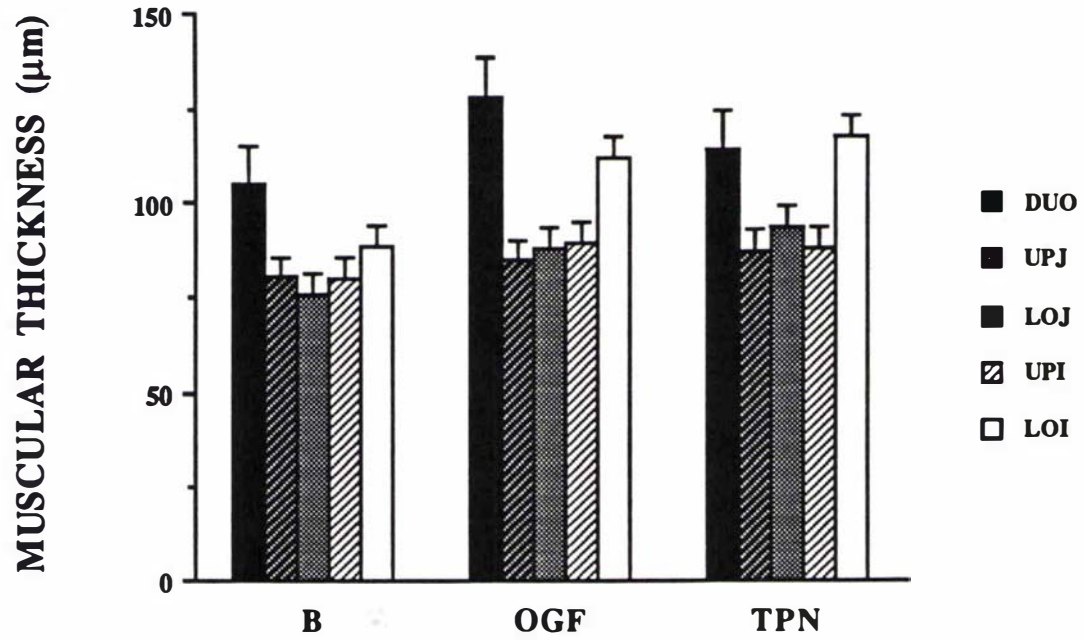
DUO:
B vs OGF+TPN **
B vs OGF *
B vs TPN *

UPJ:
N.S.

LOJ:
N.S.

UPI:
N.S.

LOI:
B vs OGF *


MUSCULAR THICKNESS (µm)
150
100
50
0
B
OGF
TPN
DUO
UPJ
LOJ
UPI
LOI

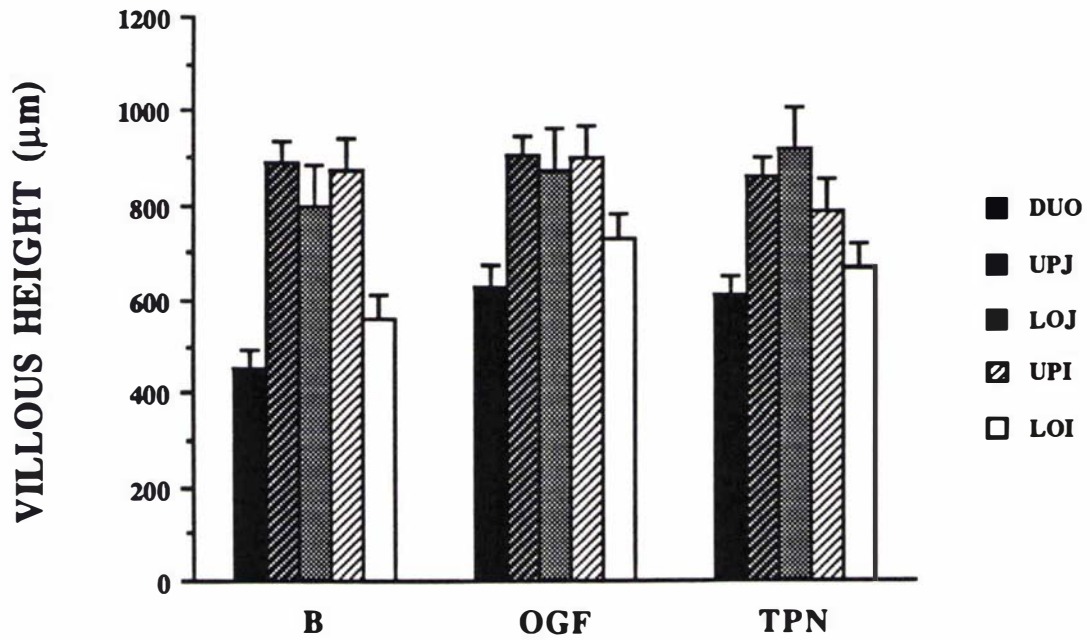
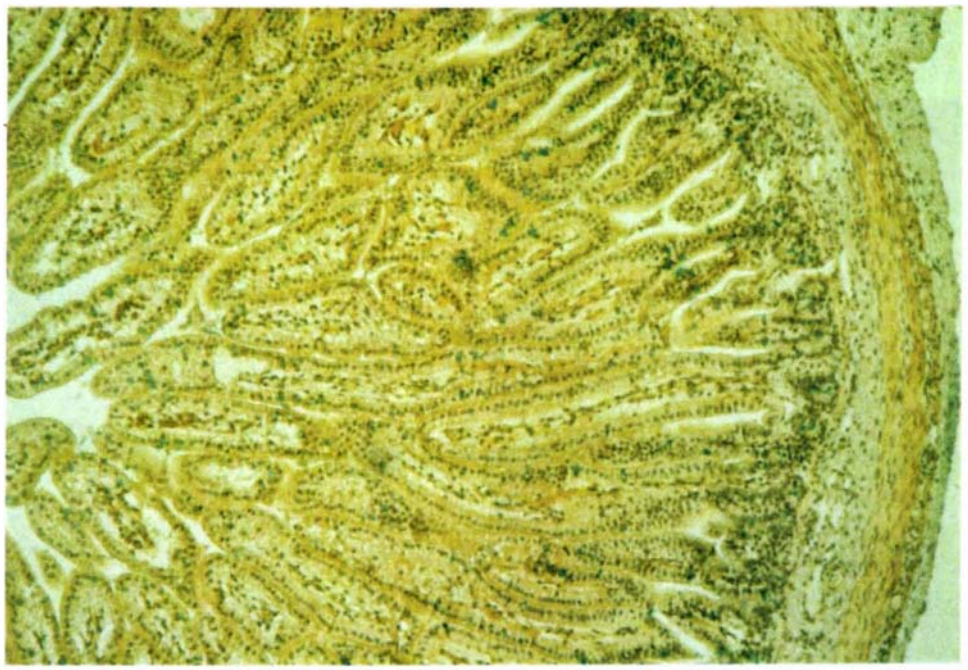
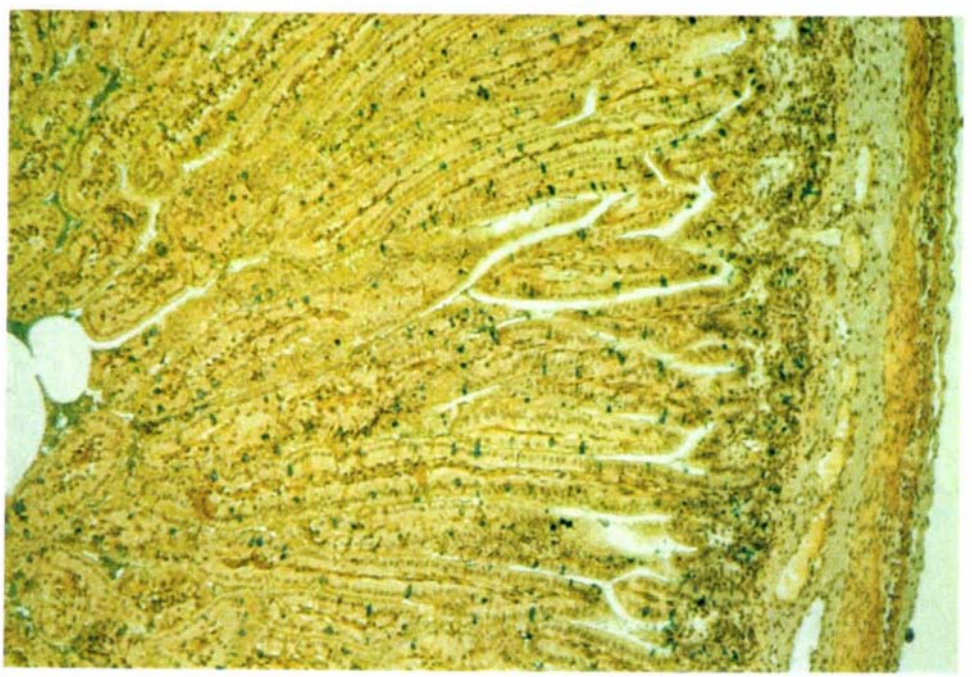

VILLOUS HEIGHT (µm)
1200
1000
800
600
400
200
0
B
OGF
TPN
DUO
UPJ
LOJ
UPI
LOI

Figure 4.12 **Villi in the upper ileum of the piglets given nutrient solution by orogastric feeding (OGF) or total parenteral nutrition (TPN) for 24 hrs. Note no difference of the villi between the two groups, except that in the TPN group sectioned villi appear more compact. (Alcian Blue, Hematoxylin, van Gieson; magnification x 96)**

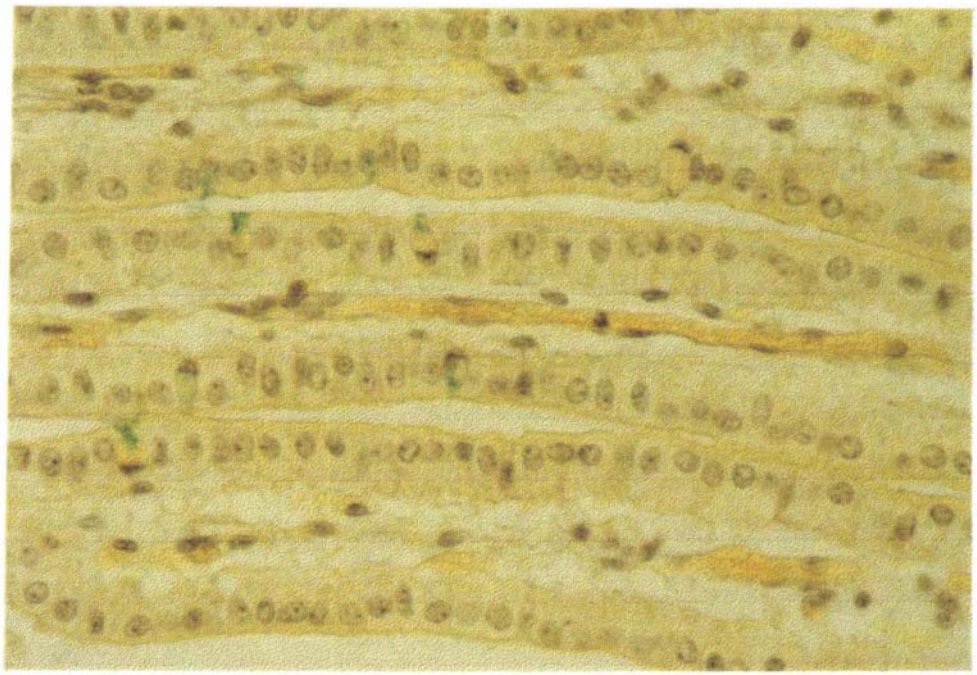


OGF



TPN

Figure 4.13 Villi in the upper ileum of the piglets given nutrient solution by orogastric feeding (OGF) or total parenteral nutrition (TPN) for 24 hrs. Note no difference of the villous cells between the two groups, except the ratio of goblet cells appears elevated in the TPN group. (Alcian Blue, Hematoxylin, van Gieson; magnification x 428)



OGF

TPN

Figure 4.14 Villous width of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B) or given nutrient solution by orogastric feeding (OGF) or total parenteral nutrition (TPN) for 24 hrs (mean ± S.E.).

DUO:
N.S.

UPJ:
B vs OGF+TPN *
B vs TPN **
OGF vs TPN **

UPI:
B vs OGF+TPN ***
B vs OGF ***
B vs TPN ***

LOJ:
B vs TPN *

LOI:
B vs OGF+TPN ***
B vs OGF ***
B vs TPN ***

Figure 4.15 Submucosal thickness of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B) or given nutrient solution by orogastric feeding (OGF) or total parenteral nutrition (TPN) for 24 hrs (mean ± S.E.).

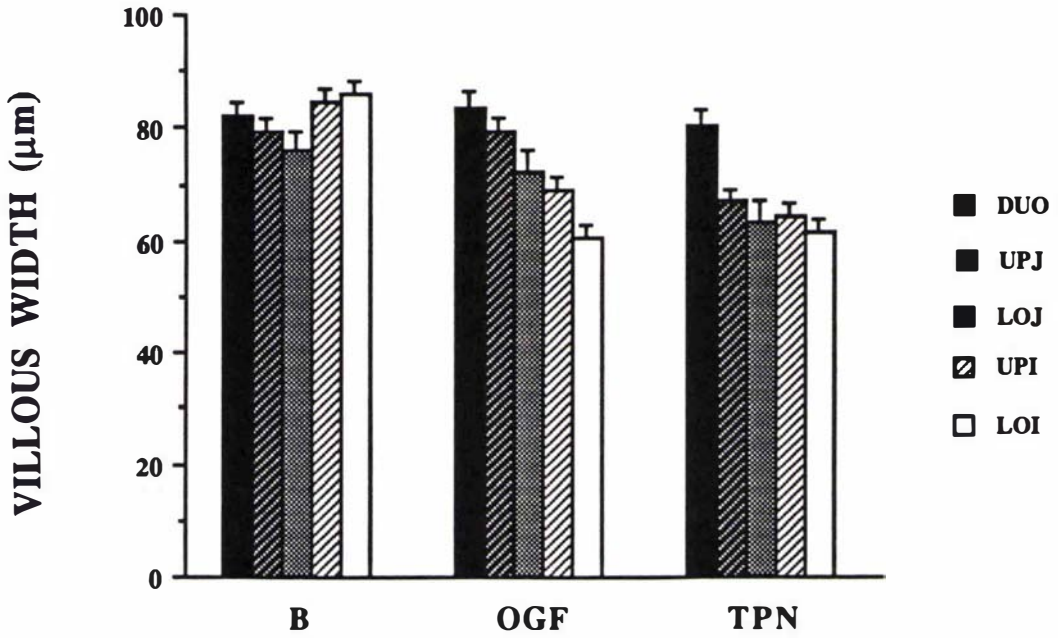
DUO:
B vs OGF+TPN *
B vs OGF *

UPJ:
B vs OGF+TPN *

UPI:
N.S.

LOJ:
N.S.

LOI:
N.S.


VILLOUS WIDTH (μm)
100
80
60
40
20
0
B
OGF
TPN
DUO
UPJ
LOJ
UPI
LOI

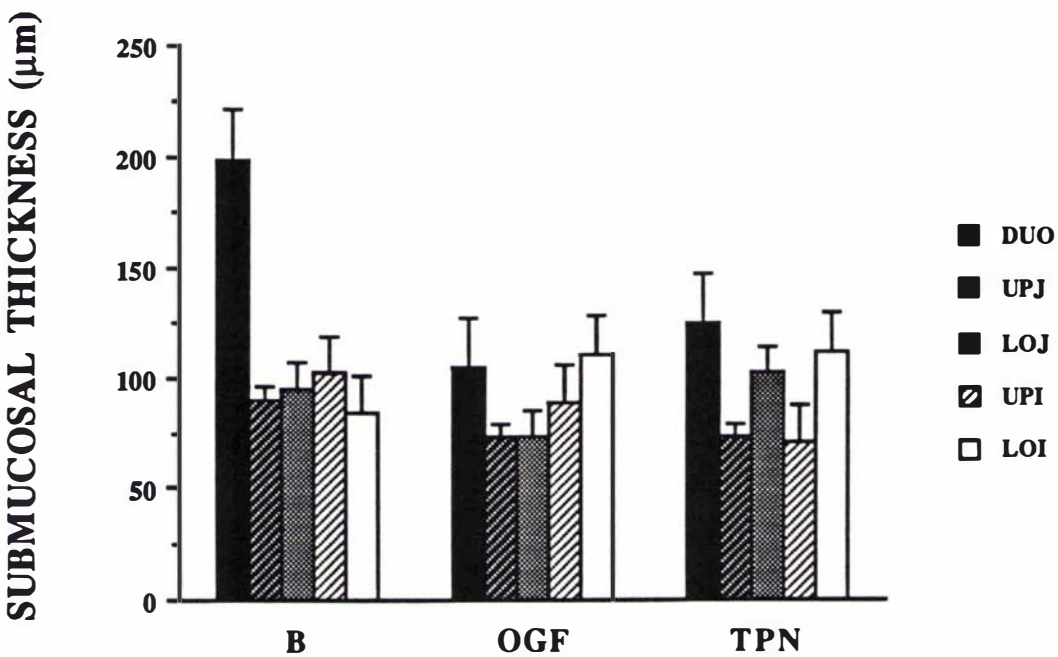

SUBMUCOSAL THICKNESS (μm)
250
200
150
100
50
0
B
OGF
TPN
DUO
UPJ
LOJ
UPI
LOI

Figure 4.16 **Number of labelled dividing cells per crypt area from the duodenum (DUO), upper jejunum(UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets given nutrient solution by orogastric feeding (OGF) or total parenteral nutrition (TPN) for 24 hrs (mean ± S.E.).**

DUO:
N.S.

UPJ:
N.S.

UPI:
N.S.

LOJ:
N.S.

LOI:
N.S.

Figure 4.17 **The relative migration distance of the labelled dividing cells of the duodenum (DUO), upper jejunum(UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets given nutrient solution by orogastric feeding (OGF) or total parenteral nutrition (TPN) for 24 hrs (mean ± S.E.).**

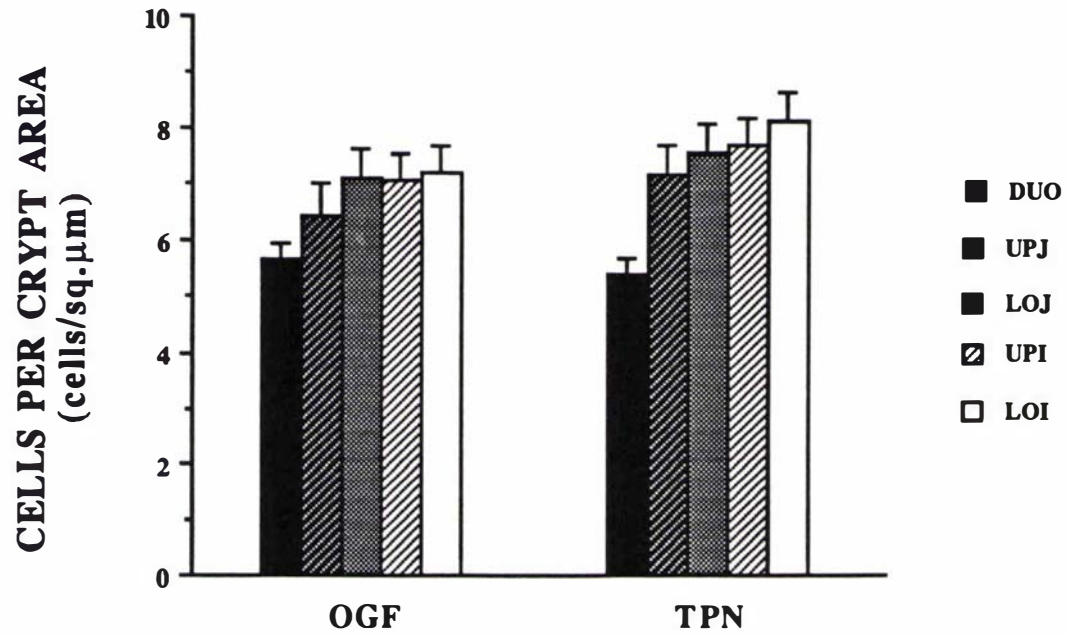
DUO:
N.S.

UPJ:
N.S.

UPI:
N.S.

LOJ:
N.S.

LOI:
N.S.


CELLS PER CRYPT AREA
(cells/sq.µm)
10
8
6
4
2
0
OGF
TPN
DUO
UPJ
LOJ
UPI
LOI

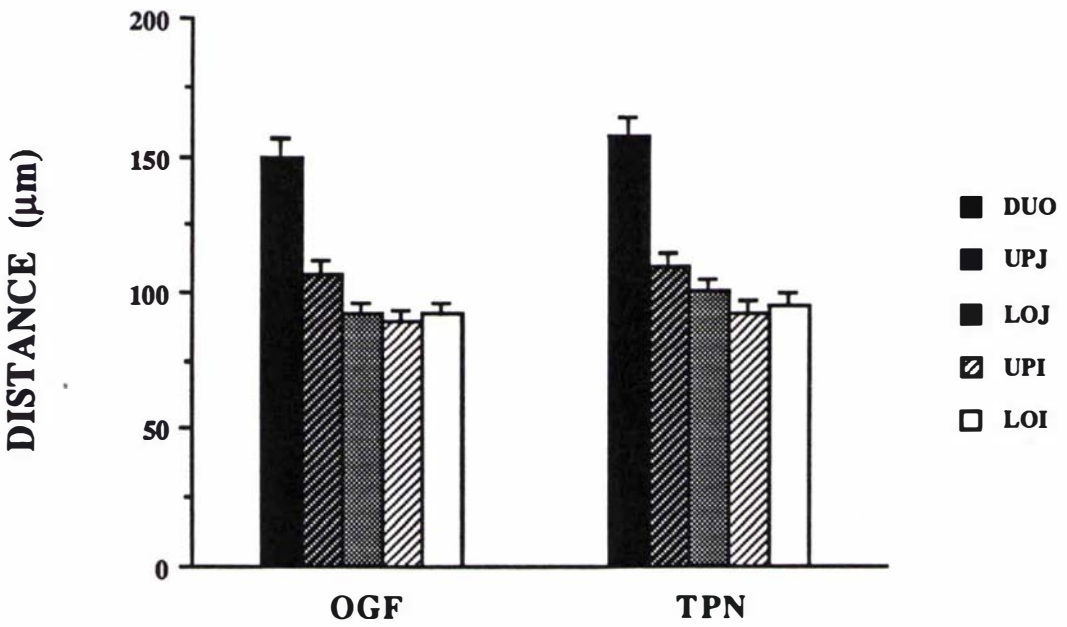

DISTANCE (µm)
200
150
100
50
0
OGF
TPN
DUO
UPJ
LOJ
UPI
LOI

Figure 4.18 **Mucosal DNA concentration of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B) or given nutrient solution by orogastric feeding (OGF) or total parenteral nutrition (TPN) for 24 hrs (mean ± S.E.).**

DUO:
***B vs OGF+TPN* ***
***B vs TPN* ***

UPJ:
***B vs TPN* ***

UPI:
***B vs OGF+TPN* ***
B vs OGF*

LOJ:
N.S.

LOI:
***B vs OGF+TPN* ***
***B vs TPN* ***

Figure 4.19 **Mucosal DNA content of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B) or given nutrient solution by orogastric feeding (OGF) or total parenteral nutrition (TPN) for 24 hrs (mean ± S.E.).**

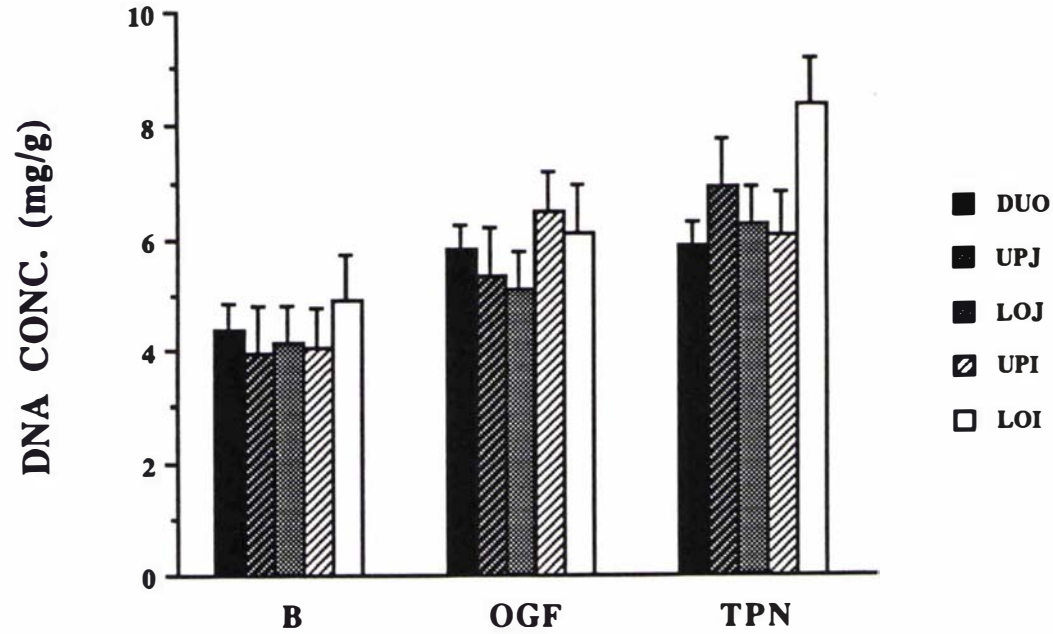
DUO:
B vs OGF+TPN* *
B vs OGF* *
B vs TPN* *

UPJ:
***B vs OGF+TPN* ***
B vs TPN* *

UPI:
B vs OGF+TPN* *
B vs OGF* *
***B vs TPN* ***

LOJ:
***B vs OGF+TPN* ***
B vs TPN* *

LOI:
N.S.


DNA CONC. (mg/g)
10
8
6
4
2
0
B
OGF
TPN
DUO
UPJ
LOJ
UPI
LOI

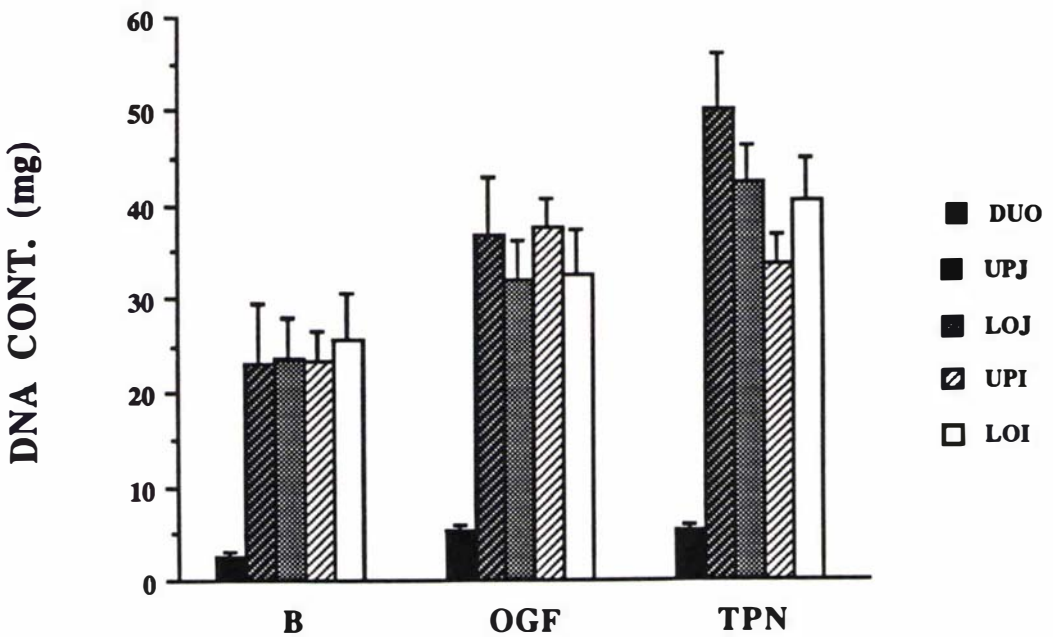

DNA CONT. (mg)
60
50
40
30
20
10
0
B
OGF
TPN
DUO
UPJ
LOJ
UPI
LOI

Figure 4.20 **Mucosal RNA concentration of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B) or given nutrient solution by orogastric feeding (OGF) or total parenteral nutrition (TPN) for 24 hrs (mean ± S.E.).**

DUO:
N.S.

UPJ:
N.S.

UPI:
N.S.

LOJ:
N.S.

LOI:
N.S.

Figure 4.21 **Mucosal RNA content of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B) or given nutrient solution by orogastric feeding (OGF) or total parenteral nutrition (TPN) for 24 hrs (mean ± S.E.).**

DUO:
***B vs OGF+TPN* ***
***B vs OGF* ***

UPJ:
N.S.

UPI:
N.S.

LOJ:
N.S.

LOI:
N.S.

Figure 4.22 **Mucosal RNA:DNA ratio of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B) or given nutrient solution by orogastric feeding (OGF) or total parenteral nutrition (TPN) for 24 hrs (mean ± S.E.).**

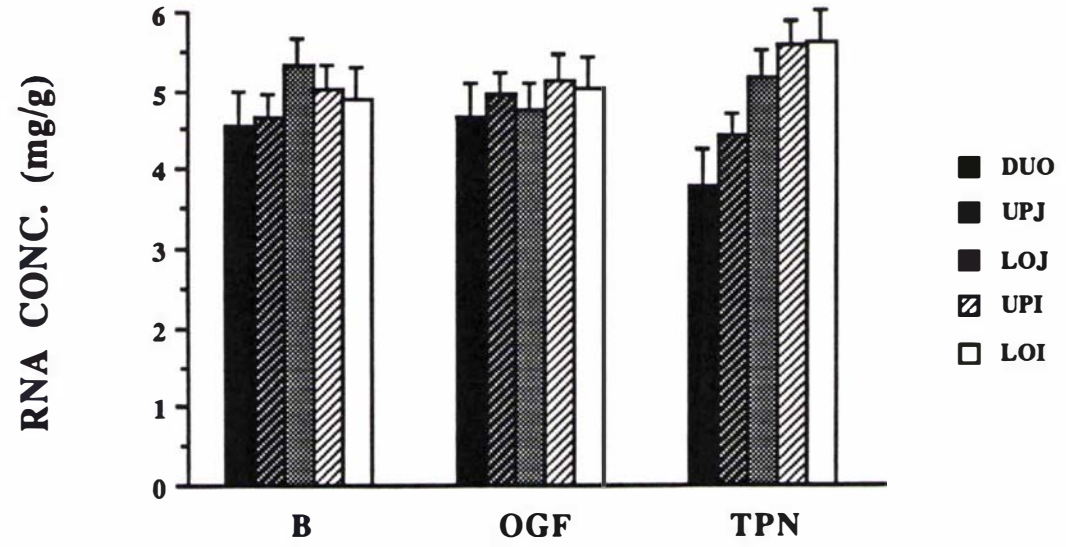
DUO:
N.S.

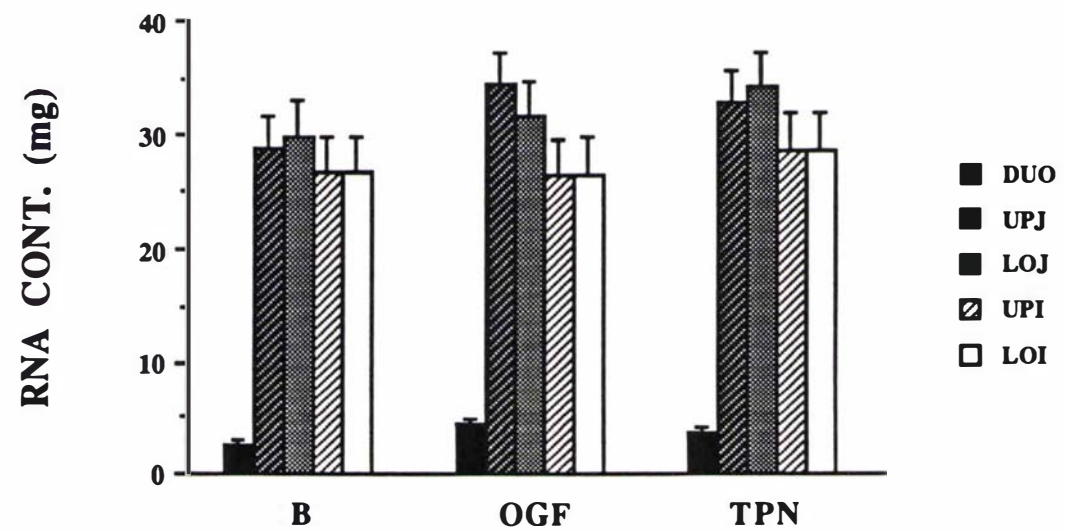
UPJ:
***B vs OGF+TPN* ***
***B vs TPN* ***

UPI:
N.S.

LOJ:
***B vs OGF+TPN* ***
***B vs TPN* ***

LOI:
N.S.


RNA CONC. (mg/g)
6
5
4
3
2
1
0
B
OGF
TPN
DUO
UPJ
LOJ
UPI
LOI


RNA CONT. (mg)
40
30
20
10
0
B
OGF
TPN
DUO
UPJ
LOJ
UPI
LOI

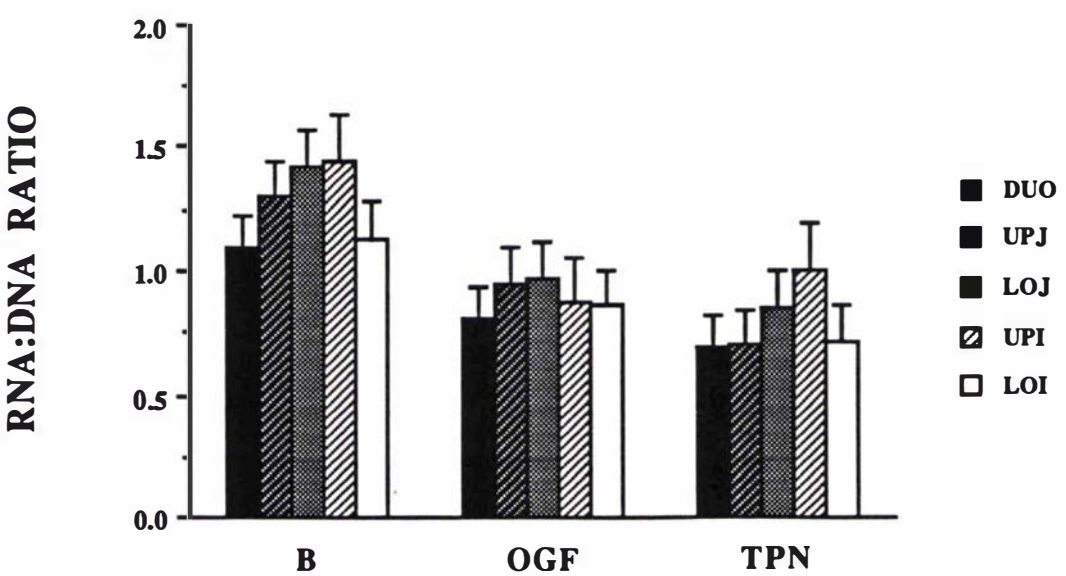

RNA:DNA RATIO
2.0
1.5
1.0
0.5
0.0
B
OGF
TPN
DUO
UPJ
LOJ
UPI
LOI

Figure 4.23 **Mucosal protein concentration of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B) or given nutrient solution by orogastric feeding (OGF) or total parenteral nutrition (TPN) for 24 hrs (mean ± S.E.).**

DUO:
N.S.

UPJ:
N.S.

UPI:
N.S.

LOJ:
N.S.

LOI:
B vs OGF+TPN *
B vs TPN **

Figure 4.24 **Mucosal protein content of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B) or given nutrient solution by orogastric feeding (OGF) or total parenteral nutrition (TPN) for 24 hrs (mean ± S.E.).**

DUO:
B vs OGF+TPN **
B vs OGF *
B vs TPN *

UPJ:
N.S.

UPI:
N.S.

LOJ:
N.S.

LOI:
N.S.

Figure 4.25 **Mucosal protein:DNA ratio of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B) or given nutrient solution by orogastric feeding (OGF) or total parenteral nutrition (TPN) for 24 hrs (mean ± S.E.).**

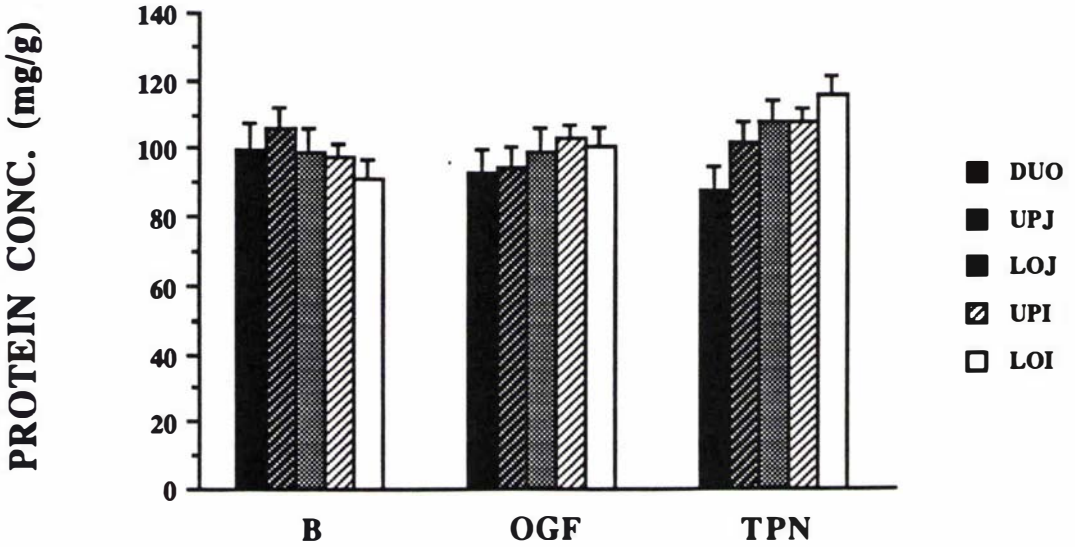
DUO:
B vs OGF+TPN **
B vs OGF *
B vs TPN *

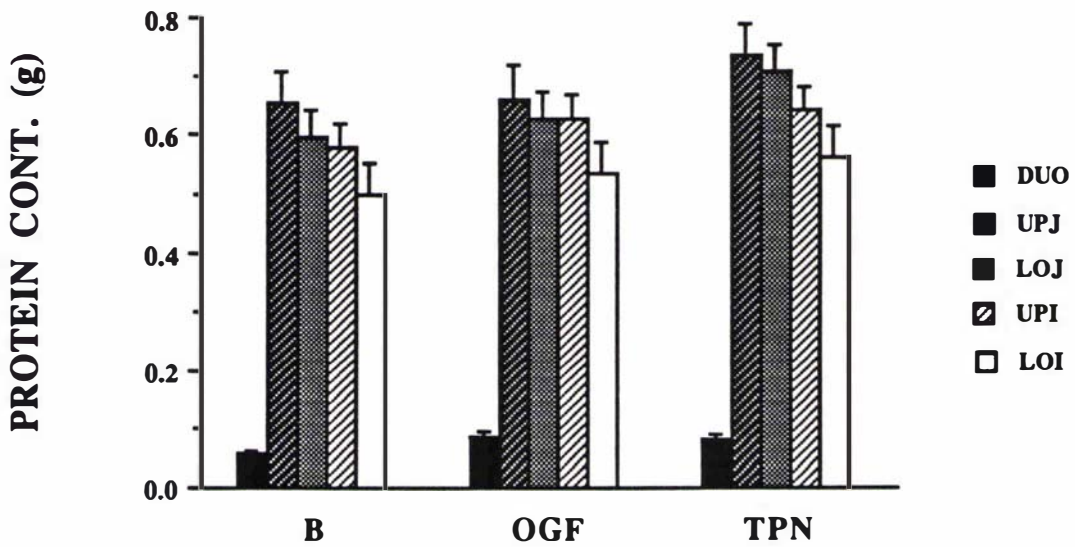
UPJ:
B vs OGF+TPN *
B vs OGF *
B vs TPN *

UPI:
B vs OGF+TPN *

LOJ:
N.S.

LOI:
N.S.


PROTEIN CONC. (mg/g)
140
120
100
80
60
40
20
0
B
OGF
TPN
DUO
UPJ
LOJ
UPI
LOI


PROTEIN CONT. (g)
0.8
0.6
0.4
0.2
0.0
B
OGF
TPN
DUO
UPJ
LOJ
UPI
LOI

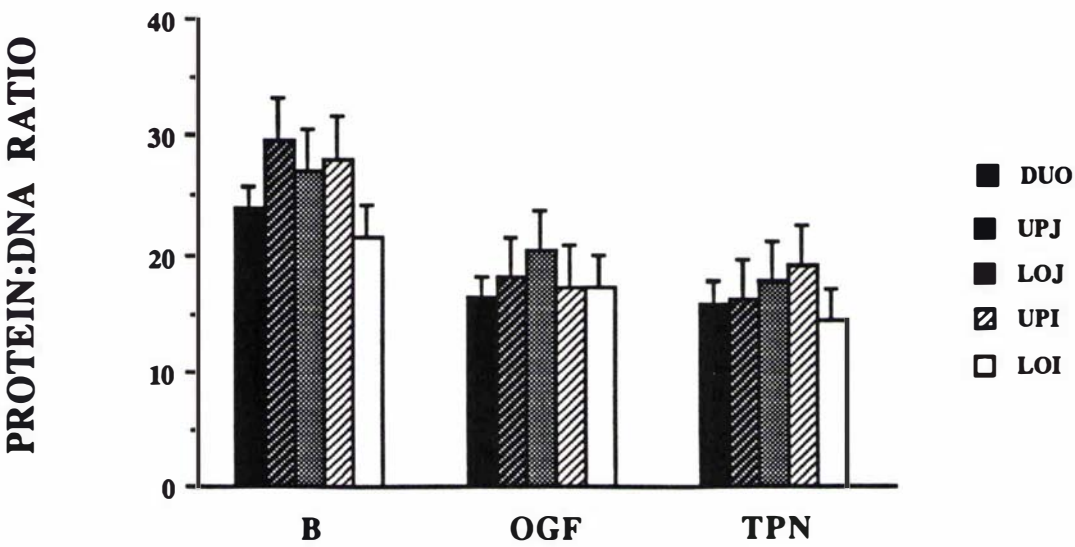

PROTEIN:DNA RATIO
40
30
20
10
0
B
OGF
TPN
DUO
UPJ
LOJ
UPI
LOI

Figure 4.26 **Lactase activity per mucosal weight of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B) or given nutrient solution by orogastric feeding (OGF) or total parenteral nutrition (TPN) for 24 hrs (mean ± S.E.).**

DUO:
N.S.

UPJ:
N.S.

UPI:
N.S.

LOJ:
N.S.

LOI:
N.S.

Figure 4.27 **Total lactase activity of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B) or given nutrient solution by orogastric feeding (OGF) or total parenteral nutrition (TPN) for 24 hrs (mean ± S.E.).**

DUO:
N.S.

UPJ:
N.S.

UPI:
N.S.

LOJ:
N.S.

LOI:
N.S.

Figure 4.28 **Lactase activity per DNA weight of the duodenum (DUO), npper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets collected at birth (B) or given nutrient solution by orogastric feeding (OGF) or total parenteral nutrition (TPN) for 24 hrs (mean ± S.E.).**

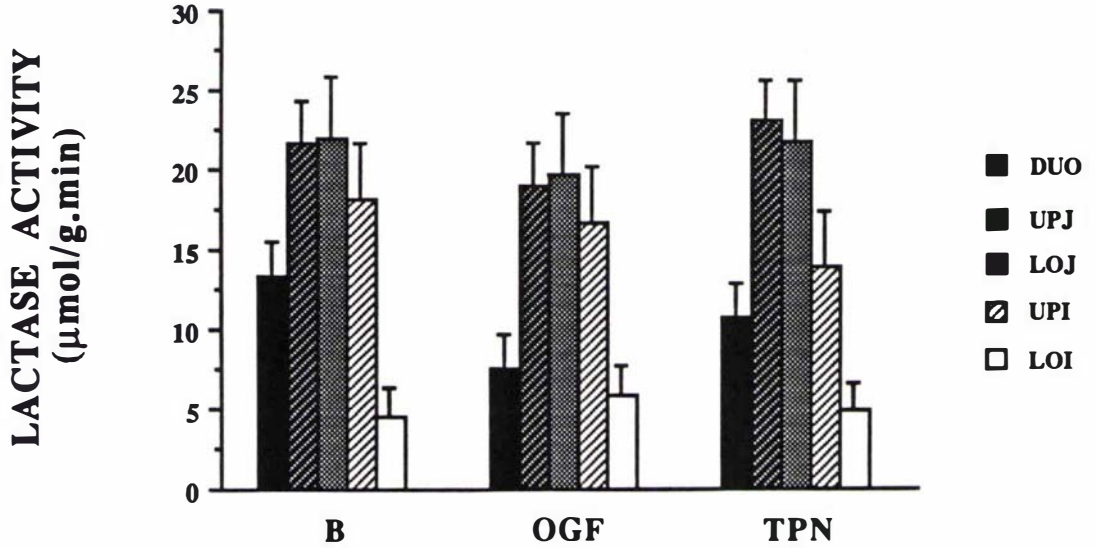
DUO:
B vs OGF+TPN *
B vs OGF *

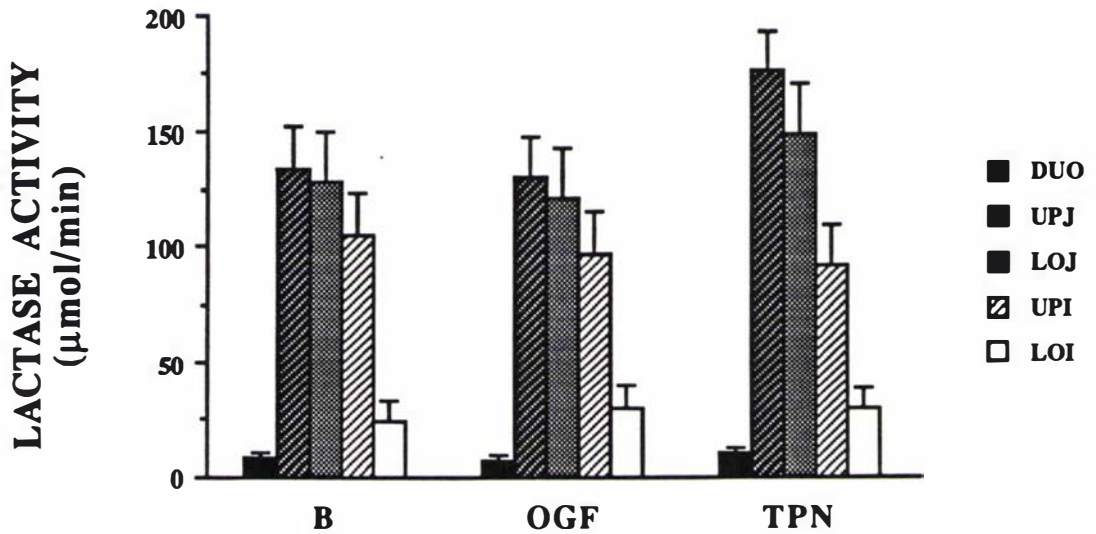
UPJ:
N.S.

UPI:
B vs OGF+TPN *

LOJ:
B vs OGF+TPN *
B vs TPN *

LOI:
N.S.


LACTASE ACTIVITY
(µmol/g.min)
30
25
20
15
10
5
0
B
OGF
TPN
DUO
UPJ
LOJ
UPI
LOI


LACTASE ACTIVITY
(µmol/min)
200
150
100
50
0
B
OGF
TPN
DUO
UPJ
LOJ
UPI
LOI

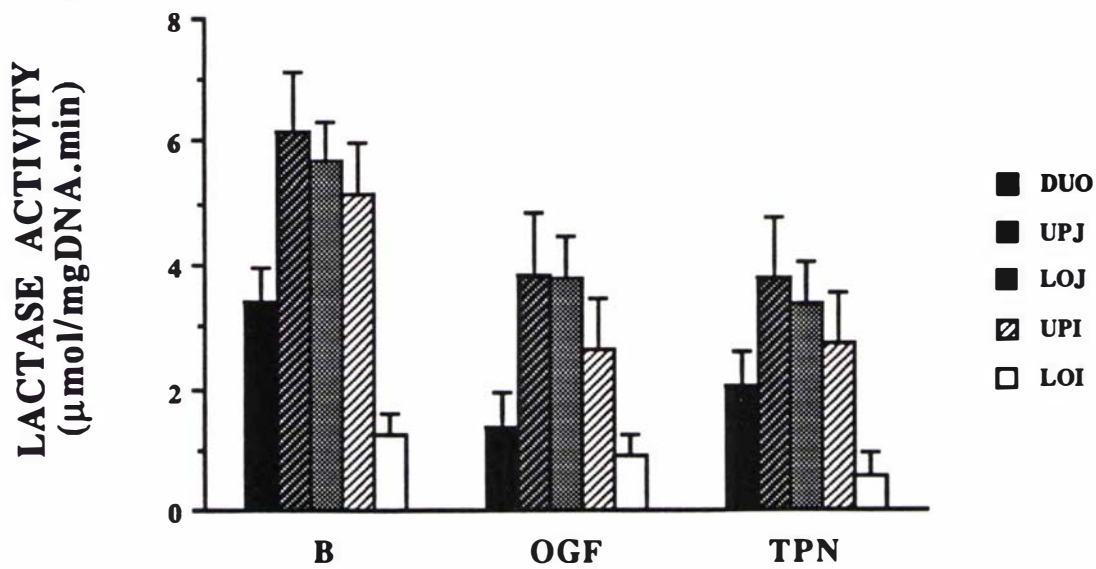
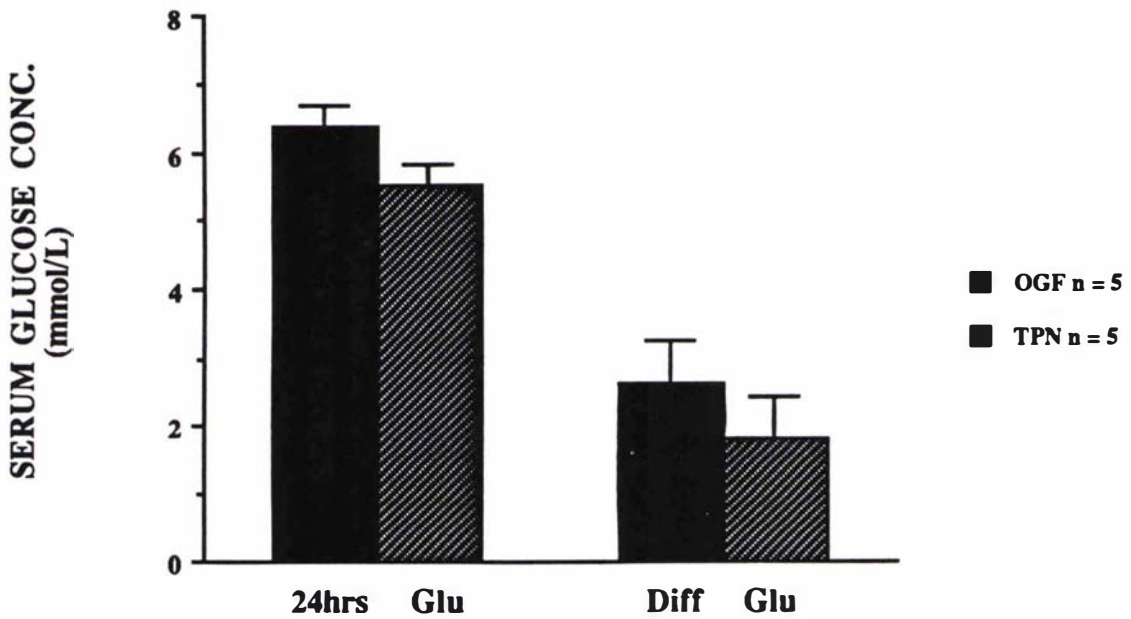

LACTASE ACTIVITY
(µmol/mgDNA.min)
8
6
4
2
0
B
OGF
TPN
DUO
UPJ
LOJ
UPI
LOI

Figure 4.29 **Serum glucose concentrations at 24 hours (24hrs Glu) and the difference between at birth and 24 hours (Diff Glu) of the piglets given nutrient solution by orogastric feeding (OGF) or total parenteral nutrition (TPN) for 24 hrs (mean ± S.E.).**

24hrs Glu:
N.S.

Diff Glu:
N.S.


SERUM GLUCOSE CONC.
(mmol/L)
8
6
4
2
0
24hrs Glu
Diff Glu
OGF n = 5
TPN n = 5

CHAPTER 5

EFFECTS OF SUCKING AND OROGASTRIC FEEDING ON POSTNATAL DEVELOPMENT OF THE SMALL INTESTINE IN PIGLETS DURING THE FIRST 24 HOURS AFTER BIRTH

FIGURES

Figure 5.1 **Body weight change and liver and pancreatic weights of piglets given either sow colostrum (SC) or infant formula (IF) by sucking (S) or orogastric feeding (OGF) for 24 hrs. Data for piglets collected at birth (B) and naturally suckled (NS) for 24 hrs are included for reference (mean ± S.E.).**

BODY WEIGHT CHANGE:
SC-S+SC-OGF vs IF-S+IF-OGF *
SC-OGF vs IF-S **

LIVER:
SC-S+SC-OGF vs IF-S+IF-OGF *
SC-S vs IF-OGF *

PANCREAS:
N.S.

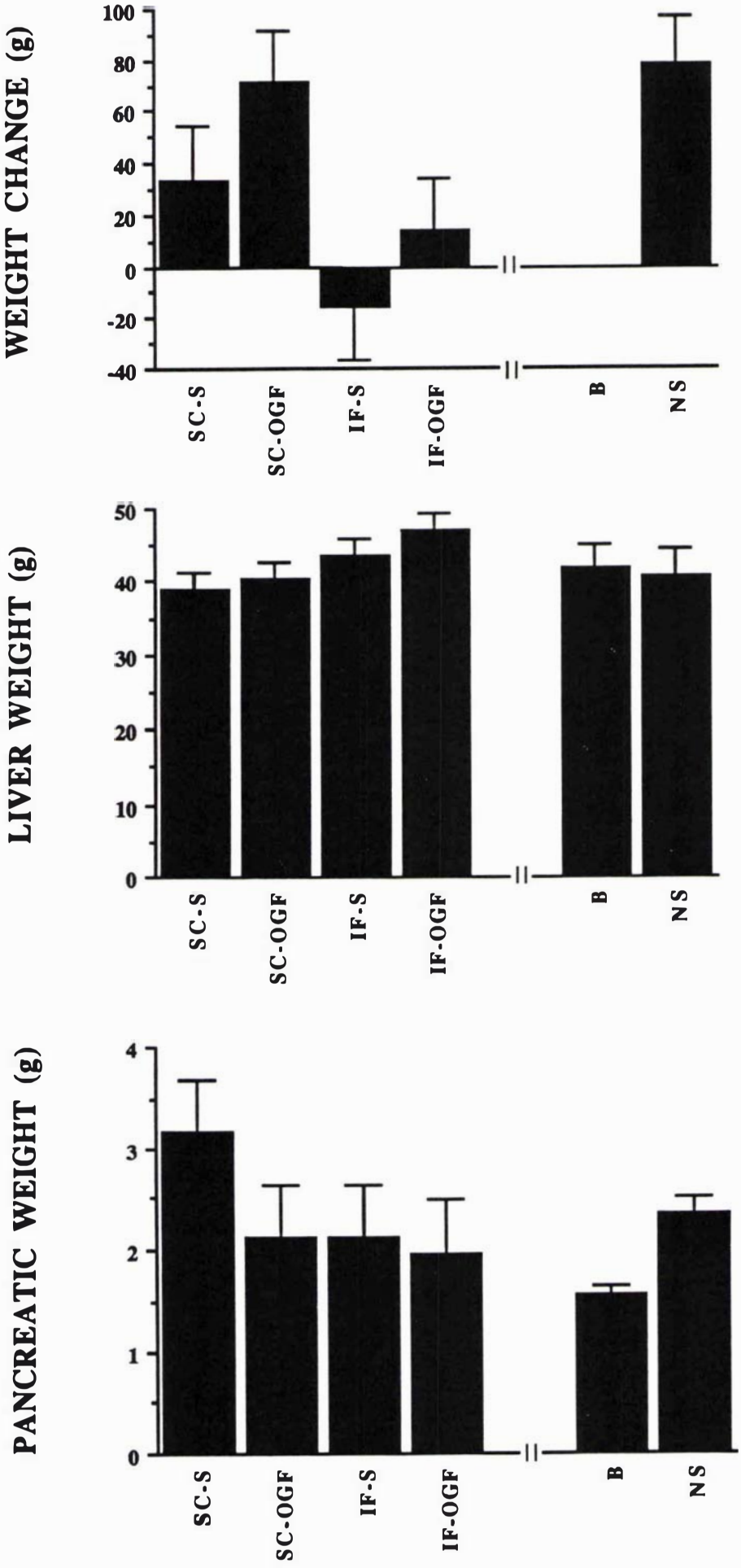

WEIGHT CHANGE (g)
100
80
60
40
20
0
-20
-40
SC-S
SC-OGF
IF-S
IF-OGF
B
NS
LIVER WEIGHT (g)
50
40
30
20
10
0
SC-S
SC-OGF
IF-S
IF-OGF
B
NS
PANCREATIC WEIGHT (g)
4
3
2
1
0
SC-S
SC-OGF
IF-S
IF-OGF
B
NS

Figure 5.2 **Length of the total small intestine (TOTAL), duodenum (DUO), jejunum (JEJ) and ileum (ILE) of piglets given either sow colostrum (SC) or infant formula (IF) by sucking (S) or orogastric feeding (OGF) for 24 hrs. Data for piglets collected at birth (B) and naturally suckled (NS) for 24 hrs are included for reference (mean ± S.E.).**

TOTAL:
SC-S+SC-OGF vs IF-S+IF-OGF ******
SC-OGF vs IF-S ******
SC-OGF vs IF-OGF *****

DUO:
N.S.

JEJ:
SC-S+SC-OGF vs IF-S+IF-OGF ******
SC-OGF vs IF-S ******
SC-OGF vs IF-OGF *****

ILE:
SC-S+SC-OGF vs IF-S+IF-OGF ******
SC-OGF vs IF-S ******
SC-OGF vs IF-OGF *****

Figure 5.3 **Total weight of the intact small intestine (INTACT) and the intestinal mucosa (MUC) and muscle (MUS) of piglets given either sow colostrum (SC) or infant formula (IF) by sucking (S) or orogastric feeding (OGF) for 24 hrs. Data for piglets collected at birth (B) and naturally suckled (NS) for 24 hrs are included for reference (mean ± S.E.).**

INTACT:
SC-S+SC-OGF vs IF-S+IF-OGF *******
SC-S vs IF-S *******
SC-S vs IF-OGF *******
SC-OGF vs IF-S *******
SC-OGF vs IF-OGF *******

MUC:
SC-S+SC-OGF vs IF-S+IF-OGF *******
SC-S vs IF-S *******
SC-S vs IF-OGF *******
SC-OGF vs IF-S *******
SC-OGF vs IF-OGF *******

MUS:
SC-S+SC-OGF vs IF-S+IF-OGF *******
SC-S vs IF-S *******
SC-S vs IF-OGF *****
SC-OGF vs IF-S *******
SC-OGF vs IF-OGF *****

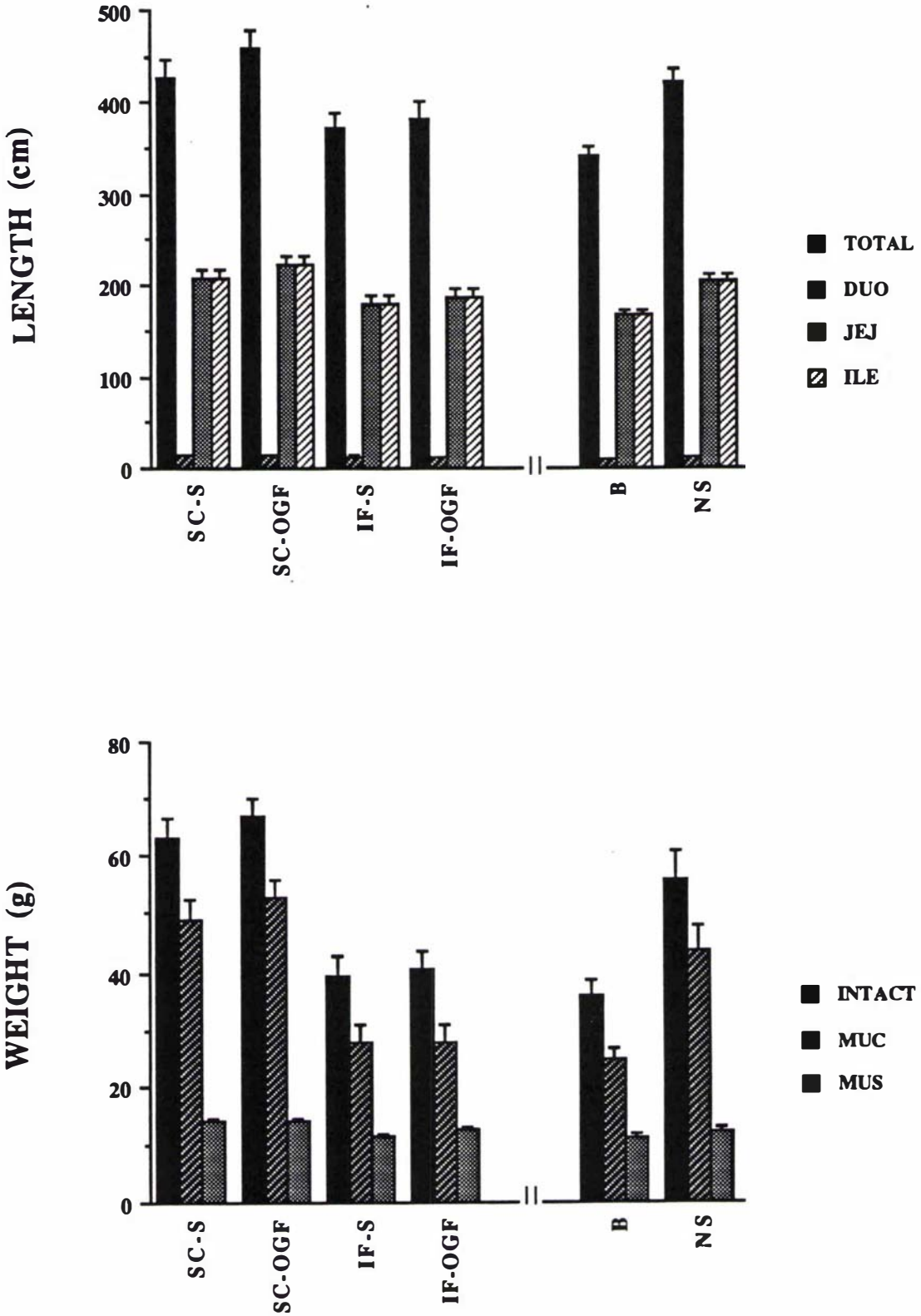

LENGTH (cm)
500
400
300
200
100
0
SC-S
SC-OGF
IF-S
IF-OGF
B
NS
TOTAL
DUO
JEJ
ILE
WEIGHT (g)
80
60
40
20
0
SC-S
SC-OGF
IF-S
IF-OGF
B
NS
INTACT
MUC
MUS

Figure 5.4 **Intact weight of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets given either sow colostrum (SC) or infant formula (IF) by sucking (S) or orogastric feeding (OGF) for 24 hrs. Data for piglets collected at birth (B) and naturally suckled (NS) for 24 hrs are included for reference (mean ± S.E.).**

DUO:
SC-S+SC-OGF vs IF-S+IF-OGF *
SC-OGF vs IF-S *
SC-OGF vs IF-OGF *

UPJ:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S **
SC-S vs IF-OGF **
SC-OGF vs IF-S ***
SC-OGF vs IF-OGF ***

LOJ:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S ***
SC-S vs IF-OGF ***
SC-OGF vs IF-S ***
SC-OGF vs IF-OGF ***

UPI:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S ***
SC-S vs IF-OGF ***
SC-OGF vs IF-S ***
SC-OGF vs IF-OGF ***

LOI:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S **
SC-S vs IF-OGF ***
SC-OGF vs IF-S **
SC-OGF vs IF-OGF ***

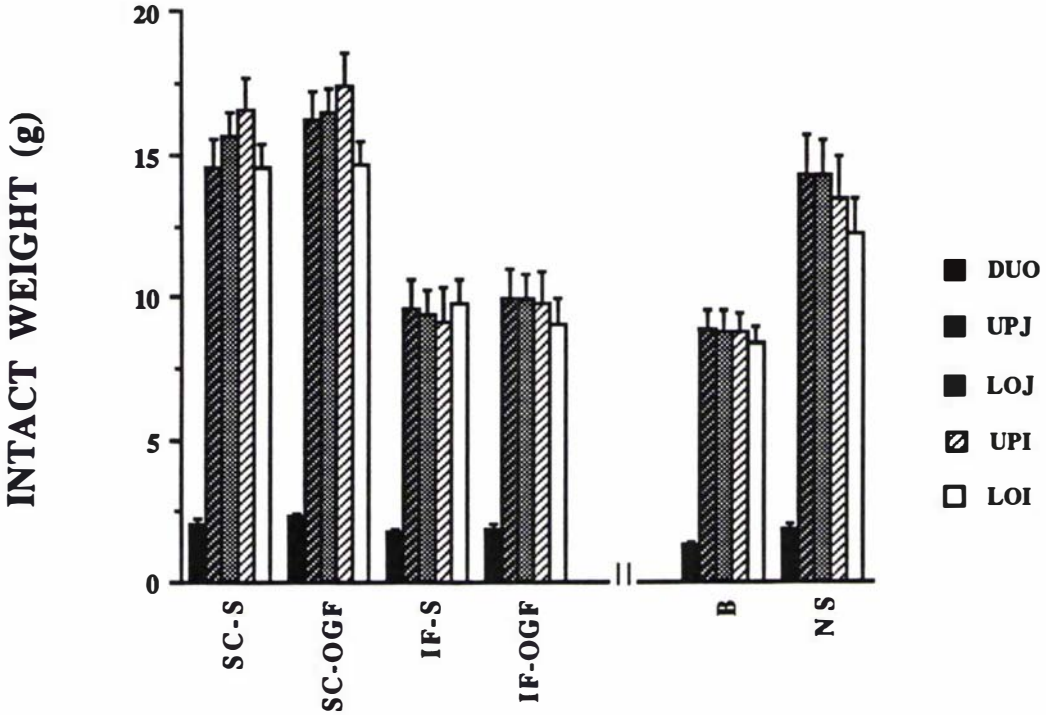

INTACT WEIGHT (g)
20
15
10
5
0
SC-S
SC-OGF
IF-S
IF-OGF
B
NS
DUO
UPJ
LOJ
UPI
LOI

Figure 5.5 **Mucosal weight of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets given either sow colostrum (SC) or infant formula (IF) by sucking (S) or orogastric feeding (OGF) for 24 hrs. Data for piglets collected at birth (B) and naturally suckled (NS) for 24 hrs are included for reference (mean ± S.E.).**

DUO:
N.S.

UPJ:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S *
SC-S vs IF-OGF *
SC-OGF vs IF-S ***
SC-OGF vs IF-OGF ***

LOJ:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S ***
SC-S vs IF-OGF ***
SC-OGF vs IF-S ***
SC-OGF vs IF-OGF ***

UPI:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S ***
SC-S vs IF-OGF ***
SC-OGF vs IF-S ***
SC-OGF vs IF-OGF ***

LOI:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S **
SC-S vs IF-OGF ***
SC-OGF vs IF-S **
SC-OGF vs IF-OGF ***

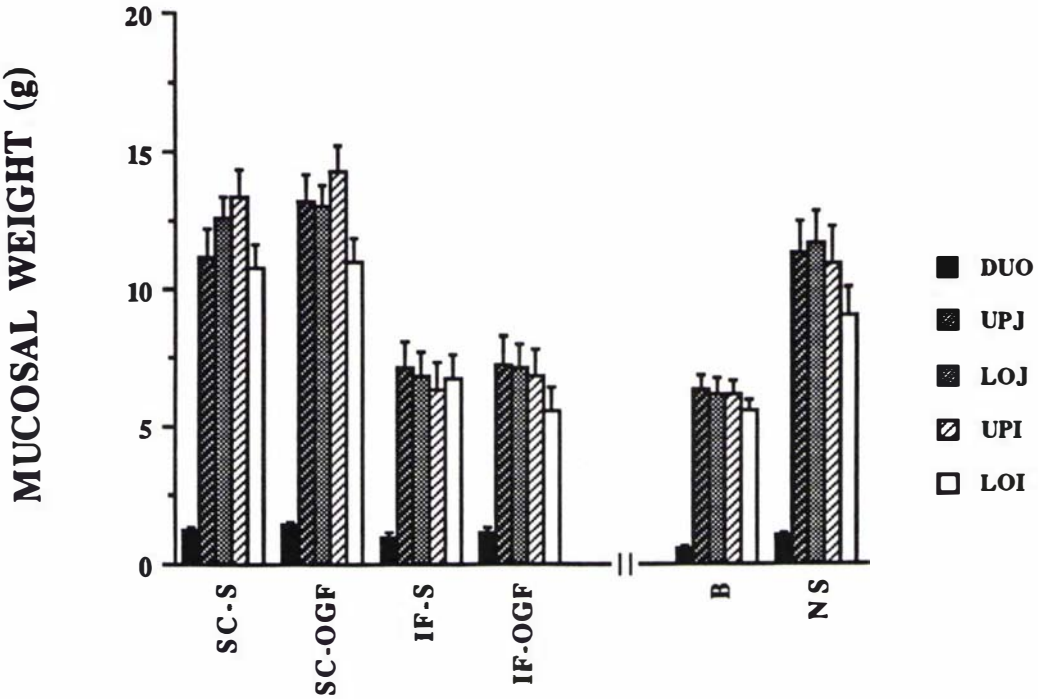

MUCOSAL WEIGHT (g)
20
15
10
5
0
SC-S
SC-OGF
IF-S
IF-OGF
B
N S
DUO
UPJ
LOJ
UPI
LOI

Figure 5.6 **Muscular weight of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets given either sow colostrum (SC) or infant formula (IF) by sucking (S) or orogastric feeding (OGF) for 24 hrs. Data for piglets collected at birth (B) and naturally suckled (NS) for 24 hrs are included for reference (mean ± S.E.).**

DUO:
***SC-S+SC-OGF vs IF-S+IF-OGF** **

UPJ:
***SC-S+SC-OGF vs IF-S+IF-OGF** ***
***SC-S vs IF-S** ***
***SC-S vs IF-OGF** **

LOJ:
***SC-S+SC-OGF vs IF-S+IF-OGF** **
***SC-OGF vs IF-S** ***
***SC-OGF vs IF-OGF** **

UPI:
N.S.

LOI:
***SC-S+SC-OGF vs IF-S+IF-OGF** **
***SC-S vs IF-S** ***
***SC-OGF vs IF-S** **

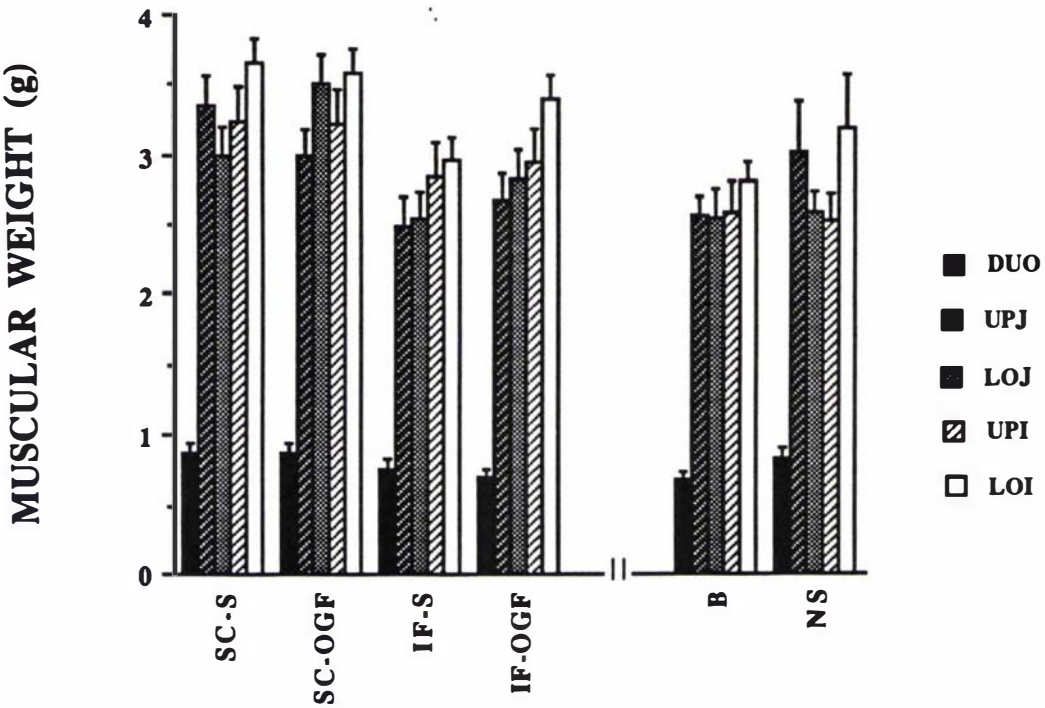

MUSCULAR WEIGHT (g)
4
3
2
1
0
SC-S
SC-OGF
IF-S
IF-OGF
B
NS
DUO
UPJ
LOJ
UPI
LOI

Figure 5.7 **Circumference of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets given either sow colostrum (SC) or infant formula (IF) by sucking (S) or orogastric feeding (OGF) for 24 hrs. Data for piglets collected at birth (B) and naturally suckled (NS) for 24 hrs are included for reference (mean ± S.E.).**

DUO:
N.S.

UPJ:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S ***
SC-S vs IF-OGF ***
SC-OGF vs IF-S ***
SC-OGF vs IF-OGF **

LOJ:
SC-S+SC-OGF vs IF-S+IF-OGF **
SC-S vs IF-S *
SC-S vs IF-OGF *
SC-OGF vs IF-S *
SC-OGF vs IF-OGF *

UPI:
SC-S+SC-OGF vs IF-S+IF-OGF **
SC-S vs IF-S *
SC-OGF vs IF-S *

LOI:
***SC-S+SC-OGF vs IF-S+IF-OGF**
SC-OGF vs IF-OGF *

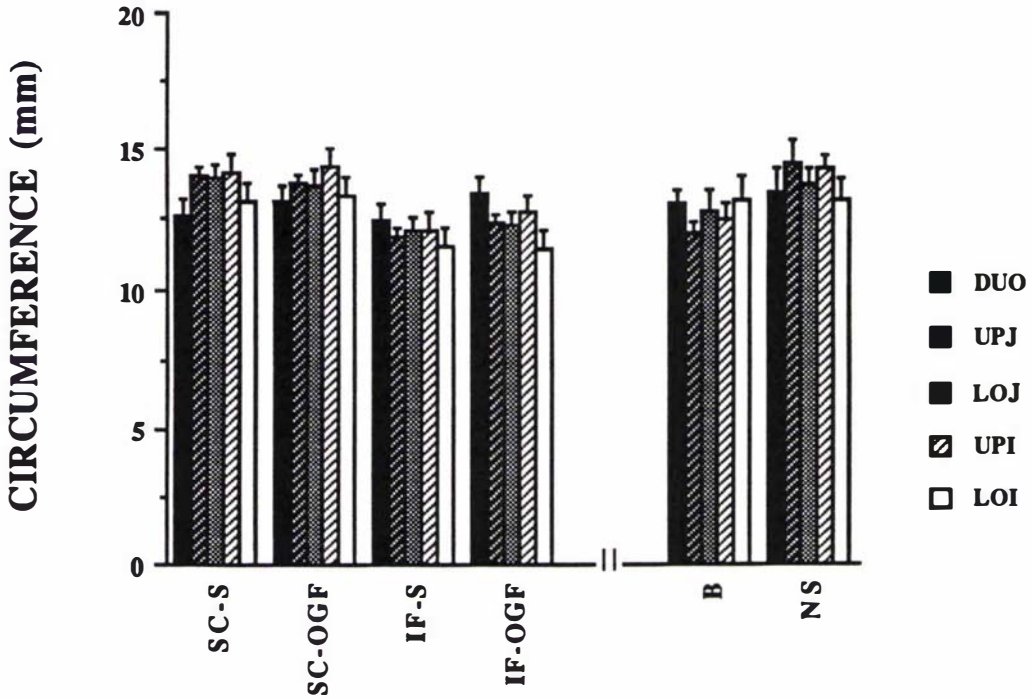

CIRCUMFERENCE (mm)
20
15
10
5
0
SC-S
SC-OGF
IF-S
IF-OGF
B
NS
DUO
UPJ
LOJ
UPI
LOI

Figure 5.8 **Wall thickness of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets given either sow colostrum (SC) or infant formula (IF) by sucking (S) or orogastric feeding (OGF) for 24 hrs. Data for piglets collected at birth (B) and naturally suckled (NS) for 24 hrs are included for reference (mean ± S.E.).**

DUO:
SC-S+SC-OGF vs IF-S+IF-OGF **
SC-OGF vs IF-S **
SC-OGF vs IF-OGF **

UPJ:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S ***
SC-S vs IF-OGF **
SC-OGF vs IF-S ***
SC-OGF vs IF-OGF ***

LOJ:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S **
SC-S vs IF-OGF **
SC-OGF vs IF-S **
SC-OGF vs IF-OGF *

UPI:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S **
SC-S vs IF-OGF *
SC-OGF vs IF-S ***
SC-OGF vs IF-OGF **

LOI:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S **
SC-S vs IF-OGF *
SC-OGF vs IF-S ***
SC-OGF vs IF-OGF **

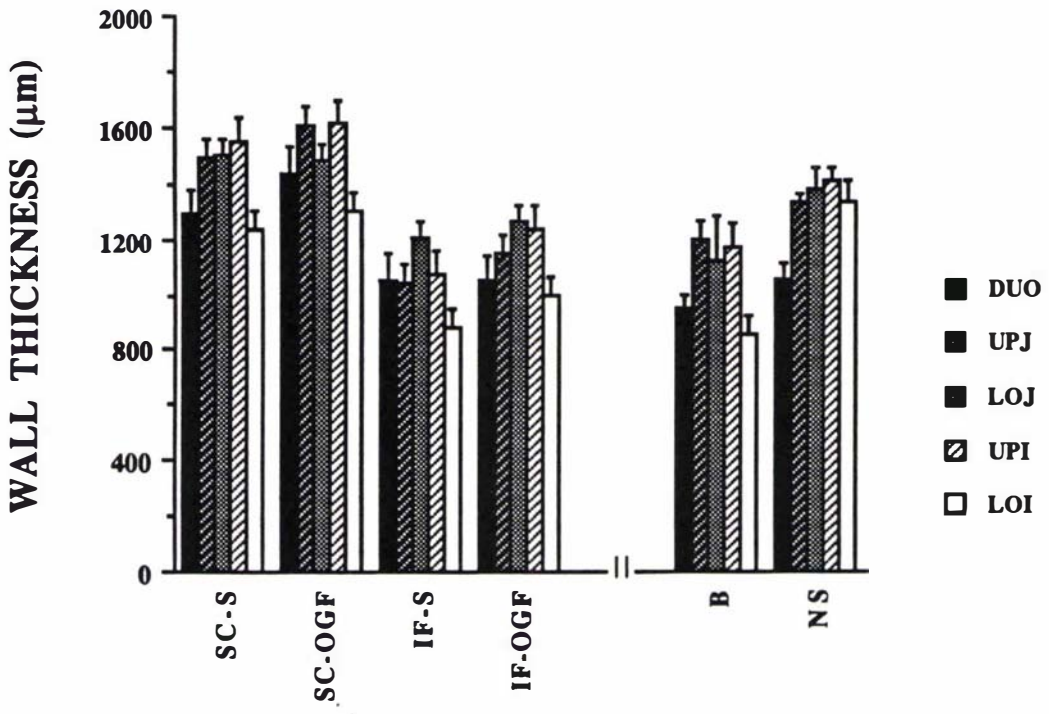

WALL THICKNESS (μm)
2000
1600
1200
800
400
0
SC-S
SC-OGF
IF-S
IF-OGF
B
NS
DUO
UPJ
LOJ
UPI
LOI

Figure 5.9 **Villous height of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets given either sow colostrum (SC) or infant formula (IF) by sucking (S) or orogastric feeding (OGF) for 24 hrs. Data for piglets collected at birth (B) and naturally suckled (NS) for 24 hrs are included for reference (mean ± S.E.).**

DUO:
SC-S+SC-OGF vs IF-S+IF-OGF *
SC-S vs IF-S *
SC-OGF vs IF-S *

UPJ:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S ***
SC-S vs IF-OGF **
SC-OGF vs IF-S ***
SC-OGF vs IF-OGF ***

LOJ:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S ***
SC-S vs IF-OGF ***
SC-OGF vs IF-S ***
SC-OGF vs IF-OGF ***

UPI:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S ***
SC-S vs IF-OGF **
SC-OGF vs IF-S ***
SC-OGF vs IF-OGF ***

LOI:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S **
SC-S vs IF-OGF **
SC-OGF vs IF-S ***
SC-OGF vs IF-OGF ***

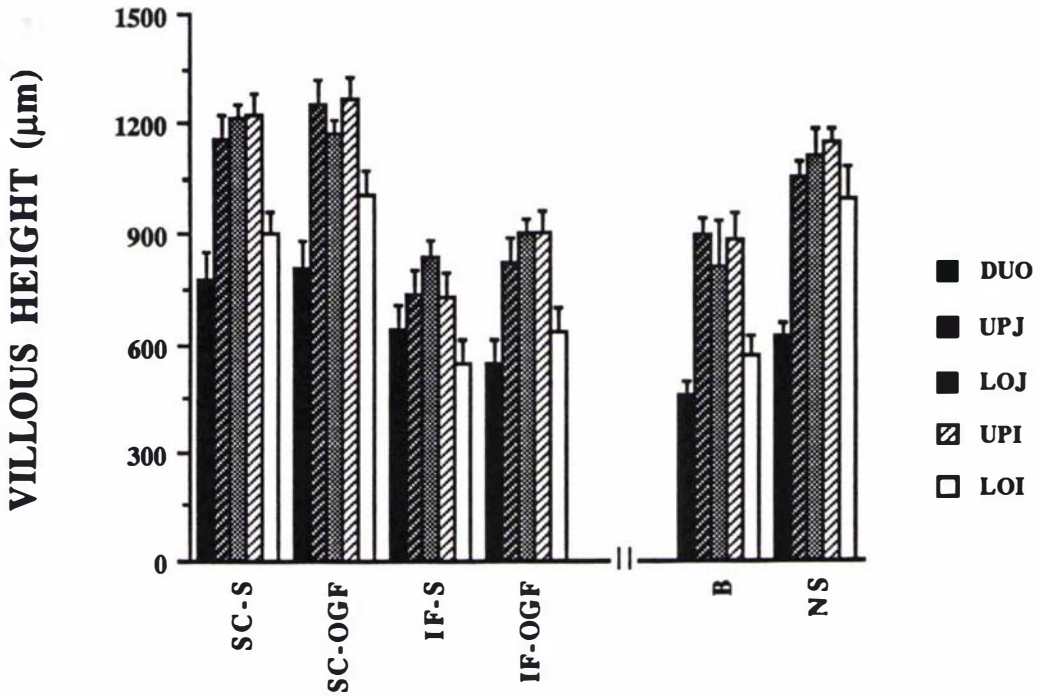

VILLOUS HEIGHT (µm)
1500
1200
900
600
300
0
SC-S
SC-OGF
IF-S
IF-OGF
B
NS
DUO
UPJ
LOJ
UPI
LOI

Figure 5.10 **Villous width of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets given either sow colostrum (SC) or infant formula (IF) by sucking (S) or orogastric feeding (OGF) for 24 hrs. Data for piglets collected at birth (B) and naturally suckled (NS) for 24 hrs are included for reference (mean ± S.E.).**

DUO:
N.S.

UPJ:
SC-S+SC-OGF vs IF-S+IF-OGF***
SC-S vs IF-S ***
SC-S vs IF-OGF ***
SC-OGF vs IF-S ***
SC-OGF vs IF-OGF ***

LOJ:
SC-S+SC-OGF vs IF-S+IF-OGF***
SC-S vs IF-S ***
SC-S vs IF-OGF ***
SC-OGF vs IF-S ***
SC-OGF vs IF-OGF **

UPI:
SC-S+SC-OGF vs IF-S+IF-OGF***
SC-S vs IF-S **
SC-S vs IF-OGF **
SC-OGF vs IF-S **
SC-OGF vs IF-OGF **

LOI:
SC-S+SC-OGF vs IF-S+IF-OGF**
SC-OGF vs IF-S *
SC-OGF vs IF-OGF **

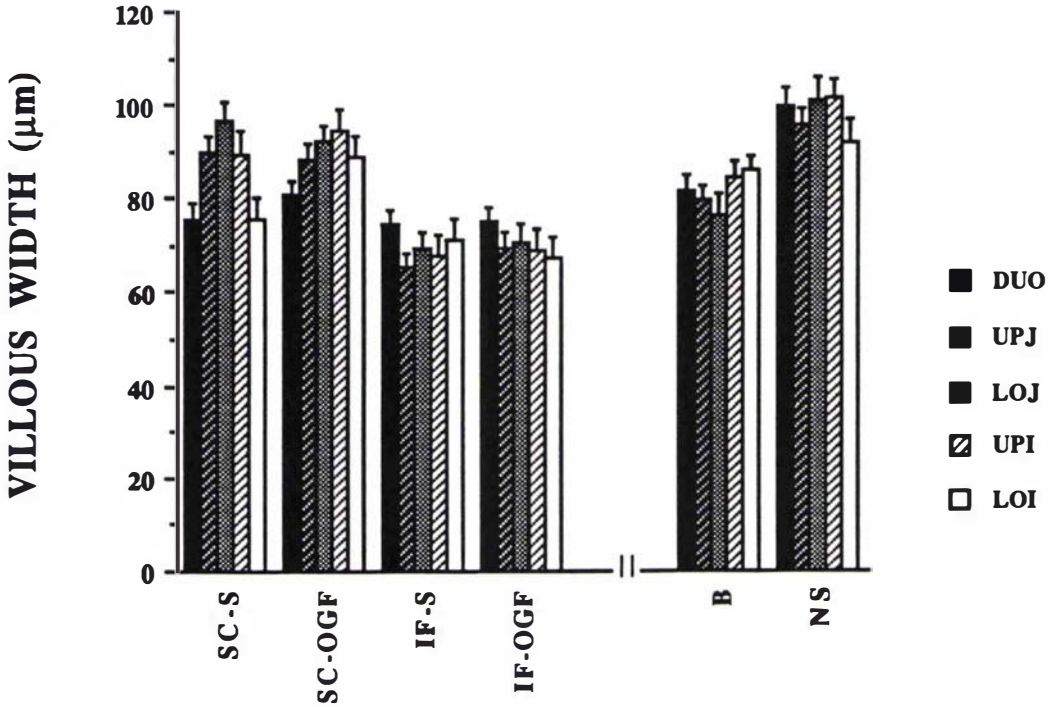

VILLOUS WIDTH (μm)
120
100
80
60
40
20
0
SC-S
SC-OGF
IF-S
IF-OGF
B
NS
DUO
UPJ
LOJ
UPI
LOI

Figure 5.11 **Crypt depth of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets given either sow colostrum (SC) or infant formula (IF) by sucking (S) or orogastric feeding (OGF) for 24 hrs. Data for piglets collected at birth (B) and naturally suckled (NS) for 24 hrs are included for reference (mean ± S.E.).**

DUO:
***SC-S + SC-OGF vs IF-S + IF-OGF** **
***SC-OGF vs IF-S** **

UPJ:
N.S.

LOJ:
N.S.

UPI:
N.S.

LOI:
N.S.

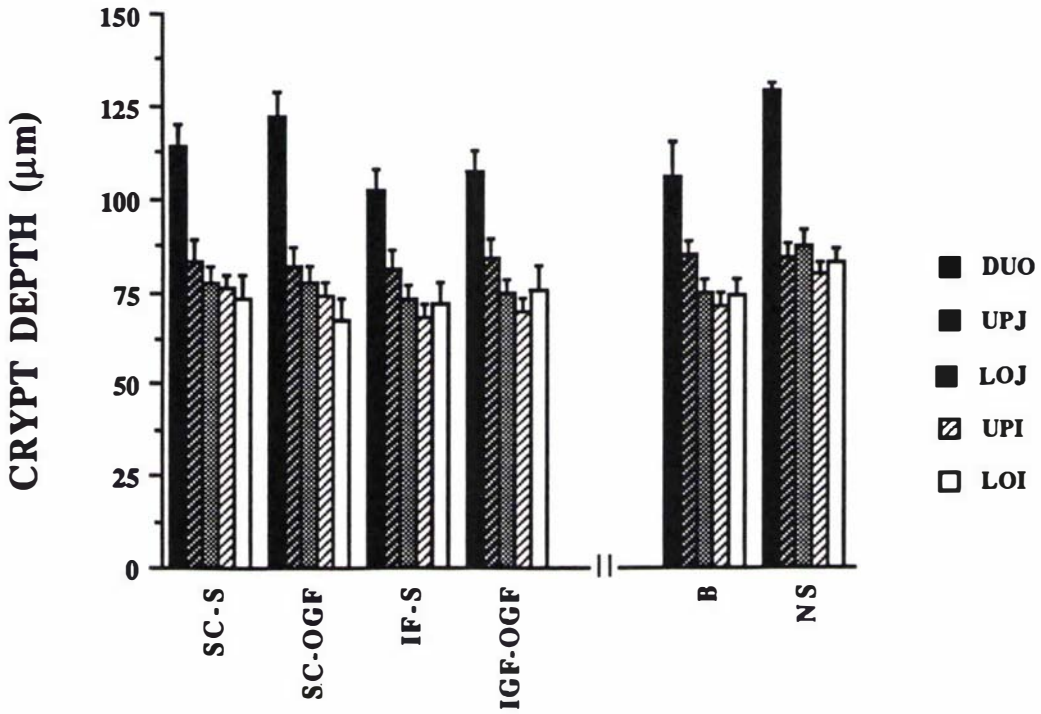

CRYPT DEPTH (µm)
150
125
100
75
50
25
0
SC-S
SC-OGF
IF-S
IGF-OGF
B
NS
DUO
UPJ
LOJ
UPI
LOI

Figure 5.12 **Muscular thickness of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets given either sow colostrum (SC) or infant formula (IF) by sucking (S) or orogastric feeding (OGF) for 24 hrs. Data for piglets collected at birth (B) and naturally suckled (NS) for 24 hrs are included for reference (mean ± S.E.).**

DUO:
N.S.

UPJ:
N.S.

LOJ:
N.S.

UPI:
N.S.

LOI:
N.S.

Figure 5.13 **Submucosal thickness of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets given either sow colostrum (SC) or infant formula (IF) by sucking (S) or orogastric feeding (OGF) for 24 hrs. Data for piglets collected at birth (B) and naturally suckled (NS) for 24 hrs are included for reference (mean ± S.E.).**

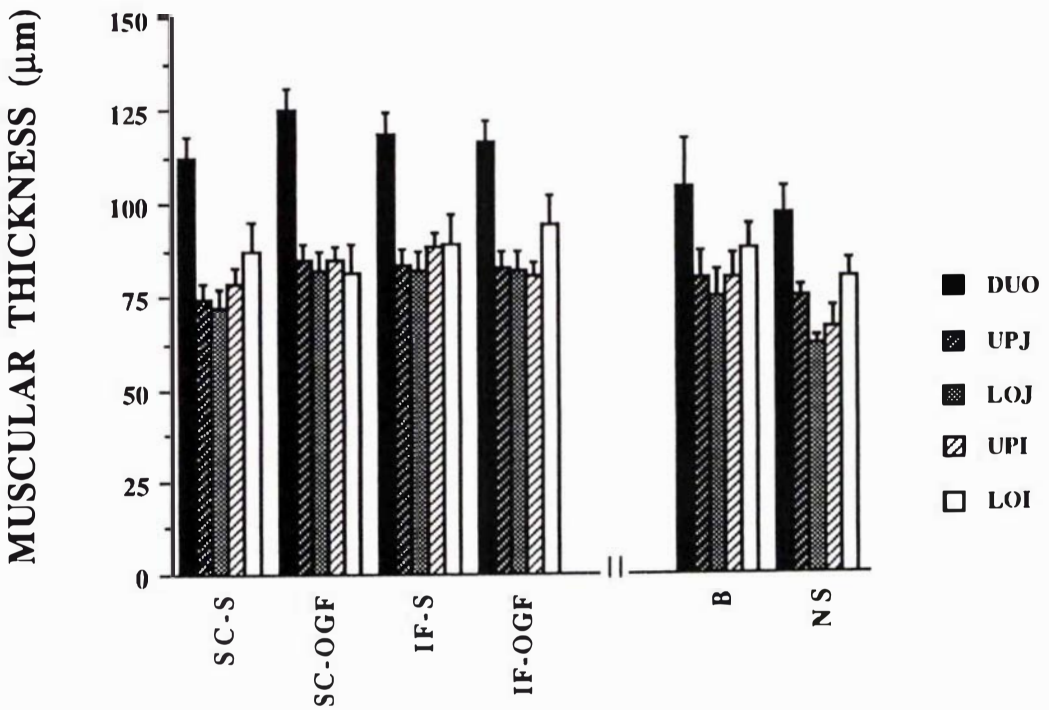
DUO:
N.S.

UPJ:
N.S.

LOJ:
N.S.

UPI:
N.S.

LOI:
N.S.


MUSCULAR THICKNESS (µm)
150
125
100
75
50
25
0
SC-S
SC-OGF
IF-S
IF-OGF
B
NS
DUO
UPJ
LOJ
UPI
LOI

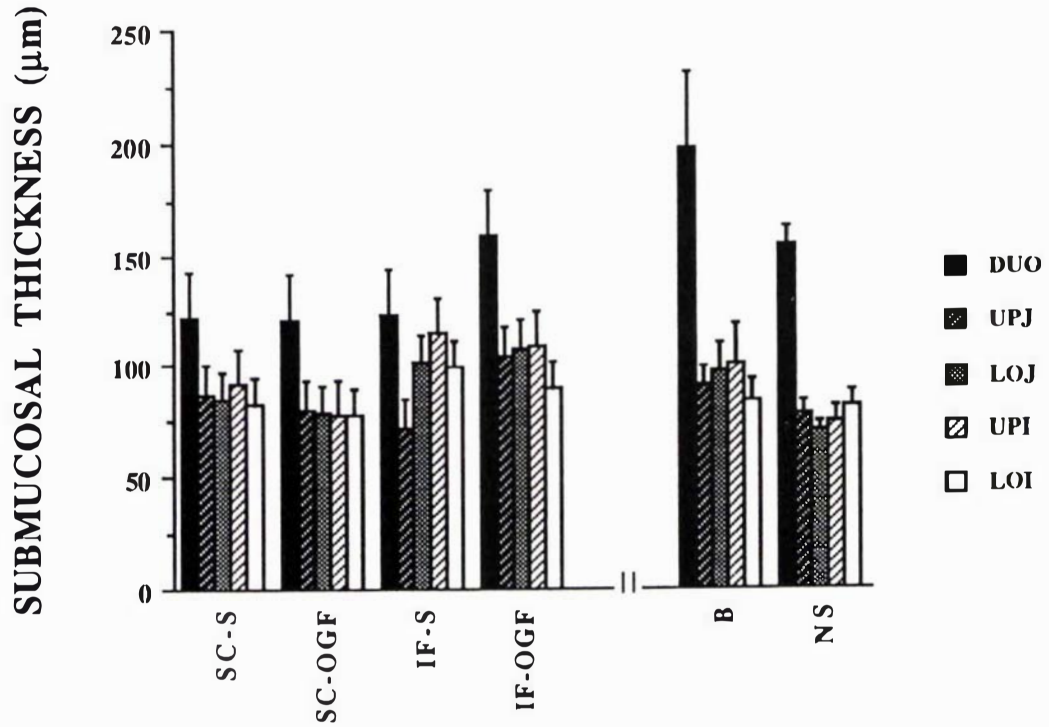
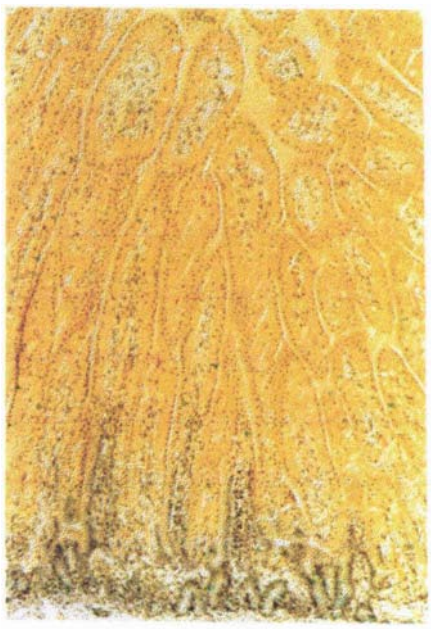
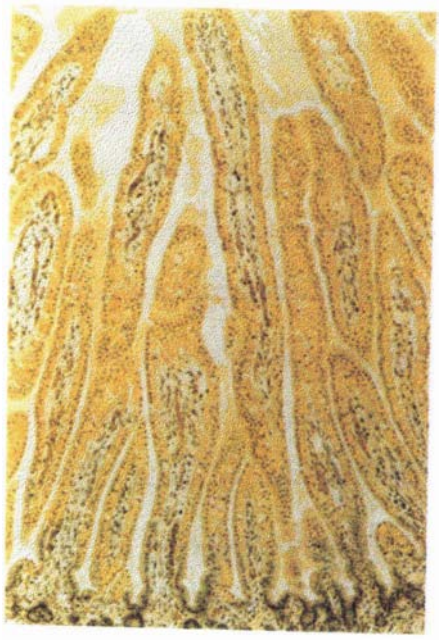

SUBMUCOSAL THICKNESS (µm)
250
200
150
100
50
0
SC-S
SC-OGF
IF-S
IF-OGF
B
NS
DUO
UPJ
LOJ
UPI
LOI

Figure 5.14 **Villi in the upper jejunum of piglets given either sow colostrum (SC) or infant formula (IF) by sucking (S) or orgastric feeding (OGF) for 24 hrs. Note the larger villi in the the piglets fed sow colostrum (SC-S and SC-OGF) compared to those fed infant formula (IF-S and IF-OGF). (Alcian Blue, Hematoxylin, van Gieson; magnification x 60)**

Figure 5.15 **Villi in the upper ileum of piglets given either sow colostrum (SC) or infant formula (IF) by sucking (S) or orogastric feeding (OGF) for 24 hrs. Note the larger villous cells in the piglets fed sow colostrum (SC-S and SC-OGF) compared to those fed infant formula (IF-S and IF-OGF). (Alcian Blue, Hematoxylin, van Gieson; magnification x 242)**



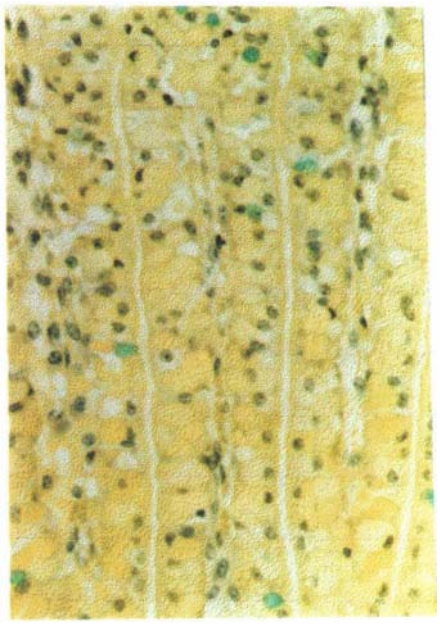
SC-S



SC-OGF

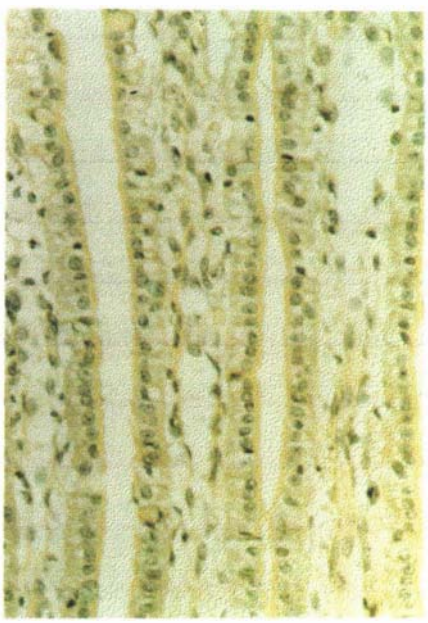
IF-S

IF-OGF

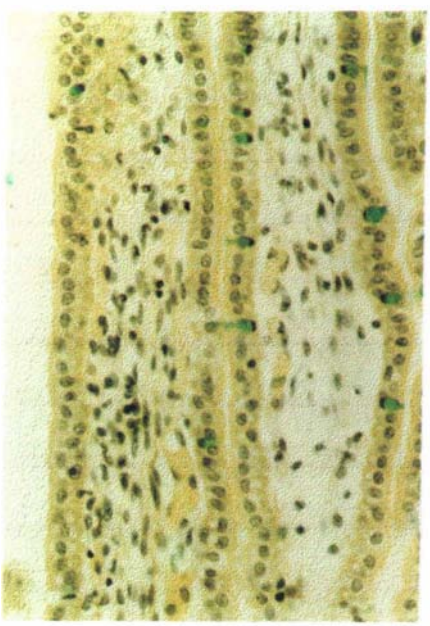


SC-S

SC-OGF



IF-S



IF-OGF

Figure 5.16 **Number of labelled dividing cells per crypt area from the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets given either sow colostrum (SC) or infant formula (IF) by sucking (S) or orogastric feeding (OGF) for 24 hrs (mean ± S.E.).**

DUO:
N.S.

UPJ:
N.S.

LOJ:
N.S.

UPI:
N.S.

LOI:
N.S.

Figure 5.17 **The relative migration distance of the labelled dividing cells of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets given either sow colostrum (SC) or infant formula (IF) by sucking (S) or orogastric feeding (OGF) for 24 hrs (mean ± S.E.).**

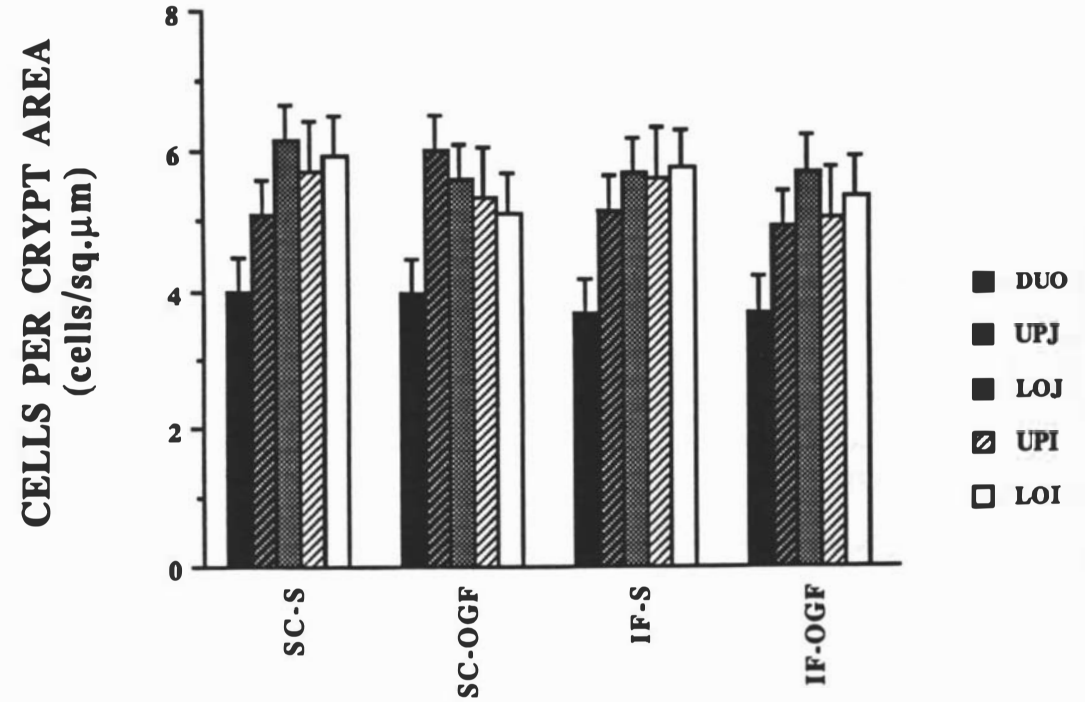
DUO:
SC-OGF vs IF-S **

UPJ:
N.S.

LOJ:
N.S.

UPI:
N.S.

LOI:
N.S.


CELLS PER CRYPT AREA
(cells/sq.µm)
8
6
4
2
0
SC-S
SC-OGF
IF-S
IF-OGF
DUO
UPJ
LOJ
UPI
LOI

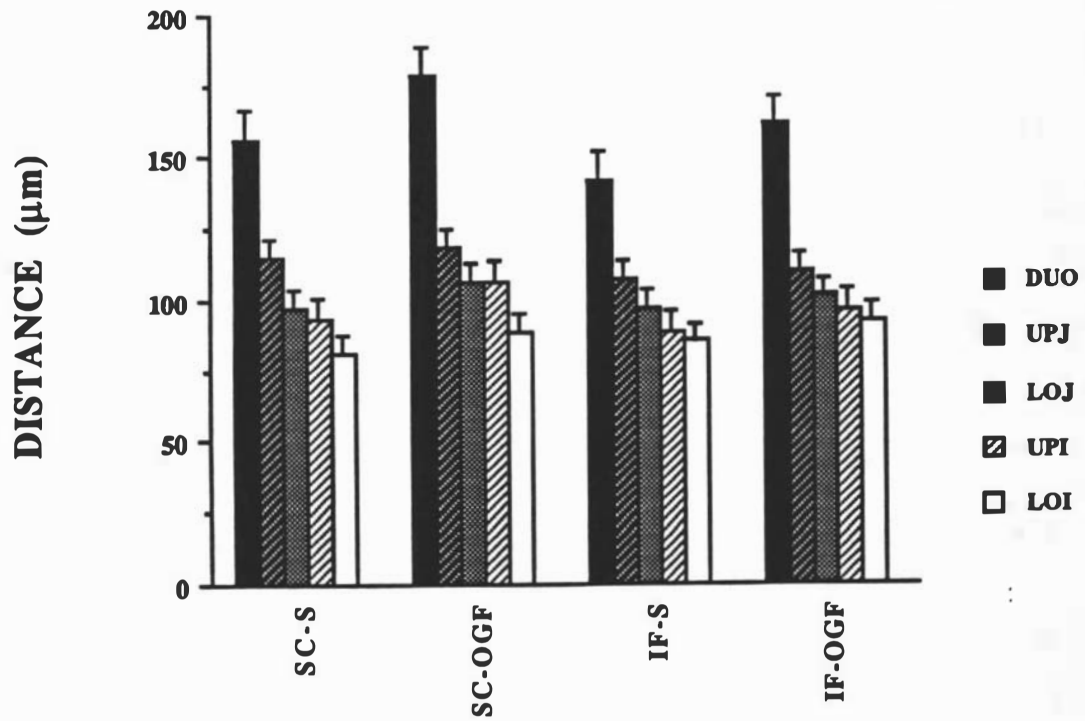

DISTANCE (µm)
200
150
100
50
0
SC-S
SC-OGF
IF-S
IF-OGF
DUO
UPJ
LOJ
UPI
LOI

Figure 5.18 **Mucosal DNA concentration of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets given either sow colostrum (SC) or infant formula (IF) by sucking (S) or orogastric feeding (OGF) for 24 hrs. Data for piglets collected at birth (B) and naturally suckled (NS) for 24 hrs are included for reference (mean ± S.E.).**

DUO:
SC-S vs IF-S *

UPJ:
SC-S+SC-OGF vs IF-S+IF-OGF *
SC-S vs IF-S *

LOJ:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S ***
SC-S vs IF-OGF ***
SC-OGF vs IF-S ***
SC-OGF vs IF-OGF ***

UPI:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S ***
SC-S vs IF-OGF ***
SC-OGF vs IF-S ***
SC-OGF vs IF-OGF ***

LOI:
SC-S+SC-OGF vs IF-S+IF-OGF *
SC-S vs IF-S *

Figure 5.19 **Mucosal RNA concentration of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets given either sow colostrum (SC) or infant formula (IF) by sucking (S) or orogastric feeding (OGF) for 24 hrs. Data for piglets collected at birth (B) and naturally suckled (NS) for 24 hrs are included for reference (mean ± S.E.).**

DUO:
N.S.

UPJ:
N.S.

LOJ:
N.S.

UPI:
N.S.

LOI:
N.S.

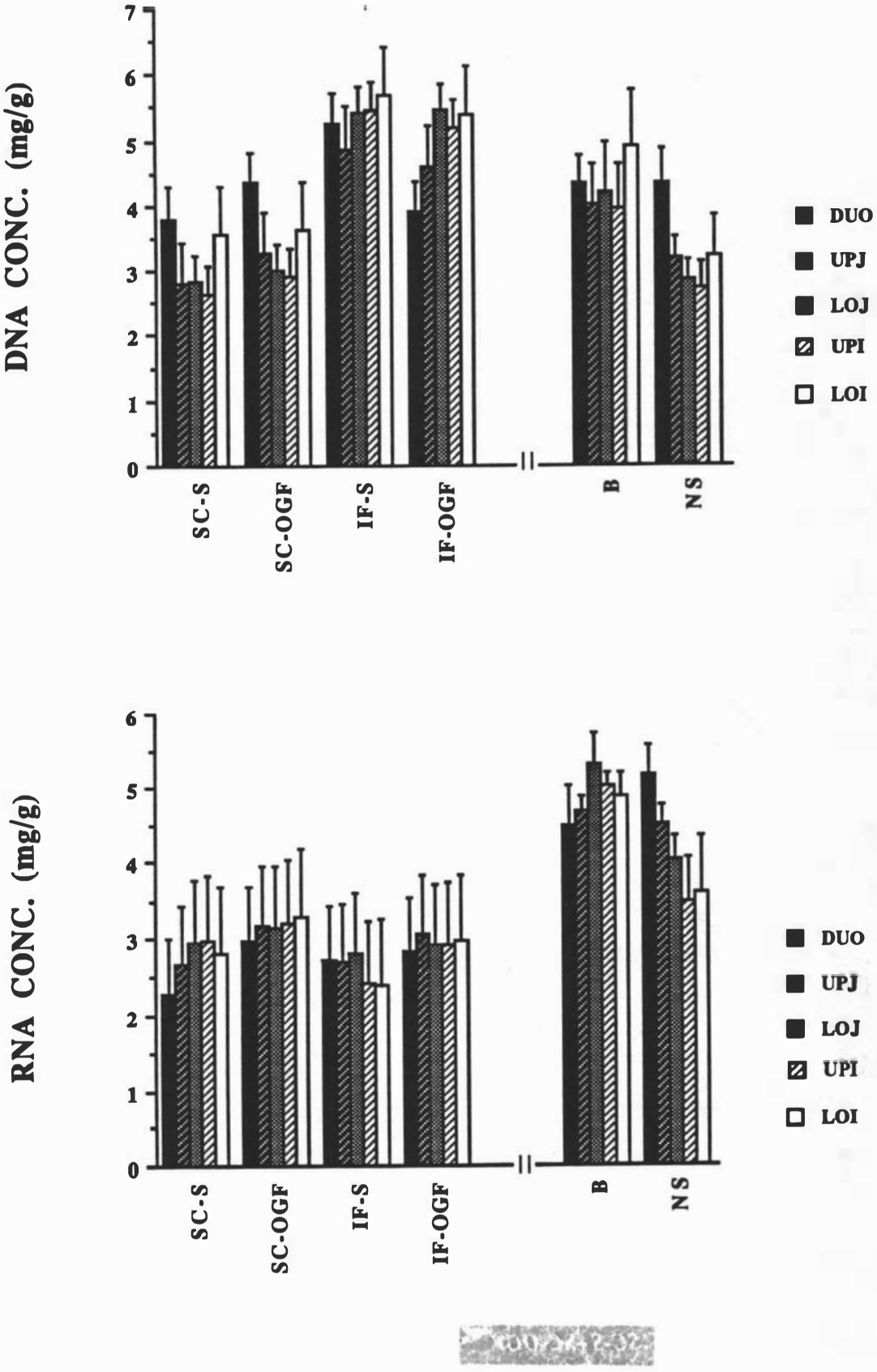

DNA CONC. (mg/g)
7
6
5
4
3
2
1
0
SC-S
SC-OGF
IF-S
IF-OGF
B
NS
DUO
UPJ
LOJ
UPI
LOI
RNA CONC. (mg/g)
6
5
4
3
2
1
0
SC-S
SC-OGF
IF-S
IF-OGF
B
NS
DUO
UPJ
LOJ
UPI
LOI

Figure 5.20 **Mucosal DNA content of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets given either sow colostrum (SC) or infant formula (IF) by sucking (S) or orogastric feeding (OGF) for 24 hrs. Data for piglets collected at birth (B) and naturally suckled (NS) for 24 hrs are included for reference (mean ± S.E.).**

DUO:
N.S.

UPJ:
N.S.

LOJ:
N.S.

UPI:
N.S.

LOI:
N.S.

Figure 5.21 **Mucosal RNA content of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets given either sow colostrum (SC) or infant formula (IF) by sucking (S) or orogastric feeding (OGF) for 24 hrs. Data for piglets collected at birth (B) and naturally suckled (NS) for 24 hrs are included for reference (mean ± S.E.).**

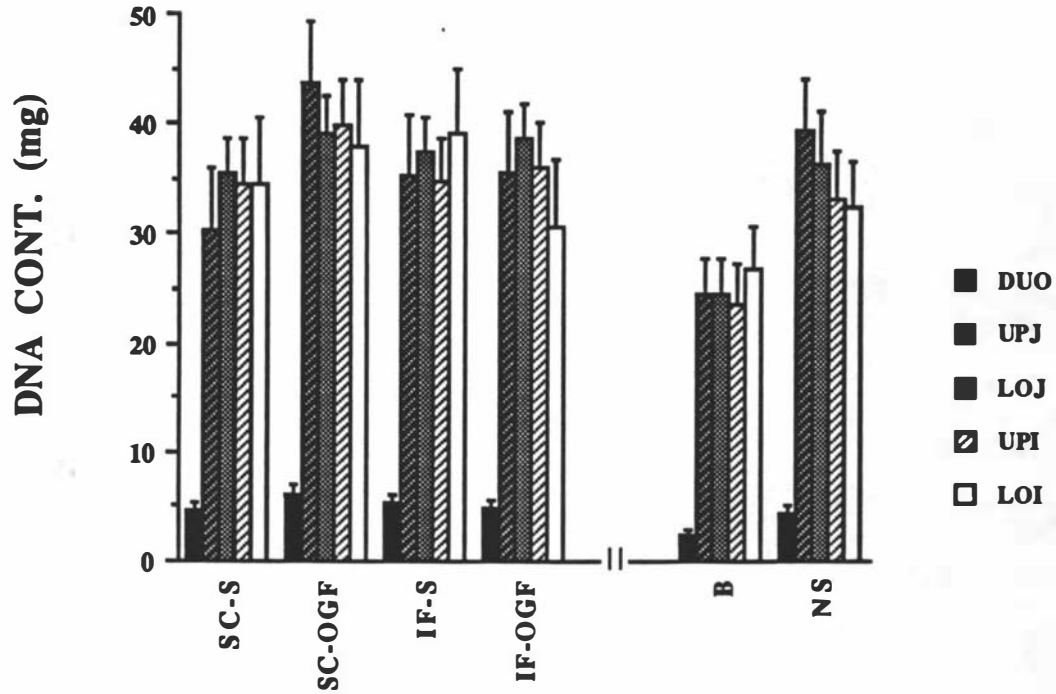
DUO:
N.S.

UPJ:
SC-S+SC-OGF vs IF-S+IF-OGF *
SC-OGF vs IF-S *
SC-OGF vs IF-OGF *

LOJ:
SC-S+SC-OGF vs IF-S+IF-OGF **
SC-S vs IF-S *
SC-OGF vs IF-S *
SC-OGF vs IF-OGF *

UPI:
SC-S+SC-OGF vs IF-S+IF-OGF **
SC-S vs IF-S *
SC-OGF vs IF-S **
SC-OGF vs IF-OGF *

LOI:
SC-S+SC-OGF vs IF-S+IF-OGF *


DNA CONT. (mg)
50
40
30
20
10
0
SC-S
SC-OGF
IF-S
IF-OGF
B
NS
DUO
UPJ
LOJ
UPI
LOI

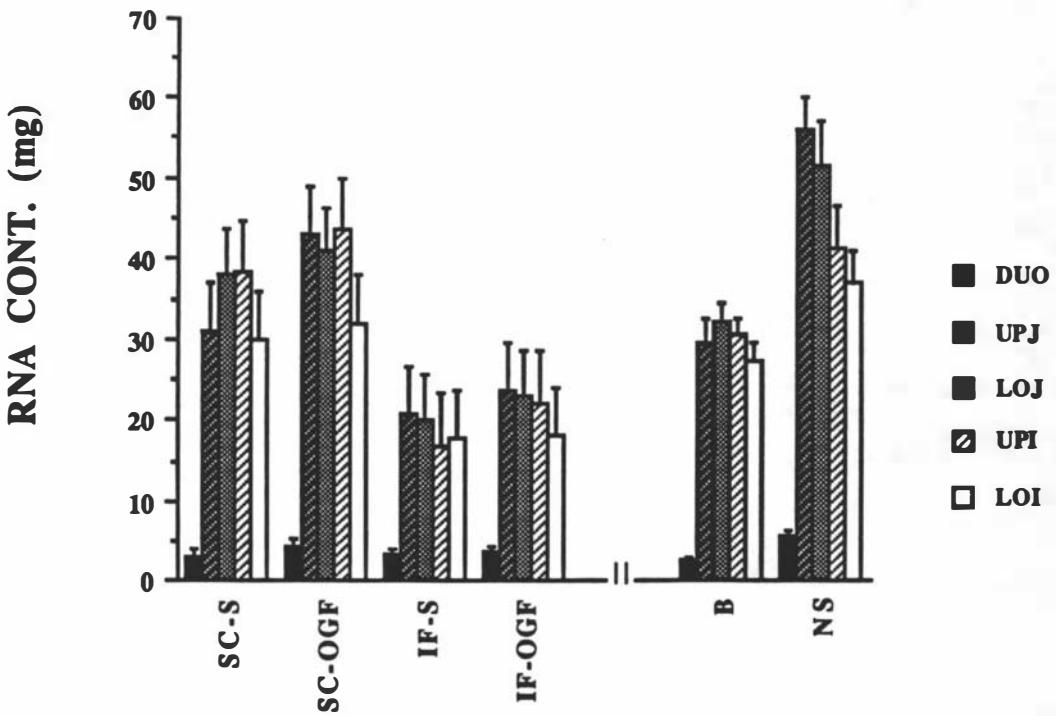

RNA CONT. (mg)
70
60
50
40
30
20
10
0
SC-S
SC-OGF
IF-S
IF-OGF
B
NS
DUO
UPJ
LOJ
UPI
LOI

Figure 5.22 **Mucosal protein concentration of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets given either sow colostrum (SC) or infant formula (IF) by sucking (S) or orogastric feeding (OGF) for 24 hrs. Data for piglets collected at birth (B) and naturally suckled (NS) for 24 hrs are included for reference (mean ± S.E.).**

DUO:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S *
SC-S vs IF-OGF ***
SC-OGF vs IF-S **
SC-OGF vs IF-OGF ***
IF-S vs IF-OGF *

UPJ:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S ***
SC-S vs IF-OGF ***
SC-OGF vs IF-S ***
SC-OGF vs IF-OGF ***

LOJ:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S ***
SC-S vs IF-OGF ***
SC-OGF vs IF-S ***
SC-OGF vs IF-OGF ***

UPI:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S ***
SC-S vs IF-OGF ***
SC-OGF vs IF-S ***
SC-OGF vs IF-OGF ***

LOI:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S ***
SC-S vs IF-OGF ***
SC-OGF vs IF-S ***
SC-OGF vs IF-OGF ***

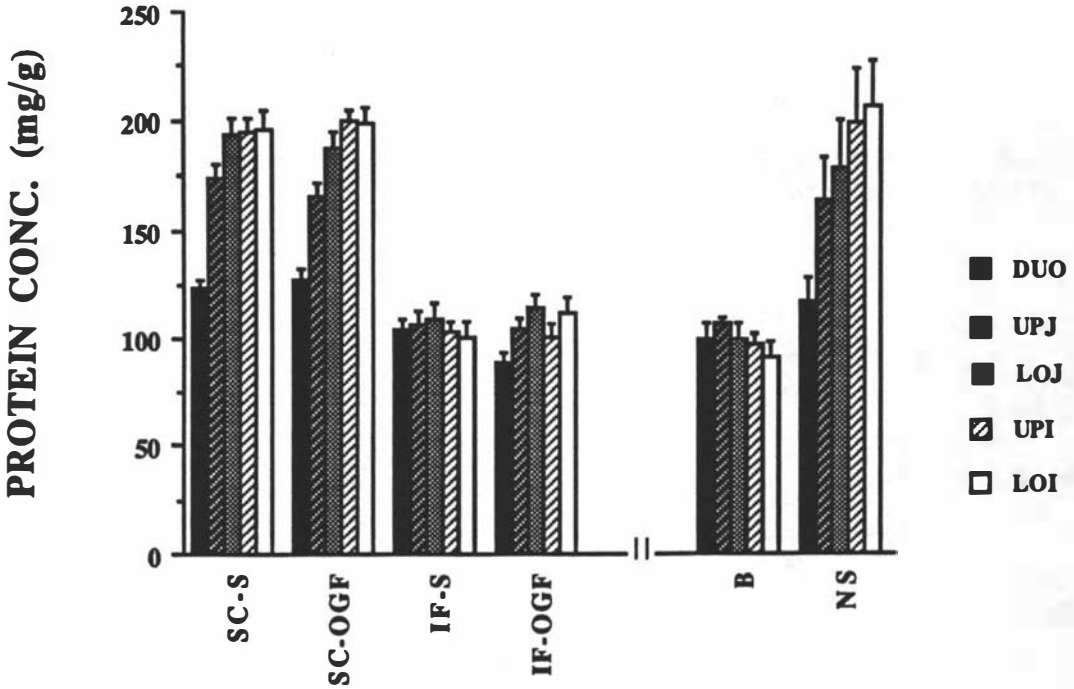

PROTEIN CONC. (mg/g)
250
200
150
100
50
0
SC-S
SC-OGF
IF-S
IF-OGF
B
NS
DUO
UPJ
LOJ
UPI
LOI

Figure 5.23 **Mucosal protein content of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets given either sow colostrum (SC) or infant formula (IF) by sucking (S) or orogastric feeding (OGF) for 24 hrs. Data for piglets collected at birth (B) and naturally suckled (NS) for 24 hrs are included for reference (mean ± S.E.).**

DUO:
SC-S+SC-OGF vs IF-S+IF-OGF **
SC-OGF vs IF-S **
SC-OGF vs IF-OGF *

UPJ:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S **
SC-S vs IF-OGF **
SC-OGF vs IF-S ***
SC-OGF vs IF-OGF ***

LOJ:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S ***
SC-S vs IF-OGF ***
SC-OGF vs IF-S ***
SC-OGF vs IF-OGF ***

UPI:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S ***
SC-S vs IF-OGF ***
SC-OGF vs IF-S ***
SC-OGF vs IF-OGF ***

LOI:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S ***
SC-S vs IF-OGF ***
SC-OGF vs IF-S ***
SC-OGF vs IF-OGF ***

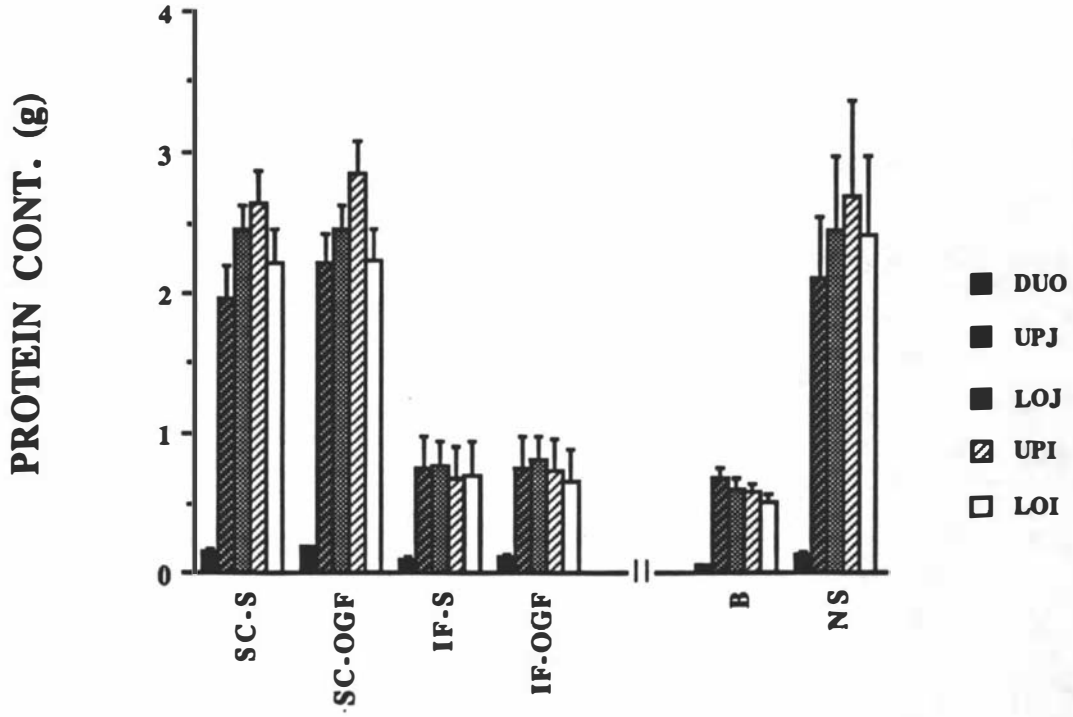

PROTEIN CONT. (g)
4
3
2
1
0
SC-S
SC-OGF
IF-S
IF-OGF
B
NS
DUO
UPJ
LOJ
UPI
LOI

Figure 5.24 Mucosal protein:DNA ratio of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets given either sow colostrum (SC) or infant formula (IF) by sucking (S) or orogastric feeding (OGF) for 24 hrs. Data for piglets collected at birth (B) and naturally suckled (NS) for 24 hrs are included for reference (mean ± S.E.).

DUO:
SC-OGF vs IF-S *

UPJ:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S ***
SC-S vs IF-OGF **
SC-OGF vs IF-S **
SC-OGF vs IF-OGF *

LOJ:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S ***
SC-S vs IF-OGF ***
SC-OGF vs IF-S ***
SC-OGF vs IF-OGF ***

UPI:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S ***
SC-S vs IF-OGF ***
SC-OGF vs IF-S ***
SC-OGF vs IF-OGF ***

LOI:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S **
SC-S vs IF-OGF **
SC-OGF vs IF-S **
SC-OGF vs IF-OGF *

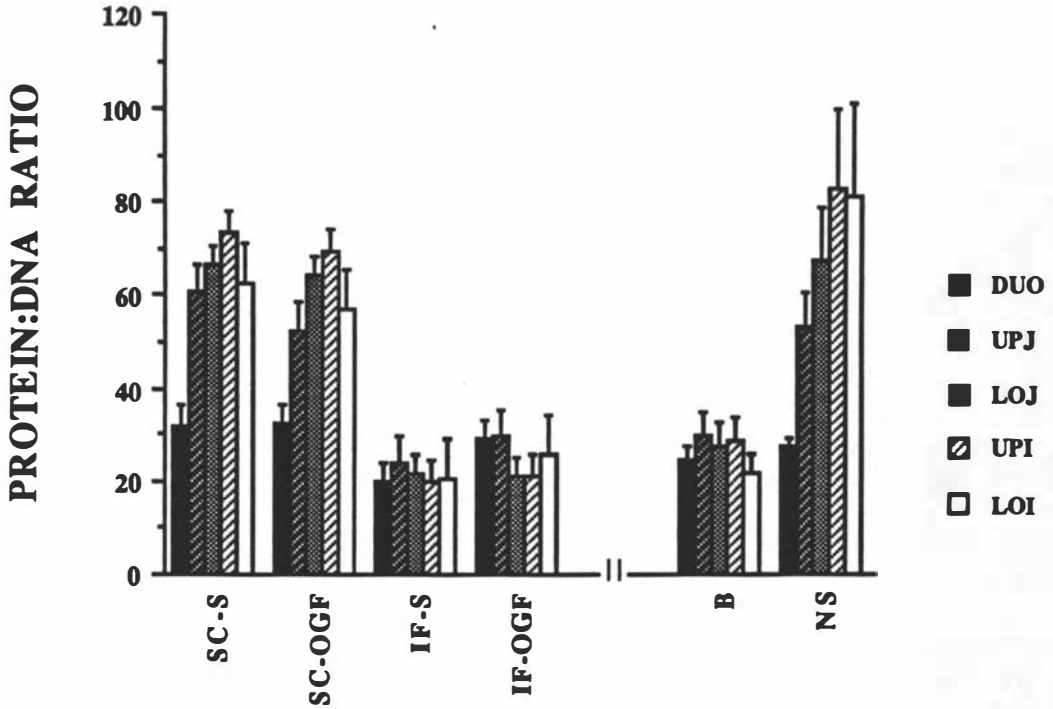

PROTEIN:DNA RATIO
120
100
80
60
40
20
0
SC-S
SC-OGF
IF-S
IF-OGF
B
NS
DUO
UPJ
LOJ
UPI
LOI

Figure 5.25 **Mucosal RNA:DNA ratio of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets given either sow colostrum (SC) or infant formula (IF) by sucking (S) or orogastric feeding (OGF) for 24 hrs. Data for piglets collected at birth (B) and naturally suckled (NS) for 24 hrs are included for reference (mean ± S.E.).**

DUO:
N.S.

UPJ:
SC-S+SC-OGF vs IF-S+IF-OGF **
SC-S vs IF-S *
SC-OGF vs IF-S *
SC-OGF vs IF-OGF *

LOJ:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S **
SC-S vs IF-OGF *
SC-OGF vs IF-S **
SC-OGF vs IF-OGF **

UPI:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S **
SC-S vs IF-OGF **
SC-OGF vs IF-S **
SC-OGF vs IF-OGF **

LOI:
SC-S+SC-OGF vs IF-S+IF-OGF **
SC-S vs IF-S *
SC-OGF vs IF-S **
SC-OGF vs IF-OGF *

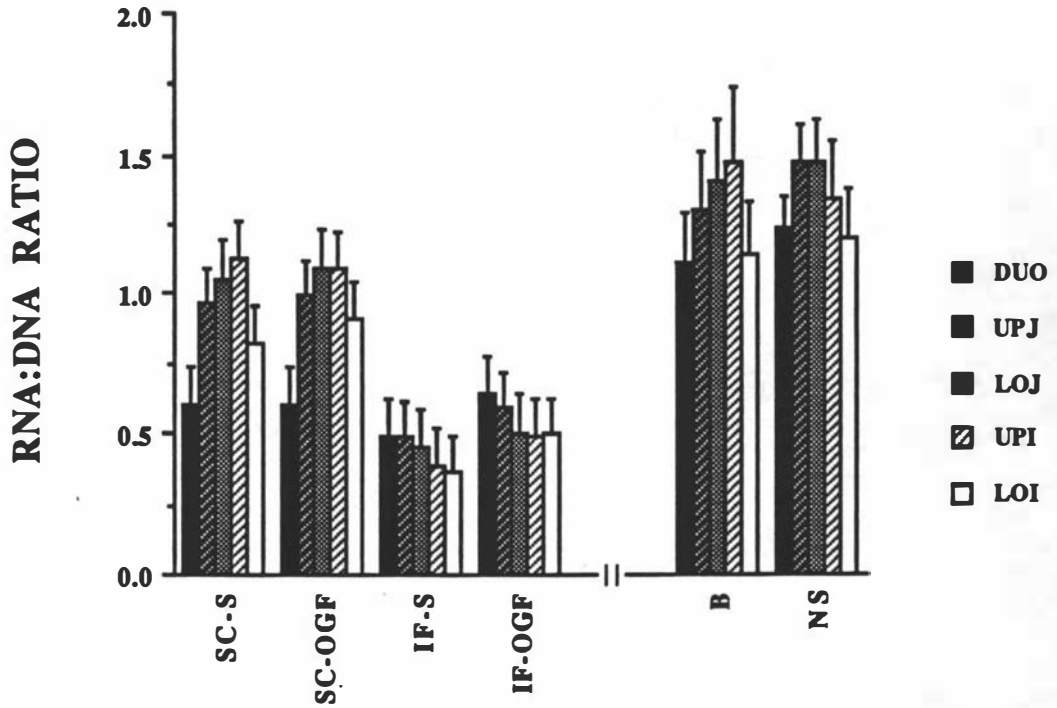

RNA:DNA RATIO
2.0
1.5
1.0
0.5
0.0
SC-S
SC-OGF
IF-S
IF-OGF
B
NS
DUO
UPJ
LOJ
UPI
LOI

Figure 5.26 **Lactase activity per mucosal weight of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets given either sow colostrum (SC) or infant formula (IF) by sucking (S) or orogastric feeding (OGF) for 24 hrs. Data for piglets collected at birth (B) and naturally suckled (NS) for 24 hrs are included for reference (mean ± S.E.).**

DUO:
N.S.

UPJ:
SC-S+SC-OGF vs IF-S+IF-OGF *
SC-S vs IF-OGF *
SC-OGF vs IF-OGF *

LOJ:
SC-S+SC-OGF vs IF-S+IF-OGF **
SC-S vs IF-OGF **
SC-OGF vs IF-OGF **

UPI:
SC-S+SC-OGF vs IF-S+IF-OGF ***
SC-S vs IF-S ***
SC-S vs IF-OGF **
SC-OGF vs IF-S ***
SC-OGF vs IF-OGF **

LOI:
SC-S+SC-OGF vs IF-S+IF-OGF **
SC-S vs IF-S *
SC-OGF vs IF-S *

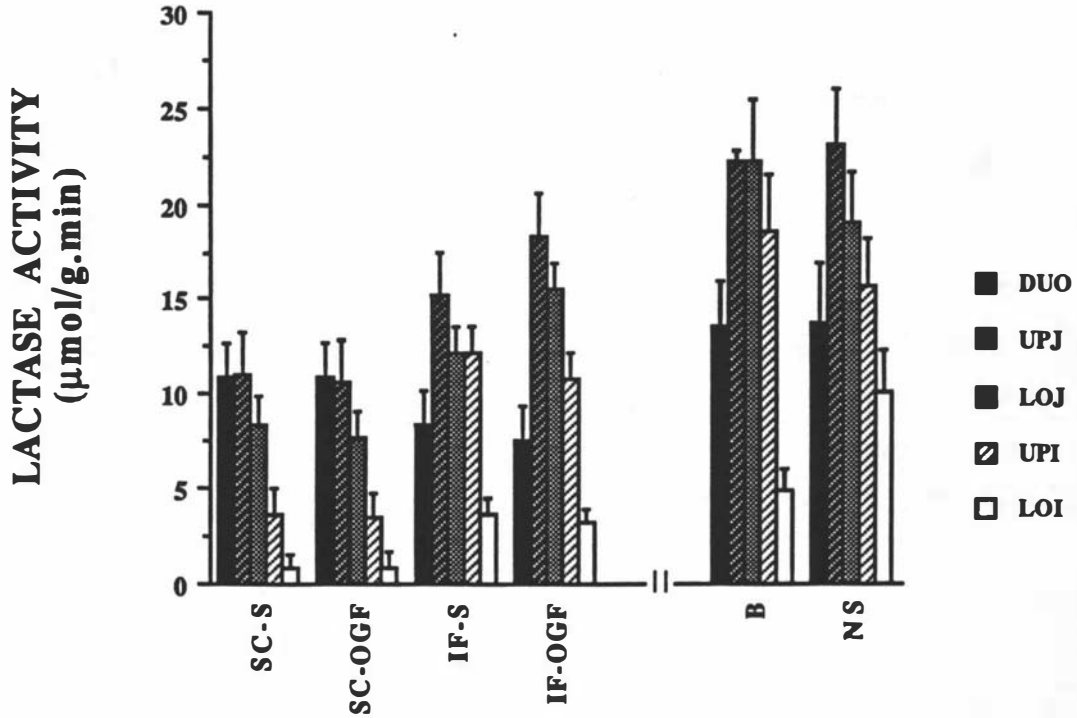

LACTASE ACTIVITY
(µmol/g.min)
30
25
20
15
10
5
0
SC-S
SC-OGF
IF-S
IF-OGF
B
N S
DUO
UPJ
LOJ
UPI
LOI

Figure 5.27 **Total lactase activity of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets given either sow colostrum (SC) or infant formula (IF) by sucking (S) or orogastric feeding (OGF) for 24 hrs. Data for piglets collected at birth (B) and naturally suckled (NS) for 24 hrs are included for reference (mean ± S.E.).**

DUO:
SC-S+SC-OGF vs IF-S+IF-OGF *

UPJ:
N.S

LOJ:
N.S.

UPI:
N.S.

LOI:
N.S.

Figure 5.28 **Lactase activity per DNA weight of the duodenum (DUO), upper jejunum (UPJ), lower jejunum (LOJ), upper ileum (UPI) and lower ileum (LOI) of piglets given either sow colostrum (SC) or infant formula (IF) by sucking (S) or orogastric feeding (OGF) for 24 hrs. Data for piglets collected at birth (B) and naturally suckled (NS) for 24 hrs are included for reference (mean ± S.E.).**

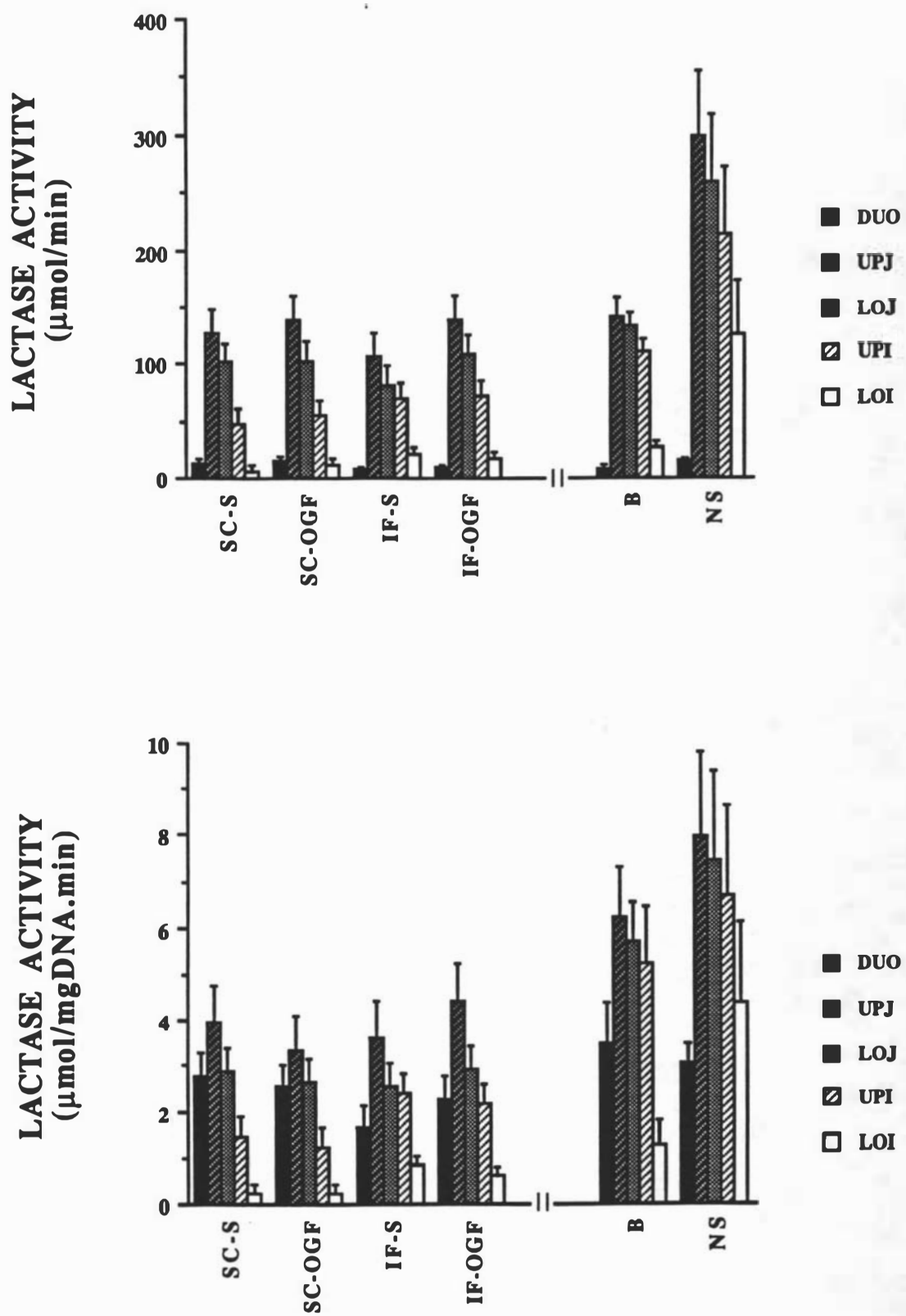
DUO:
N.S.

UPJ:
N.S.

LOJ:
N.S.

UPI:
SC-S+SC-OGF vs IF-S+IF-OGF *

LOI:
SC-S+SC-OGF vs IF-S+IF-OGF *


LACTASE ACTIVITY
(µmol/min)
400
300
200
100
0
SC-S
SC-OGF
IF-S
IF-OGF
B
NS
DUO
UPJ
LOJ
UPI
LOI
LACTASE ACTIVITY
(µmol/mgDNA.min)
10
8
6
4
2
0
SC-S
SC-OGF
IF-S
IF-OGF
B
NS
DUO
UPJ
LOJ
UPI
LOI

CHAPTER 3

EFFECTS OF COLOSTRUM AND MILK ON POSTNATAL DEVELOPMENT OF THE SMALL INTESTINE IN PIGLETS DURING THE FIRST 24 HOURS AFTER BIRTH

APPENDICES

APPENDIX 3.1

Table A1 Tissue thicknesses (μm) and circumference (mm) of 5 separate cross-sections (no.1, 11, 21, 31 and 41) from the *duodenum* of a 24-hour-old suckled piglet. Each value is the average of 12 measurements except for the circumference which was measured once.

Structure	Section no.1	Section no.11	Section no.21	Section no.31	Section no.41
Wall thickness	1298	1277	1276	1300	1281
Muscular layer	207	200	229	227	212
Submucosal layer	334	344	335	313	346
Crypt depth	118	130	119	119	122
Villous height	521	535	522	507	523
Villous width	89	98	90	93	90
Circumference	12.32	12.32	12.25	12.25	12.25

Table A2 Mean values, S.D., S.E. and 95% confidence interval (CI) of the measurements shown in Table A1.

Structure	Mean 5 sections	S.D.	S.E.	95% CI lower	95% CI upper
Wall thickness	1286.40	11.67	5.22	1271.90	1300.90
Muscular layer	215.00	12.63	5.65	199.31	230.69
Submucosal layer	334.40	13.09	5.85	318.14	350.66
Crypt depth	121.60	4.93	2.20	115.48	127.72
Villous height	521.60	9.94	4.45	509.25	533.95
Villous width	92.00	3.67	1.64	87.44	96.56
Circumference	12.28	0.04	0.02	12.23	12.33

(Contd.)

APPENDIX 3.1

Table B1 Tissue thicknesses (μm) and circumference (mm) of 5 separate cross-sections (no.1, 11, 21, 31 and 41) from the *upper jejunum* of a 24-hour-old suckled piglet. Each value is the average of 12 measurements except for the circumference which was measured once.

Structure	Section no.1	Section no.11	Section no.21	Section no.31	Section no.41
Wall thickness	1295	1277	1281	1281	1320
Muscular layer	86	87	79	74	82
Submucosal layer	63	58	55	57	62
Crypt depth	77	75	86	77	71
Villous height	1031	991	1006	1029	1023
Villous width	97	107	104	97	97
Circumference	14.31	13.95	14.19	14.27	14.61

Table B2 Mean values, S.D., S.E. and 95% confidence interval (CI) of the measurements shown in Table B1.

Structure	Mean 5 sections	S.D.	S.E.	95% CI lower	95% CI upper
Wall thickness	1290.80	17.70	7.90	1268.82	1312.78
Muscular layer	81.60	5.32	2.38	74.99	88.21
Submucosal layer	59.00	3.39	1.52	54.79	63.21
Crypt depth	77.20	5.50	2.46	70.37	84.03
Villous height	1016.00	17.09	7.64	994.78	1037.22
Villous width	100.40	4.77	2.14	94.47	106.33
Circumference	14.27	0.24	0.11	13.97	14.56

(Contd.)

APPENDIX 3.1

Table C1 Tissue thicknesses (μm) and circumference (mm) of 5 separate cross-sections (no.1, 11, 21, 31 and 41) from the *lower jejunum* of a 24-hour-old suckled piglet. Each value is the average of 12 measurements except for the circumference which was measured once.

Structure	Section no.1	Section no.11	Section no.21	Section no.31	Section no.41
Wall thickness	1198	1197	1199	1235	1149
Muscular layer	79	77	74	75	79
Submucosal layer	46	45	45	47	47
Crypt depth	74	75	75	74	77
Villous height	956	941	993	995	981
Villous width	95	94	98	92	88
Circumference	14.22	14.22	14.13	14.43	14.21

Table C2 Mean values, S.D., S.E. and 95% confidence interval (CI) of the measurements shown in Table C1.

Structure	Mean 5 sections	S.D.	S.E.	95% CI lower	95% CI upper
Wall thickness	1195.60	30.60	13.70	1157.60	1233.60
Muscular layer	76.80	2.28	1.02	73.97	79.63
Submucosal layer	46.00	1.00	0.45	44.76	47.24
Crypt depth	75.00	1.22	0.55	73.48	76.52
Villous height	973.20	23.80	10.60	943.70	1002.70
Villous width	93.40	3.71	1.66	88.79	98.01
Circumference	14.24	0.11	0.05	14.10	14.38

(Contd.)

APPENDIX 3.1

Table D1 Tissue thicknesses (μm) and circumference (mm) of 5 separate cross-sections (no.1, 11, 21, 31 and 41) from the *upper ileum* of a 24-hour-old suckled piglet. Each value is the average of 12 measurements except for the circumference which was measured once.

Structure	Section no.1	Section no.11	Section no.21	Section no.31	Section no.41
Wall thickness	1156	1179	1153	1184	1164
Muscular layer	95	98	95	89	96
Submucosal layer	52	60	54	53	55
Crypt depth	77	79	79	79	74
Villous height	904	904	891	881	906
Villous width	97	94	96	93	93
Circumference	13.87	13.72	13.86	13.95	13.93

Table D2 Mean values, S.D., S.E. and 95% confidence interval (CI) of the measurements shown in Table D1.

Structure	Mean 5 sections	S.D.	S.E.	95% CI lower	95% CI upper
Wall thickness	1167.20	13.77	6.16	1150.09	1184.31
Muscular layer	94.60	3.36	1.50	90.42	98.78
Submucosal layer	54.80	3.11	1.39	50.93	58.67
Crypt depth	77.60	2.19	0.98	74.88	80.32
Villous height	897.20	10.85	4.85	883.73	910.67
Villous width	94.60	1.82	0.81	92.34	96.86
Circumference	13.87	0.09	0.04	13.75	13.98

(Contd.)

APPENDIX 3.1

Table E1 Tissue thicknesses (μm) and circumference (mm) of 5 separate cross-sections (no.1, 11, 21, 31 and 41) from the *lower ileum* of a 24-hour-old suckled piglet. Each value is the average of 12 measurements except for the circumference which was measured once.

Structure	Section no.1	Section no.11	Section no.21	Section no.31	Section no.41
Wall thickness	1004	996	1037	1000	1000
Muscular layer	117	108	117	116	114
Submucosal layer	116	114	109	122	115
Crypt depth	78	74	76	81	75
Villous height	580	582	584	573	555
Villous width	83	98	88	89	85
Circumference	12.16	12.02	12.09	12.22	12.15

Table E2 Mean values, S.D., S.E. and 95% confidence interval (CI) of the measurements shown in Table E1.

Structure	Mean 5 sections	S.D.	S.E.	95% CI lower	95% CI upper
Wall thickness	1007.40	16.79	7.51	986.55	1028.25
Muscular layer	114.40	3.78	1.69	109.70	119.10
Submucosal layer	115.20	4.66	2.08	109.41	120.99
Crypt depth	76.80	2.77	1.24	73.35	80.25
Villous height	574.80	11.82	5.29	560.12	589.48
Villous width	88.60	5.77	2.58	81.43	95.77
Circumference	12.13	0.08	0.03	12.03	12.22

APPENDIX 3.2

Mean ± S.D. for the SI weight and length, body weight change, and liver and pancreatic weights for the experimental groups described in Chapter 3.

PARAMETERS	B	NS	SC	CC	SM	CM	IF	H_2O
Total Intact SI (g)	35.99 ±5.78	55.82 ±11.37	73.25 ±20.82	54.01 ±10.87	32.19 ±2.18	42.48 ±6.56	42.81 ±11.07	35.60 ±5.22
Total SI mucosa (g)	24.83 ±4.49	43.69 ±9.71	59.31 ±17.83	41.66 ±9.59	26.28 ±1.99	30.82 ±5.08	31.35 ±8.44	25.32 ±3.90
Total SI muscle (g)	11.16 ±1.67	12.14 ±2.35	13.94 ±3.03	12.36 ±1.45	10.92 ±0.59	11.65 ±1.75	11.46 ±2.83	10.27 ±1.47
Intact SI (g)								
Duodenum	1.28 ±0.27	1.02 ±0.33	1.29 ±0.30	1.21 ±0.20	0.88 ±0.10	1.01 ±0.15	0.89 ±0.28	0.74 ±0.10
Upper jejunum	8.87 ±1.46	11.23 ±2.60	13.10 ±2.50	10.25 ±2.98	7.09 ±0.68	7.53 ±1.35	8.31 ±2.04	6.76 ±1.61
Lower jejunum	8.72 ±1.61	11.64 ±2.55	15.22 ±4.41	11.09 ±2.62	7.34 ±0.57	7.88 ±1.45	8.25 ±2.10	6.71 ±1.18
Upper ileum	8.72 ±1.51	10.83 ±3.04	16.64 ±6.97	11.28 ±2.46	6.37 ±0.81	7.20 ±1.09	7.48 ±2.36	6.27 ±0.82
Lower ileum	8.40 ±1.15	8.96 ±2.35	13.06 ±3.84	7.82 ±1.77	4.60 ±0.94	7.20 ±1.87	6.41 ±1.76	4.85 ±0.78
SI Mucosa (g)								
Duodenum	0.59 ±0.17	0.83 ±0.19	0.88 ±0.18	0.91 ±0.20	0.63 ±0.28	0.67 ±0.13	0.78 ±0.23	0.68 ±0.08
Upper jejunum	6.32 ±1.22	3.01 ±0.79	2.87 ±0.85	2.72 ±0.34	2.63 ±0.35	2.62 ±0.62	2.42 ±0.75	2.32 ±0.45
Lower jejunum	6.19 ±1.29	2.58 ±0.34	3.17 ±0.76	2.65 ±0.26	2.29 ±0.29	2.48 ±0.30	2.48 ±0.64	2.35 ±0.35
Upper ileum	6.14 ±1.11	2.53 ±0.39	16.64 ±3.95	2.60 ±0.44	2.40 ±0.25	2.65 ±0.29	2.59 ±0.64	2.36 ±0.33
Lower ileum	5.60 ±0.88	3.18 ±0.85	13.06 ±0.91	3.48 ±0.66	2.96 ±0.24	3.23 ±0.74	3.19 ±0.68	2.56 ±0.50
SI Muscle (g)								
Duodenum	0.69 ±0.10	0.83 ±0.19	0.88 ±0.18	0.91 ±0.20	0.63 ±0.28	0.67 ±0.13	0.78 ±0.23	0.68 ±0.08
Upper jejunum	2.55 ±0.31	3.01 ±0.79	2.87 ±0.85	2.72 ±0.34	2.63 ±0.35	2.62 ±0.62	2.42 ±0.75	2.32 ±0.45
Lower jejunum	2.53 ±0.49	2.58 ±0.34	3.07 ±0.58	2.65 ±0.26	2.29 ±0.29	2.48 ±0.30	2.48 ±0.64	2.35 ±0.35
Upper ileum	2.58 ±0.52	2.53 ±0.39	3.17 ±0.76	2.60 ±0.44	2.40 ±0.25	2.65 ±0.29	2.59 ±0.64	2.36 ±0.33
Lower ileum	2.80 ±0.33	3.18 ±0.85	3.95 ±0.91	3.48 ±0.66	2.96 ±0.24	3.23 ±0.74	3.19 ±0.68	2.56 ±0.50
Total SI length (cm)	341.40 ±20.94	420.00 ±32.72	418.40 ±46.27	403.90 ±16.35	378.20 ±33.37	402.80 ±30.00	357.60 ±20.06	326.40 ±35.75
Duodenum (cm)	9.40 ±0.65	12.00 ±1.70	12.80 ±2.77	13.50 ±0.71	11.80 ±0.84	12.80 ±0.91	11.20 ±0.84	10.80 ±1.04
Jejunum (cm)	166.00 ±10.30	204.00 ±15.75	202.80 ±22.03	195.20 ±7.82	183.20 ±16.71	195.00 ±15.23	173.20 ±9.96	157.80 ±17.67
Ileum (cm)	166.00 ±10.30	204.00 ±15.75	202.80 ±22.03	195.20 ±7.82	183.20 ±16.71	195.00 ±15.23	173.20 ±9.96	157.80 ±17.67
Body weight change (g)	- -	78.08 ±42.02	108.47 ±30.16	50.49 ±37.26	33.16 ±89.77	-6.05 ±19.39	29.74 ±34.75	-46.48 ±37.24
Liver weight (g)	41.96 ±7.06	40.77 ±7.98	40.48 ±6.76	40.32 ±3.84	42.94 ±3.99	44.80 ±5.88	51.16 ±11.88	25.33 ±3.07
Pancreatic weight (g)	1.55 ±0.22	2.35 ±0.39	2.23 ±0.41	2.06 ±0.12	1.89 ±0.34	1.83 ±0.21	1.89 ±0.44	1.63 ±0.11

APPENDIX 3.3

Mean ± S.D. for the SI microscopic structures, number of labelled dividing cells per crypt area and relative migration distance for the experimental groups described in Chapter 3.

PARAMETERS	B	NS	SC	CC	SM	CM	IF	H_2O
Circumference (mm)								
Duodenum	12.974	13.358	14.195	13.960	12.832	13.382	15.466	13.672
	±1.071	±1.915	±0.861	±2.156	±0.741	±1.099	±1.164	±1.815
Upper jejunum	11.950	14.438	15.200	15.470	14.597	14.362	14.750	13.364
	±0.955	±1.913	±1.319	±1.668	±1.688	±1.089	±1.133	±1.706
Lower jejunum	12.744	13.724	16.115	15.506	14.295	14.678	14.268	13.178
	±1.715	±1.222	±1.901	±1.472	±1.676	±0.676	±0.660	±0.944
Upper ileum	12.468	14.232	17.040	15.742	13.615	14.826	14.082	12.604
	±1.163	±1.165	±1.933	±1.304	±1.524	±1.040	±1.956	±1.178
Lower ileum	13.150	13.156	15.667	14.718	13.937	13.886	14.402	14.082
	±1.788	±1.669	±1.026	±0.940	±2.770	±0.504	±1.326	±1.574
Wall thickness (µm)								
Duodenum	944.4	1050.2	1081.0	1038.4	1091.5	1182.4	1245.6	1167.4
	±111.8	±135.9	±154.7	±142.7	±224.1	±119.2	±260.3	±244.1
Upper jejunum	1195.3	1334.8	1398.7	1304.2	1120.2	1174.0	1323.8	1054.6
	±142.3	±47.18	±193.7	±160.4	±87.5	±107.2	±116.7	±54.7
Lower jejunum	1121.0	1373.6	1453.0	1215.4	1057.5	1047.8	1131.2	1206.2
	±352.8	±172.2	±110.7	±88.3	±89.4	±74.4	±74.3	±240.3
Upper ileum	1164.6	1407.4	1349.5	1195.8	1061.7	971.6	1025.8	1086.2
	±198.9	±103.4	±169.5	±97.6	±43.5	±79.1	±155.2	±85.7
Lower ileum	849.0	1326.2	1401.2	1018.8	832.2	1026.8	910.2	773.2
	±156.4	±186.7	±19.2	±29.6	±209.3	±159.3	±130.5	±156.3
Muscular thickness (µm)								
Duodenum	104.6	97.4	127.0	125.6	155.0	140.0	151.4	181.6
	±28.8	±15.4	±19.5	±40.0	±35.2	±36.7	±27.6	±48.8
Upper jejunum	80.4	75.2	86.0	86.2	94.0	97.6	92.2	92.4
	±15.6	±6.7	±12.0	±9.7	±11.3	±12.6	±8.9	±10.3
Lower jejunum	75.6	62.8	81.7	90.0	89.5	92.4	88.0	102.2
	±15.6	±4.8	±6.5	±16.3	±15.3	±10.0	±8.1	±27.0
Upper ileum	80.2	67.0	79.7	80.2	101.2	99.0	101.0	85.8
	±15.1	±12.6	±5.9	±4.7	±15.9	±9.1	±10.4	±11.8
Lower ileum	88.4	80.2	85.5	103.4	105.5	123.6	112.2	96.2
	±13.1	±11.2	±7.4	±6.7	±27.6	±26.4	±13.6	±15.2
Submucosal thickness (µm)								
Duodenum	197.0	153.8	132.5	154.4	146.5	170.6	198.4	210.8
	±74.7	±18.6	±23.4	±49.6	±41.5	±47.9	±57.5	±52.0
Upper jejunum	90.6	77.8	97.7	86.4	85.7	83.0	102.0	97.4
	±18.2	±12.0	±18.5	±9.8	±12.4	±4.8	±8.9	±12.6
Lower jejunum	97.0	70.4	86.5	87.6	70.0	86.8	77.8	121.2
	±28.3	±7.2	±18.4	±18.9	±9.4	±21.6	±10.1	±39.0
Upper ileum	101.0	74.2	73.0	80.6	88.2	89.2	75.0	85.2
	±40.2	±16.2	±10.2	±14.4	±14.0	±13.7	±13.2	±9.2
Lower ileum	83.4	81.0	86.7	96.6	78.2	103.4	88.8	78.4
	±21.6	±16.5	±13.6	±26.6	±25.3	±25.2	±24.1	±14.9
Crypt depth (µm)								
Duodenum	105.4	128.4	125.0	119.0	124.7	129.6	124.6	127.2
	±21.0	±5.6	±11.4	±18.5	±8.6	±19.0	±21.8	±9.7
Upper jejunum	84.6	84.6	92.7	91.6	87.7	94.0	88.4	81.4
	±8.9	±7.6	±13.7	±3.6	±7.4	±8.0	±10.6	±9.1
Lower jejunum	74.6	87.0	86.7	82.2	82.0	75.0	73.2	84.4
	±8.5	±8.7	±11.9	±10.1	±3.7	±11.0	±10.9	±10.3
Upper ileum	70.8	79.4	71.0	77.4	81.0	72.0	68.8	66.0
	±8.7	±6.3	±9.4	±7.1	±2.6	±3.7	±5.4	±7.1
Lower ileum	74.0	82.4	76.7	78.2	77.2	75.8	76.6	67.0
	±10.1	±8.2	±3.3	±4.3	±12.3	±5.8	±3.9	±6.1

(contd.)

APPENDIX 3.3

Mean ± S.D. for the SI microscopic structures, number of labelled dividing cells per crypt area and relative migration distance for the experimental groups described in Chapter 3. (contd.)

PARAMETERS	B	NS	SC	CC	SM	CM	IF	H_2O
Villous height (μm)								
Duodenum	455.4	621.6	597.0	536.2	552.7	623.6	633.6	527.4
	±87.4	±81.3	±98.7	±94.4	±140.1	±72.9	±110.8	±116.9
Upper jejunum	897.6	1051.0	1108.7	936.4	799.7	825.6	945.4	687.0
	±92.6	±95.2	±186.0	±132.5	±77.2	±88.0	±84.5	±41.6
Lower jejunum	809.0	1107.8	1100.7	895.6	780.7	705.0	832.4	893.2
	±276.7	±156.5	±101.9	±55.7	±71.9	±77.3	±76.8	±172.5
Upper ileum	881.8	1141.2	1062.5	908.8	723.5	639.8	720.8	767.5
	±159.8	±93.5	±149.1	±85.5	±56.3	±79.3	±104.4	±59.0
Lower ileum	564.6	990.6	1017.0	626.2	540.5	657.8	563.0	481.4
	±114.0	±200.2	±22.2	±67.8	±96.6	±70.1	±89.6	±125.6
Villous width (μm)								
Duodenum	81.6	99.6	89.7	85.2	89.2	86.8	85.0	81.2
	±7.0	±8.8	±4.0	±9.9	±4.3	±6.1	±8.4	±7.2
Upper jejunum	79.6	95.6	92.2	95.4	94.5	85.2	83.2	73.2
	±5.9	±6.9	±9.3	±7.4	±5.2	±6.8	±7.3	±4.9
Lower jejunum	76.2	100.8	104.0	87.2	94.2	84.4	84.2	77.8
	±10.1	±10.8	±9.5	±6.5	±4.5	±7.8	±4.0	±9.6
Upper ileum	84.4	101.2	107.7	101.4	86.0	91.2	84.2	78.4
	±6.8	±8.6	±3.8	±8.6	±7.3	±5.9	±8.6	±8.2
Lower ileum	85.6	91.8	101.2	88.6	77.7	84.0	84.2	82.0
	±7.1	±11.3	±7.9	±3.9	±7.8	±6.8	±3.6	±5.9
# labelled dividing cells per crypt area (cell/sq. μm)								
Duodenum	-	-	5.4	5.3	4.7	5.3	5.9	6.1
			±1.1	±1.0	±0.8	±0.4	±1.0	±0.5
Upper jejunum	-	-	5.4	6.0	5.1	7.3	7.2	6.8
			±1.6	±0.9	±0.8	±0.6	±0.7	±1.0
Lower jejunum	-	-	6.6	6.4	6.1	6.8	7.6	7.6
			±0.9	±1.0	±0.8	±0.8	±0.9	±0.5
Upper ileum	-	-	6.6	6.9	7.1	7.4	7.4	8.9
			±1.1	±0.6	±1.2	±0.2	±0.9	±0.9
Lower ileum	-	-	7.9	7.1	6.6	7.6	8.1	8.2
			±1.0	±1.1	±0.5	±1.1	±0.8	±0.7
Relation migration distance (μm)								
Duodenum	-	-	198.5	173.6	175.7	184.0	173.4	180.2
			±21.6	±22.1	±16.6	±23.3	±11.9	±16.0
Upper jejunum	-	-	142.5	122.2	128.2	117.4	111.6	109.4
			±16.0	±12.9	±7.3	±9.6	±10.3	±11.2
Lower jejunum	-	-	152.0	113.6	117.0	120.4	118.2	102.4
			±10.7	±6.1	±9.6	±15.0	±24.4	±12.6
Upper ileum	-	-	134.0	99.6	102.0	91.4	94.0	89.8
			±34.0	±12.7	±10.2	±11.3	±8.4	±3.7
Lower ileum	-	-	124.0	106.4	101.7	112.8	103.8	83.6
			±8.9	±7.8	±25.0	±16.9	±12.1	±8.1
Total # dividing cells (from 12 crypts)								
Duodenum	-	-	150.2	135.6	126.2	140.8	144.2	151.4
			±31.5	±22.1	±20.0	±8.6	±29.2	±13.9
Upper jejunum	-	-	134.0	136.2	129.7	146.4	144.6	136.6
			±24.7	±19.0	±12.8	±9.4	±22.2	±19.6
Lower jejunum	-	-	152.2	132.8	133.7	134.0	159.8	131.8
			±22.5	±20.8	±9.7	±15.7	±33.7	±10.3
Upper ileum	-	-	128.7	135.0	132.2	128.8	124.6	151.6
			±19.4	±11.2	±13.5	±14.0	±17.4	±11.5
Lower ileum	-	-	155.0	140.0	125.2	142.2	142.0	131.8
			±17.6	±23.2	±25.1	±21.2	±15.5	±18.1

(Contd.)

APPENDIX 3.3

Mean ± S.D. for the SI microscopic structures, number of labelled dividing cells per crypt area and relative migration distance for the experimental groups described in Chapter 3. (contd.)

PARAMETERS	B	NS	SC	CC	SM	CM	IF	H_2O
Total area of crypts (sq μm) (from 12 crypts)								
Duodenum	-	-	28.2	25.6	27.1	27.1	24.4	24.9
			±4.4	±3.5	±1.0	±3.3	±2.3	±2.6
Upper jejunum	-	-	25.8	22.8	25.6	20.0	20.1	20.2
			±4.3	±2.3	±2.2	±2.0	±1.3	±1.8
Lower jejunum	-	-	23.0	20.7	21.8	19.7	21.0	17.3
			±0.9	±1.8	±2.5	±1.5	±2.6	±1.3
Upper ileum	-	-	19.6	19.5	18.8	17.3	16.8	17.2
			±1.6	±1.2	±1.9	±2.0	±1.0	±2.2
Lower ileum	-	-	19.8	19.8	18.8	18.8	17.5	16.0
			±0.8	±1.3	±2.5	±1.7	±0.9	±1.2

APPENDIX 3.4

Mean ± S.D. for the DNA, RNA, protein concentrations and content, and the RNA:DNA and protein:DNA ratios for the experimental groups described in Chapter 3.

PARAMETERS	B	NS	SC	CC	SM	CM	IF	H_2O
DNA concentration. (mg/g wet tissue)								
Duodenum	4.31 ±0.96	4.33 ±1.15	2.77 ±0.52	4.01 ±0.29	4.52 ±1.09	5.65 ±1.09	6.74 ±1.21	5.97 ±1.31
Upper jejunum	3.98 ±1.47	3.17 ±0.71	3.95 ±0.83	4.53 ±1.39	5.25 ±0.74	6.22 ±0.69	5.92 ±1.64	6.71 ±0.55
Lower jejunum	4.18 ±1.70	2.83 ±0.70	3.23 ±0.17	4.07 ±0.47	4.85 ±0.63	5.76 ±0.90	5.88 ±0.61	5.80 ±0.81
Upper ileum	3.92 ±1.58	2.72 ±0.89	2.77 ±0.52	4.01 ±0.29	5.45 ±1.06	5.65 ±1.09	6.74 ±1.21	5.97 ±1.31
Lower ileum	4.90 ±1.90	3.20 ±1.44	3.15 ±0.97	5.15 ±0.70	7.00 ±1.40	5.82 ±1.19	6.09 ±0.77	6.60 ±0.57
DNA content (mg)								
Duodenum	2.49 ±0.74	4.45 ±1.42	3.50 ±0.73	4.89 ±1.03	3.90 ±0.75	5.80 ±1.75	6.09 ±2.38	4.37 ±1.06
Upper jejunum	24.40 ±7.08	39.39 ±10.20	53.26 ±21.13	43.62 ±8.63	37.05 ±4.86	47.49 ±12.41	51.42 ±23.46	45.90 ±14.11
Lower jejunum	24.60 ±6.79	36.15 ±10.66	48.78 ±12.25	44.16 ±5.84	35.75 ±6.71	44.58 ±4.58	48.01 ±10.46	38.51 ±6.78
Upper ileum	23.53 ±8.38	32.92 ±9.91	43.37 ±11.27	45.70 ±11.89	34.34 ±5.91	40.41 ±9.13	51.12 ±20.64	36.82 ±5.75
Lower ileum	26.68 ±8.48	32.39 ±8.75	40.35 ±13.09	39.84 ±8.48	32.73 ±11.84	40.76 ±7.00	38.51 ±10.00	32.24 ±7.68
RNA concentration (mg/g wet tissue)								
Duodenum	4.51 ±1.19	5.17 ±0.89	5.89 ±0.64	5.00 ±2.09	5.17 ±1.31	6.00 ±0.72	5.27 ±0.29	5.84 ±0.94
Upper jejunum	4.70 ±0.41	4.52 ±0.59	4.37 ±0.85	2.83 ±1.57	4.82 ±1.07	5.35 ±0.40	5.26 ±1.33	5.34 ±0.49
Lower jejunum	5.31 ±0.98	4.02 ±0.74	3.78 ±0.44	2.57 ±0.85	5.89 ±0.30	5.73 ±1.01	5.60 ±0.40	5.88 ±1.32
Upper ileum	5.03 ±0.38	3.49 ±1.32	3.17 ±0.81	2.87 ±1.08	6.04 ±0.69	6.72 ±0.58	6.17 ±0.76	6.12 ±0.45
Lower ileum	4.89 ±0.67	3.61 ±1.63	2.93 ±0.87	3.49 ±1.37	6.24 ±0.53	5.79 ±0.82	5.70 ±0.97	5.81 ±0.46
RNA content (mg)								
Duodenum	2.60 ±0.83	5.49 ±1.97	7.77 ±2.54	5.79 ±1.55	4.44 ±0.84	6.03 ±0.74	4.74 ±1.63	4.26 ±0.66
Upper jejunum	29.73 ±6.29	55.99 ±9.51	58.86 ±22.49	25.85 ±7.29	34.75 ±10.99	40.20 ±6.96	45.26 ±19.55	36.31 ±10.22
Lower jejunum	32.30 ±5.12	51.51 ±12.48	56.68 ±13.43	26.81 ±3.04	43.18 ±2.48	44.05 ±2.86	46.34 ±12.45	38.69 ±7.15
Upper ileum	30.72 ±4.62	41.42 ±11.22	48.61 ±10.22	30.33 ±3.82	38.17 ±4.41	47.91 ±4.41	46.35 ±16.79	38.33 ±5.02
Lower ileum	27.36 ±5.33	37.00 ±8.97	37.15 ±10.29	26.00 ±7.84	28.61 ±5.86	40.53 ±3.94	35.52 ±7.96	28.21 ±5.15
Protein concentration (mg/g wet tissue)								
Duodenum	99.72 ±15.53	116.98 ±23.85	122.28 ±9.41	103.70 ±12.17	86.42 ±18.71	100.52 ±9.24	90.76 ±9.28	105.74 ±18.31
Upper jejunum	106.36 ±5.48	162.58 ±45.52	174.66 ±24.40	159.24 ±16.18	100.58 ±6.40	108.54 ±12.79	105.18 ±25.26	98.16 ±5.97
Lower jejunum	98.86 ±17.98	178.08 ±48.10	227.62 ±9.81	179.38 ±10.45	101.92 ±3.90	117.64 ±7.12	101.00 ±12.27	114.60 ±11.44
Upper ileum	97.30 ±8.81	198.66 ±54.20	253.24 ±18.95	200.16 ±7.71	101.30 ±5.93	110.52 ±10.80	108.12 ±10.52	99.18 ±9.42
Lower ileum	91.04 ±14.78	206.00 ±47.60	258.44 ±38.01	147.34 ±34.17	97.64 ±9.39	92.42 ±10.78	98.54 ±11.02	94.64 ±9.05

(contd.)

APPENDIX 3.4

Mean ± S.D. for the DNA, RNA, protein concentrations and content, and the RNA:DNA and protein:DNA ratios for the experimental groups described in Chapter 3. (contd.)

PARAMETERS	B	NS	SC	CC	SM	CM	IF	H_2O
Protein content (g)								
Duodenum	0.058	0.124	0.157	0.124	0.074	0.101	0.081	0.077
	±0.017	±0.044	±0.030	±0.014	±0.010	±0.014	±0.027	±0.014
Upper jejunum	0.676	2.100	2.255	1.633	0.715	0.818	0.887	0.669
	±0.162	±0.944	±0.332	±0.457	±0.103	±0.183	±0.332	±0.191
Lower jejunum	0.610	2.428	3.448	1.982	0.748	0.927	0.842	0.764
	±0.146	±1.209	±0.952	±0.456	±0.059	±0.173	±0.272	±0.128
Upper ileum	0.594	2.686	4.271	2.256	0.643	0.788	0.820	0.624
	±0.094	±1.500	±2.020	±0.490	±0.076	±0.081	±0.306	±0.113
Lower ileum	0.512	2.404	3.386	1.135	0.449	0.653	0.619	0.461
	±0.123	±1.236	±1.149	±0.308	±0.101	±0.109	±0.137	±0.098
RNA:DNA								
Duodenum	1.106	1.231	2.221	1.284	1.148	1.096	0.806	1.036
	±0.408	±0.248	±0.642	±0.654	±0.142	±0.241	±0.180	±0.358
Upper jejunum	1.303	1.470	1.112	0.596	0.940	0.868	0.898	0.795
	±0.460	±0.299	±0.055	±0.166	±0.263	±0.112	±0.113	±0.038
Lower jejunum	1.416	1.472	1.168	0.622	1.231	0.995	0.957	1.011
	±0.488	±0.327	±0.096	±0.146	±0.165	±0.110	±0.073	±0.160
Upper ileum	1.468	1.332	1.134	0.732	1.140	1.220	0.924	1.064
	±0.599	±0.475	±0.088	±0.336	±0.231	±0.221	±0.097	±0.231
Lower ileum	1.133	1.199	0.935	0.660	0.910	1.016	0.935	0.888
	±0.442	±0.384	±0.059	±0.178	±0.134	±0.182	±0.090	±0.129
Protein: DNA								
Duodenum	24.181	27.542	44.994	26.111	19.757	18.721	13.781	18.870
	±6.617	±3.880	±5.396	±5.012	±4.886	±6.218	±2.726	±6.839
Upper jejunum	29.848	52.905	46.362	38.183	19.474	17.509	18.237	14.670
	±11.236	±16.381	±13.709	±12.532	±2.926	±1.900	±4.590	±1.005
Lower jejunum	27.164	67.337	70.603	44.584	21.274	20.801	17.465	19.903
	±11.458	±25.553	±4.992	5.797	±2.621	±3.232	±3.583	±1.782
Upper ileum	28.503	82.490	94.907	50.115	19.042	19.984	16.253	17.257
	±11.805	±37.656	±23.496	±4.834	±3.101	±3.072	±1.731	±3.788
Lower ileum	21.529	80.627	89.473	29.342	14.342	16.193	16.277	14.434
	±9.576	±45.264	±32.413	±9.067	±2.813	±2.215	±1.772	±1.958

APPENDIX 3.5

Mean ± S.D. for the lactase activity for the experimental groups described in Chapter 3.

PARAMETERS	B	NS	SC	CC	SM	CM	IF	H_2O
Lactase activity (μmol/g wet tissue.min)								
Duodenum	13.536	13.720	16.900	13.640	5.528	9.040	12.680	22.140
	±5.202	±7.091	±7.577	±10.121	±5.533	±3.586	±8.869	±6.544
Upper jejunum	22.120	22.960	19.200	23.540	20.146	22.940	29.460	35.260
	±1.445	±6.711	±8.180	±3.706	±7.747	±6.023	±4.700	±7.545
Lower jejunum	22.166	18.930	16.880	22.140	19.200	26.680	31.400	36.680
	±7.186	±5.999	±4.361	±2.787	±5.732	±6.220	±8.575	±7.440
Upper ileum	18.586	15.566	8.660	12.460	13.200	14.352	24.800	22.520
	±6.538	±5.819	±2.926	±3.614	±7.406	±4.360	±10.833	±3.923
Lower ileum	4.836	10.036	4.760	6.680	2.196	8.000	9.860	6.720
	±2.538	±4.933	±2.633	±3.863	±1.666	±10.202	±5.160	±3.577
Lactase activity (μmol/g DNA.min)								
Duodenum	3.478	3.066	6.441	3.330	1.538	1.674	1.794	3.983
	±2.006	±0.906	±3.047	±2.353	±1.913	±0.805	±1.054	±1.720
Upper jejunum	6.234	7.957	4.854	5.842	3.996	3.669	5.385	5.312
	±2.458	±4.139	±1.618	±2.719	±1.768	±0.784	±2.079	±1.348
Lower jejunum	5.687	7.467	5.230	5.539	4.033	4.817	5.418	6.388
	±1.898	±4.269	±1.383	±1.165	±1.394	±1.834	±1.740	±1.290
Upper ileum	5.259	6.700	3.311	3.075	2.555	2.514	3.583	3.869
	±2.657	±4.366	±1.413	±0.750	±1.484	±0.461	±1.047	±0.783
Lower ileum	1.267	4.405	1.613	1.381	0.333	1.676	1.652	1.023
	±1.167	±3.848	±1.109	±0.928	±0.242	±2.433	±0.901	±0.540
Total lactase activity ((μmol/min)								
Duodenum	8.393	14.235	21.159	16.896	5.125	9.191	12.709	16.292
	±5.199	±7.986	±9.533	±12.820	±5.341	±3.822	±10.156	±5.410
Upper jejunum	141.022	297.403	260.890	249.952	143.971	174.269	239.871	233.369
	±36.055	±126.151	±143.181	±105.35	±59.296	±63.732	±49.462	±48.902
Lower jejunum	132.164	256.908	260.827	248.626	139.162	217.040	257.378	240.444
	±26.785	±132.569	±113.275	±76.089	±33.684	±89.804	±98.140	±26.375
Upper ileum	109.718	211.539	154.913	145.210	83.282	104.538	198.349	141.404
	±25.832	±133.475	±95.542	±65.495	±47.766	±43.508	±118.363	±31.213
Lower ileum	26.552	125.816	69.797	52.127	9.666	71.388	66.839	31.246
	±13.115	±104.996	±54.079	±29.495	±7.657	±111.441	±46.645	±12.988

CHAPTER 4

EFFECTS OF INTRALUMINAL NUTRITION AND TOTAL PARENTERAL NUTRITION ON POSTNATAL DEVELOPMENT OF THE SMALL INTESTINE IN PIGLETS DURING THE FIRST 24 HOURS AFTER BIRTH

APPENDICES

NUTRIENT CONSUMPTON OF THE NEWBORN PIGLET

Colostrum intake of naturally suckled piglets during the first 24 hours = 210 - 290 ml/kg (Mellor & Cockburn; 1986)

Average composition of colostrum at 12 hours of lactation (Klobasa *et al.*, 1987).

Lactose	4.1 %W/W
Lipid	4.9 %W/W
Protein	8.8 %W/W

Nutrient consumption by piglets during the first 24 hours after birth.

Lactose	61.00 - 11.89 g/kg
Lipid	10.90 - 14.21 g/kg
Protein	18.48 - 25.52 g/kg

CALORIC REQUIREMENT OF THE NEWBORN PIGLET
(Data adapted from Mellor & Cockburn, 1986)

Metabolic rate of piglets during the first 24 hours after birth = 9.5 kJ/kg.hr at 32 - 38°C

Respiratory Quotients and percentage of carbohydrate and lipid utilization.

Period	R.Q.	%CHO	%Lipid
0 - 2 hrs	0.90	66	34
2 - 6 hrs	0.84	46	54
6 - 24 hrs	0.81	36	64

Energy requirement from carbohydrate and lipid.

Period	CHO (kJ/kg.hr)	Lipid (kJ/kg.hr)
0 - 2 hrs	6.27	3.23
2 - 6 hrs	4.37	5.13
6 - 24 hrs	3.42	6.08

Carbohydrate and lipid requirement.
(CHO = 17.2 kJ/g; Lipid 38.9 kJ/g)

Period	CHO (mg/kg.hr)	Lipid (mg/kg.hr)
0 - 2 hrs	365	83
2 - 6 hrs	254	132
6 - 24 hrs	199	156
Period	**CHO (mg/kg)**	**Lipid (mg/kg)**
0 - 2 hrs	730	166
2 - 6 hrs	1016	528
6 - 24 hrs	3582	2808
0 - 24 hrs	5328	3502

Therefore, the nuritional requirement of piglets during the first 24 hours are: carbohydrate 5.3 g/kg (91.16 kJ/kg), lipid 3.5 g/kg (136.15 kJ/kg).

APPENDIX 4.2

Mean ± S.D. for the SI weight and length, body weight change, and liver and pancreatic weights for the experimental groups described in Chapter 4.

PARAMETERS	OGF	TPN
Total intact SI (g)	37.22 ±3.17	34.83 ±9.34
Total SI mucosa (g)	26.79 ±2.38	24.10 ±7.48
Total SI muscle (g)	10.43 ±0.84	10.73 ±2.02
Intact SI (g)		
Duodenum	1.66 ±0.27	1.68 ±0.55
Upper jejunum	9.95 ±1.15	8.93 ±2.54
Lower jejunum	8.91 ±0.73	8.62 ±1.80
Upper ileum	8.82 ±0.97	7.92 ±2.22
Lower ileum	7.88 ±0.83	7.67 ±2.48
SI mucosa (g)		
Duodenum	0.97 ±0.10	0.91 ±0.26
Upper jejunum	7.55 ±1.09	6.50 ±2.24
Lower jejunum	6.55 ±0.58	6.33 ±1.35
Upper ileum	6.30 ±0.93	5.64 ±1.89
Lower ileum	5.42 ±0.69	4.71 ±2.01
SI muscle (g)		
Duodenum	0.69 ±0.20	0.77 ±0.32
Upper jejunum	2.39 ±0.20	2.43 ±0.37
Lower jejunum	2.36 ±0.21	2.28 ±0.48
Upper ileum	2.52 ±0.36	2.29 ±0.40
Lower ileum	2.46 ±0.59	2.96 ±0.50
Total SI length (cm)	391.60 ±18.23	353.76 ±20.96
Duodenum	12.96 ±2.29	11.76 ±2.08
Jejunum	189.32 ±8.88	171.00 ±9.85
Ileum	189.32 ±8.88	171.00 ±9.85
Body weight change (g)	0.09 ±0.04	0.08 ±0.04
Liver weight (g)	34.54 ±3.31	40.30 ±9.74
Pancreatic weight (g)	1.66 ±0.24	1.75 ±0.23

APPENDIX 4.3

Mean ± S.D. for the SI microscopic structures, number of labelled dividing cells per crypt area and relative migration distances for the experimental groups described in Chapter 4.

PARAMETERS	OGF	TPN
Circumference (mm)		
Duodenum	12.293 ±2.046	12.432 ±1.344
Upper jejunum	12.530 ±1.198	12.053 ±1.384
Lower jejunum	11.261 ±0.461	11.451 ±1.313
Upper ileum	12.437 ±0.658	12.402 ±2.401
Lower ileum	11.303 ±0.992	11.272 ±1.018
Wall thickness (µm)		
Duodenum	1095.8 ±92.2	1086.4 ±115.6
Upper jejunum	1194.0 ±150.8	1199.6 ±189.6
Lower jejunum	1171.4 ±171.7	1286.8 ±253.7
Upper ileum	1223.6 ±210.0	1093.6 ±220.6
Lower ileum	1123.8 ±129.1	1113.2 ±178.2
Muscular thickness (µm)		
Duodenum	128.0 ±21.3	113.6 ±12.9
Upper jejunum	85.0 ±5.2	87.2 ±8.7
Lower jejunum	87.8 ±8.5	93.4 ±9.3
Upper ileum	88.0 ±13.6	87.6 ±8.7
Lower ileum	110.6 ±13.8	117.0 ±10.0
Submmucosal thickness (µm)		
Duodenum	106.0 ±18.8	125.0 ±38.1
Upper jejunum	72.8 ±9.7	73.0 ±10.3
Lower jejunum	70.6 ±18.6	103.0 ±36.6
Upper Ileum	90.8 ±43.2	70.8 ±21.9
Lower ileum	112.0 ±48.1	112.0 ±37.6
Crypt depth (µm)		
Duodenum	119.0 ±12.8	134.4 ±14.9
Upper jejunum	86.6 ±16.5	80.8 ±5.4
Lower jejunum	79.2 ±11.4	73.6 ±3.8
Upper ileum	64.0 ±6.6	64.2 ±9.1
Lower ileum	63.6 ±7.6	70.4 ±12.8

(contd.)

Mean ± S.D. for the SI microscopic structures, number of labelled dividing cells per crypt area and relative migration distances for the experimental groups described in Chapter 4. (contd.)

PARAMETERS	OGF	TPN
Villous height (μm)		
Duodenum	625.4	613.0
	±95.1	±89.5
Upper jejunum	892.6	863.0
	±85.1	±133.0
Lower jejunum	856.0	922.0
	±173.4	±160.5
Upper ileum	884.0	791.6
	±141.8	±179.3
Lower ileum	722.2	672.0
	±89.0	±134.0
Villous width (μm)		
Duodenum	84.2	80.2
	±5.4	±4.9
Upper jejunum	78.8	67.0
	±6.4	±3.7
Lower jejunum	71.6	63.6
	±5.0	±8.4
Upper ileum	69.2	64.0
	±4.1	±4.5
Lower ileum	60.6	61.4
	±4.2	±3.8
# Labelled dividing cells per crypt area (cell/sq.μm)		
Duodenum	5.7	5.4
	±0.6	±0.4
Upper jejunum	6.6	7.0
	±1.3	±1.2
Lower jejunum	7.2	7.4
	±1.6	±0.7
Upper ileum	7.1	7.6
	±1.1	±0.8
Lower ileum	7.3	8.0
	±0.8	±1.3
Relative migration distance (μm)		
Duodenum	147.8	158.6
	±14.7	±15.7
Upper jejunum	104.6	111.8
	±9.4	±16.5
Lower jejunum	91.0	101.8
	±4.8	±12.0
Upper ileum	86.8	94.8
	±9.6	±14.6
Lower ileum	91.2	96.6
	±5.4	±11.9

APPENDIX 4.4

Mean ± S.D. for the DNA, RNA, protein concentrations and content, and the RNA:DNA and protein:DNA ratios for the experimental groups described in Chapter 4.

PARAMETERS	OGF	TPN
DNA concentration (mg/g wet tissue)		
Duodenum	5.94 ±0.46	5.79 ±1.73
Upper jejunum	5.33 ±1.52	6.91 ±2.28
Lower jejunum	5.02 ±1.09	6.24 ±1.50
Upper ileum	6.64 ±2.06	5.98 ±1.92
Lower ileum	6.13 ±1.42	8.33 ±1.87
DNA content (mg)		
Duodenum	5.39 ±0.83	5.47 ±1.59
Upper jejunum	35.32 ±11.55	50.62 ±22.44
Lower jejunum	30.71 ±6.23	42.75 ±16.69
Upper ileum	37.53 ±7.87	33.65 ±1.83
Lower ileum	31.17 ±9.33	40.83 ±16.90
RNA concentration (mg/g wet tissue)		
Duodenum	4.71 ±0.80	3.76 ±1.02
Upper jejunum	4.90 ±0.97	4.42 ±0.41
Lower jejunum	4.76 ±0.49	5.14 ±0.70
Upper ileum	5.10 ±0.64	5.56 ±0.95
Lower ileum	5.01 ±0.77	5.62 ±1.06
RNA content (mg)		
Duodenum	4.30 ±1.12	3.64 ±1.30
Upper jejunum	33.09 ±10.96	33.32 ±10.75
Lower jejunum	29.29 ±3.27	34.38 ±7.39
Upper ileum	30.32 ±8.79	34.49 ±12.48
Lower ileum	25.44 ±5.72	29.03 ±12.99

(contd.)

APPENDIX 4.4

Mean ± S.D. for the DNA, RNA, protein concentrations and content, and the RNA:DNA and protein:DNA ratios for the experimental groups described in Chapter 4. (contd.)

PARAMETERS	OGF	TPN
Protein concentration (mg/g wet tissue)		
Duodenum	92.46 ±15.73	87.08 ±14.98
Upper jejunum	93.42 ±20.72	101.38 ±10.02
Lower jejunum	99.20 ±8.44	107.06 ±15.28
Upper ileum	102.18 ±9.17	107.12 ±7.58
Lower ileum	101.15 ±9.61	114.95 ±9.64
Protein content (g)		
Duodenum	0.084 ±0.020	0.083 ±0.020
Upper jejunum	0.633 ±0.219	0.747 ±0.186
Lower jejunum	0.612 ±0.077	0.716 ±0.161
Upper ileum	0.603 ±0.148	0.648 ±0.197
Lower ileum	0.517 ±0.116	0.567 ±0.199
RNA: DNA ratio		
Duodenum	0.795 ±0.140	0.690 ±0.234
Upper jejunum	0.938 ±0.131	0.702 ±0.258
Lower jejunum	0.976 ±0.171	0.847 ±0.162
Upper ileum	0.834 ±0.287	1.014 ±0.335
Lower ileum	0.849 ±0.210	0.716 ±0.244
Protein: DNA ratio		
Duodenum	15.704 ±3.319	15.781 ±4.176
Upper jejunum	17.807 ±2.461	16.010 ±5.570
Lower jejunum	20.355 ±3.639	17.596 ±5.192
Upper ileum	16.645 ±5.250	19.180 ±5.560
Lower ileum	17.015 ±2.780	14.203 ±2.396

APPENDIX 4.5

Mean ± S.D. for the lactase activity and serum glucose concentration for the experimental groups described in Chapter 4.

PARAMETERS	OGF	TPN
Lactase activity (μmol/g wet tissue. min)		
Duodenum	7.150 ±5.564	10.820 ±4.110
Upper jejunum	18.390 ±8.069	23.192 ±7.525
Lower jejunum	19.308 ±8.664	21.750 ±9.382
Upper ileum	16.196 ±8.460	13.988 ±8.242
Lower ileum	5.446 ±5.388	4.906 ±4.836
Lactase activity (μmol/g DNA. min)		
Duodenum	1.237 ±1.040	2.067 ±0.924
Upper jejunum	3.703 ±2.068	3.803 ±2.205
Lower jejunum	3.754 ±1.345	3.373 ±0.829
Upper ileum	2.443 ±1.040	2.745 ±1.911
Lower ileum	0.834 ±0.683	0.589 ±0.546
Total lactase activity (μmol/min)		
Duodenum	6.646 ±6.225	10.802 ±5.076
Upper jejunum	120.098 ±67.279	178.831 ±82.535
Lower ileum	114.782 ±45.776	149.991 ±83.393
Upper ileum	91.615 ±48.316	93.953 ±67.093
Lower ileum	27.126 ±25.788	30.908 ±33.432
Serum glucose concentration (mmol/L) at 24 hrs	6.320 ±0.370	5.560 ±0.950
Difference between 0 and 24 hrs	2.640 ±1.568	1.840 ±0.921

CHAPTER 5

EFFECTS OF SUCKING AND OROGASTRIC FEEDING ON POSTNATAL DEVELOPMENT OF THE SMALL INTESTINE IN PIGLETS DURING THE FIRST 24 HOURS AFTER BIRTH

APPENDICES

APPENDIX 5.1

Mean ± S.D. for the SI weigh and length, body weight, and liver and pancreatic weights for the experimental groups described in Chapter 5.

PARAMETERS	SC-S	SC-OGF	IF-S	IF-OGF
Total intact SI (g)	65.85 ±17.60	67.41 ±17.00	38.24 ±6.23	38.78 ±6.42
Total SI mucosa (g)	51.49 ±16.24	53.19 ±16.07	26.79 ±5.33	26.41 ±5.61
Total SI muscle (g)	14.37 ±1.70	14.22 ±1.25	11.46 ±1.04	12.37 ±1.31
Intact SI (g)				
Duodenum	2.13 ±0.31	2.29 ±0.56	1.74 ±0.21	1.86 ±0.27
Upper jejunum	14.89 ±3.57	16.24 ±3.42	9.39 ±1.29	9.67 ±2.03
Lower jejunum	16.10 ±4.28	16.56 ±2.86	9.12 ±1.19	9.61 ±1.87
Upper ileum	17.36 ±5.13	17.56 ±6.17	8.73 ±1.33	9.22 ±1.53
Lower ileum	15.37 ±5.25	14.76 ±5.75	9.26 ±2.88	8.42 ±1.40
SI mucosa (g)				
Duodenum	1.25 ±0.31	1.42 ±0.47	0.97 ±0.32	1.17 ±0.27
Upper jejunum	11.52 ±3.65	13.24 ±3.30	6.91 ±1.16	7.00 ±1.65
Lower jejunum	13.10 ±3.96	13.04 ±3.24	6.59 ±0.89	6.79 ±1.61
Upper ileum	14.05 ±4.85	14.33 ±5.26	5.93 ±1.38	6.33 ±1.58
Lower ileum	11.57 ±4.52	11.15 ±5.19	6.37 ±2.39	5.11 ±0.99
SI muscle (g)				
Duodenum	0.88 ±0.07	0.87 ±0.14	0.76 ±0.15	0.69 ±0.20
Upper jejunum	3.37 ±0.54	3.00 ±0.29	2.48 ±6.22	2.67 ±0.55
Lower jejunum	3.00 ±0.37	3.52 ±0.64	2.53 ±0.31	2.81 ±0.35
Upper ileum	3.31 ±0.40	3.23 ±1.09	2.80 ±0.30	2.89 ±0.32
Lower ileum	3.80 ±0.90	3.61 ±0.61	2.89 ±0.51	3.31 ±0.61
Total SI length (cm)	432.20 ±24.83	459.20 ±49.15	368.60 ±41.31	379.50 ±59.11
Duodenum	13.80 ±0.84	14.00 ±2.00	13.00 ±1.00	12.30 ±0.84
Jejunum	209.20 ±12.62	222.60 ±23.95	177.80 ±20.38	183.60 ±29.44
Ileum	209.20 ±12.62	222.60 ±23.95	177.80 ±20.38	183.60 ±29.44
Body weight change (g)	34.70 ±26.21	71.54 ±31.70	-15.92 ±54.15	13.48 ±57.65
Liver weight (g)	40.06 ±5.29	40.65 ±5.15	43.14 ±7.08	46.42 ±8.94
Pancreatic weight (g)	3.34 ±2.45	2.16 ±0.40	2.03 ±0.92	1.84 ±0.63

APPENDIX 5.2

Mean ± S.D. for the SI microscopic structures, number of labelled dividing cells per crypt area and relative migration distances for the experimental groups described in Chapter 5.

PARAMETERS	SC-S	SC-OGF	IF-S	IF-OGF
Circumference (mm)				
Duodenum	12.829	13.179	12.346	13.246
	±1.076	±1.980	±0.633	±2.191
Upper jejunum	14.210	13.817	11.791	12.273
	±1.077	±0.636	±0.296	±0.703
Lower jejunum	14.135	13.770	11.937	12.099
	±0.944	±1.716	±0.988	±1.388
Upper ileum	14.389	14.408	11.936	12.567
	±1.276	±0.664	±1.222	±2.699
Lower ileum	13.271	13.350	11.389	11.275
	±1.026	±1.541	±1.955	±1.380
Wall thickness (µm)				
Duodenum	1309.2	1441.2	1047.4	1040.2
	±169.3	±247.6	±164.9	±237.4
Upper jejunum	1487.4	1605.8	1049.2	1156.4
	±112.9	±189.0	±138.5	±125.0
Lower jejunum	1515.0	1487.8	1199.0	1253.0
	±67.0	±88.8	±162.5	±172.1
Upper ileum	1574.6	1620.2	1059.8	1217.4
	±175.7	±247.1	±95.5	±274.2
Lower ileum	1275.8	1311.4	861.2	969.2
	±256.9	±332.4	±97.1	±112.3
Muscular thickness (µm)				
Duodenum	115.4	125.4	117.4	114.4
	±23.7	±16.1	±9.1	±15.5
Upper jejunum	75.4	85.6	83.8	83.2
	±2.5	±7.8	±9.9	±10.7
Lower jejunum	73.2	82.4	82.2	82.0
	±4.0	±5.7	±9.8	±18.9
Upper ileum	80.0	85.6	88.4	80.4
	±7.2	±7.6	±12.0	±6.9
Lower ileum	89.4	82.4	88.8	93.6
	±18.3	±15.3	±18.5	±17.7
Submucosal thickness (µm)				
Duodenum	119.4	120.6	123.8	160.2
	±20.5	±32.1	±34.1	±73.6
Upper jejunum	83.6	80.0	74.0	106.8
	±30.0	±15.5	±18.7	±49.0
Lower jejunum	86.0	78.8	100.8	107.2
	±11.0	±16.4	±39.1	±31.1
Upper Ileum	91.8	78.0	115.4	109.8
	±19.6	±14.2	±34.6	±51.5
Lower ileum	84.6	77.6	98.2	87.8
	±18.7	±29.2	±32.0	±31.2
Crypt depth (µm)				
Duodenum	114.8	122.4	101.6	106.2
	±16.7	±11.5	±10.8	±11.7
Upper jejunum	83.0	81.8	81.2	84.4
	±10.3	±8.4	±13.2	±13.2
Lower jejunum	77.2	77.6	73.4	74.8
	±7.1	±8.4	±9.4	±10.7
Upper ileum	75.2	73.8	68.8	70.6
	±12.6	±10.6	±5.8	±3.4
Lower ileum	72.8	67.2	71.8	76.0
	±15.9	±5.9	±7.0	±19.2

(Contd.)

APPENDIX 5.2

Mean ± S.D. for the SI microscopic structures, number of labelled dividing cells per crypt area and relative migration distances for the experimental groups described in Chapter 5. (contd.)

PARAMETERS	SC-S	SC-OGF	IF-S	IF-OGF
Villous height (μm)				
Duodenum	787.6	810.6	634.8	537.6
	±150.7	±142.7	±164.0	±154.7
Upper jejunum	1148.6	1254.2	737.6	830.2
	±76.4	±200.6	±114.6	±158.8
Lower jejunum	1216.2	1172.4	840.8	900.0
	±59.8	±83.4	±93.1	±88.0
Upper ileum	1234.8	1269.0	723.8	891.0
	±129.2	±142.4	±66.8	±199.1
Lower ileum	926.8	1012.0	535.6	617.2
	±197.2	±270.4	±67.4	±56.0
Villous width (μm)				
Duodenum	75.6	80.6	74.4	75.0
	±6.5	±6.8	±4.9	±7.0
Upper jejunum	89.0	88.2	65.8	70.2
	±7.3	±7.7	±6.1	±9.5
Lower jejunum	96.6	92.0	69.2	70.8
	±10.1	±6.3	±7.6	±8.4
Upper ileum	88.6	94.0	68.2	69.2
	±10.0	±15.2	±8.7	±7.4
Lower ileum	73.8	88.2	71.8	68.4
	±13.2	±10.5	±17.0	±6.2
# Labelled dividing cells per crypt area (cell/sq.μm)				
Duodenum	3.7	3.9	3.8	3.8
	±1.7	±1.5	±1.3	±1.4
Upper jejunum	4.8	5.9	5.3	5.1
	±1.1	±2.1	±1.6	±1.5
Lower jejunum	6.0	5.5	5.8	5.8
	±1.2	±1.5	±1.0	±1.6
Upper ileum	5.4	5.3	5.8	5.3
	±2.4	±1.9	±2.2	±2.0
Lower ileum	5.6	5.0	5.9	5.5
	±2.0	±2.2	±1.4	±1.5
Relative migration distance (μm)				
Duodenum	162.0	180.0	139.6	157.8
	±27.3	±34.7	±23.9	±36.5
Upper jejunum	118.8	119.6	105.2	107.8
	±15.3	±22.4	±22.5	±25.2
Lower jejunum	100.6	107.2	95.4	99.2
	±13.3	±17.9	±17.6	±25.9
Upper ileum	96.6	107.2	87.2	94.0
	±13.0	±27.2	±17.0	±20.8
Lower ileum	84.0	89.4	84.2	90.6
	±16.9	±18.8	±16.2	±20.0

APPENDIX 5.3

Mean ± S.D. for the DNA, RNA, protein concentrations and content, and the RNA:DNA and protein:DNA ratios for the experimental groups described in Chapter 5.

PARAMETERS	SC-S	SC-OGF	IF-S	IF-OGF
DNA concentration (mg/g wet tissue)				
Duodenum	3.97 ±0.31	4.40 ±1.55	5.17 ±0.56	3.70 ±1.76
Upper jejunum	2.94 ±0.46	3.29 ±0.66	4.80 ±1.37	4.50 ±2.52
Lower jejunum	2.95 ±0.34	3.02 ±0.62	5.37 ±1.53	5.38 ±0.90
Upper ileum	2.70 ±0.50	2.92 ±0.38	5.43 ±1.05	5.14 ±1.50
Lower ileum	3.54 ±1.27	3.64 ±0.82	5.70 ±1.99	5.41 ±1.85
DNA content (mg)				
Duodenum	4.92 ±1.18	6.24 ±2.72	5.11 ±2.05	4.64 ±2.83
Upper jejunum	32.81 ±7.21	44.08 ±14.37	33.84 ±13.60	33.86 ±23.51
Lower jejunum	37.89 ±9.73	39.68 ±12.52	35.97 ±14.09	36.90 ±13.37
Upper ileum	37.00 ±12.05	40.38 ±10.79	33.22 ±13.05	34.26 ±18.99
Lower ileum	36.79 ±8.35	38.40 ±14.65	37.84 ±23.33	29.04 ±14.81
RNA concentration (mg/g wet tissue)				
Duodenum	2.66 ±2.09	3.07 ±2.45	2.52 ±2.08	2.59 ±2.25
Upper jejunum	2.90 ±0.58	3.23 ±0.93	2.59 ±2.33	2.91 ±2.83
Lower jejunum	3.13 ±0.30	3.19 ±0.25	2.73 ±2.62	2.81 ±2.64
Upper ileum	3.06 ±0.86	3.23 ±0.76	2.37 ±2.06	2.87 ±2.81
Lower ileum	2.82 ±0.89	3.30 ±1.15	2.40 ±2.14	2.97 ±2.72
RNA content (mg)				
Duodenum	3.62 ±3.16	4.50 ±3.56	2.88 ±2.92	3.14 ±2.88
Upper jejunum	34.32 ±15.85	43.63 ±17.71	19.10 ±18.54	21.43 ±22.77
Lower jejunum	40.77 ±12.37	41.36 ±10.37	18.80 ±19.48	21.13 ±22.47
Upper ileum	40.47 ±10.76	44.04 ±13.52	15.73 ±15.45	20.80 ±23.73
Lower ileum	10.76 ±31.68	32.48 ±8.73	16.85 ±17.14	16.88 ±17.27

(contd.)

APPENDIX 5.3

Mean ± S.D. for the DNA, RNA, protein concentrations and content, and the RNA:DNA and protein:DNA ratios for the experimental groups described in Chapter 5. (contd.)

PARAMETERS	SC-S	SC-OGF	IF-S	IF-OGF
Protein concentration (mg/g wet tissue)				
Duodenum	121.84 ±13.79	127.29 ±11.067	105.37 ±15.47	88.99 ±4.04
Upper jejunum	173.45 ±17.92	165.35 ±16.94	106.83 ±10.67	104.29 ±3.61
Lower jejunum	194.19 ±11.39	188.01 ±8.89	109.42 ±11.20	113.10 ±23.39
Upper ileum	196.18 ±12.15	199.67 ±14.81	102.27 ±15.39	100.09 ±7.56
Lower ileum	198.02 ±26.41	198.70 ±15.81	99.46 ±10.41	110.39 ±13.64
Protein content (g)				
Duodenum	0.150 ±0.035	0.181 ±0.066	0.099 ±0.022	0.103 ±0.023
Upper jejunum	2.011 ±0.728	2.209 ±0.699	0.731 ±0.074	0.727 ±0.157
Lower jejunum	2.556 ±0.852	2.466 ±0.677	0.717 ±0.090	0.744 ±0.117
Upper ileum	2.789 ±1.082	2.875 ±1.129	0.605 ±0.150	0.630 ±0.142
Lower ileum	2.372 ±1.154	2.256 ±1.185	0.620 ±0.171	0.555 ±0.059
RNA: DNA ratio				
Duodenum	0.673 ±0.528	0.620 ±0.305	0.461 ±0.346	0.601 ±0.325
Upper jejunum	1.006 ±0.279	0.998 ±0.259	0.473 ±0.326	0.575 ±0.365
Lower jejunum	1.066 ±0.072	1.094 ±0.258	0.444 ±0.344	0.493 ±0.427
Upper ileum	1.124 ±0.214	1.094 ±0.160	0.394 ±0.287	0.498 ±0.411
Lower ileum	0.834 ±0.225	0.913 ±0.285	0.364 ±0.218	0.498 ±0.348
Protein: DNA ratio				
Duodenum	30.684 ±2.370	31.991 ±11.351	20.725 ±4.571	29.670 ±16.944
Upper jejunum	59.773 ±8.951	52.346 ±13.623	24.383 ±9.630	30.163 ±17.881
Lower jejunum	66.434 ±6.446	64.278 ±13.084	21.928 ±7.025	21.368 ±4.819
Upper ileum	74.461 ±13.740	69.646 ±13.381	19.600 ±5.395	20.700 ±5.484
Lower ileum	64.936 ±34.357	57.410 ±16.350	19.454 ±7.371	24.033 ±13.912

APPENDIX 5.4

Mean ± S.D. for the lactase activity for the experimental groups described in Chapter 5.

PARAMETERS	SC-S	SC-OGF	IF-S	IF-OGF
Lactase activity (μmol/g wet tissue.min)				
Duodenum	11.026	10.883	8.255	7.363
	±4.683	±4.804	±3.646	±2.430
Upper jejunum	11.533	10.753	14.957	17.945
	±2.928	±4.868	±5.226	±6.840
Lower jejunum	8.353	7.635	12.097	15.479
	±1.992	±2.855	±4.262	±3.338
Upper ileum	3.605	3.429	12.137	10.763
	±1.878	±1.600	±5.034	±1.774
Lower ileum	0.755	0.841	3.638	3.194
	±0.818	±0.859	±3.006	±1.036
Lactase activity (μmol/gDNA.min)				
Duodenum	2.749	2.522	1.664	2.299
	±1.091	±0.815	±0.839	±1.438
Upper jejunum	3.992	3.340	3.620	4.420
	±1.220	±1.608	±2.366	±1.356
Lower jejunum	2.828	2.654	2.587	2.985
	±0.607	±1.137	±1.604	±0.941
Upper ileum	1.441	1.240	2.433	2.190
	±0.954	±0.686	±1.301	±0.553
Lower ileum	0.206	0.228	0.836	0.598
	±0.206	±0.209	±0.826	±0.067
Total lactase activity (μmol/min)				
Duodenum	14.172	15.503	7.313	8.922
	±7.343	±8.139	±2.796	±4.360
Upper jejunum	136.361	139.988	100.239	131.442
	±76.756	±71.317	±27.684	±69.258
Lower jejunum	105.633	103.764	79.516	105.295
	±31.618	±55.577	±29.692	±35.118
Upper ileum	50.432	55.159	67.831	69.001
	±39.266	±37.999	±24.249	±24.943
Lower ileum	6.986	11.005	20.582	16.997
	±6.653	±10.668	±18.319	±8.005

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