THE ENTERIC NERVOUS SYSTEM IN THE RUMINANT STOMACH OF THE SHEEP (OVIS ARIES)

HET ENTERISCHE ZENUWSTELSEL IN DE HERKAUWERSMAAG VAN HET SCHAAP (OVIS ARIES)

ADDENDUM

PROEFSCHRIFT

TER VERKRIJGING VAN DE GRAAD VAN DOCTOR
AAN DE ERASMUS UNIVERSITEIT ROTTERDAM
OP GEZAG VAN DE RECTOR MAGNIFICUS PROF. DR. A.H.G. RINNOOY KAN
EN VOLGENS BESLUIT VAN HET COLLEGE VAN DEKANEN.

DE OPENBARE VERDEDIGING ZAL PLAATSVINDEN OP

VRIJDAG 17 JUNI 1988 OM 13.30 UUR

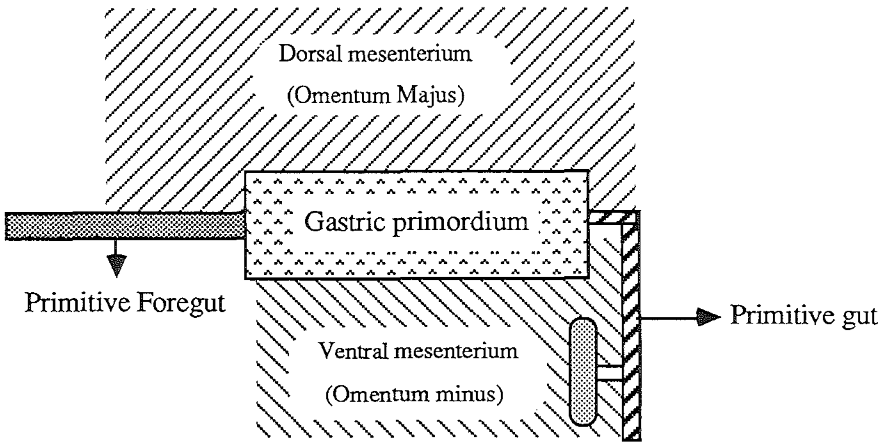
DOOR

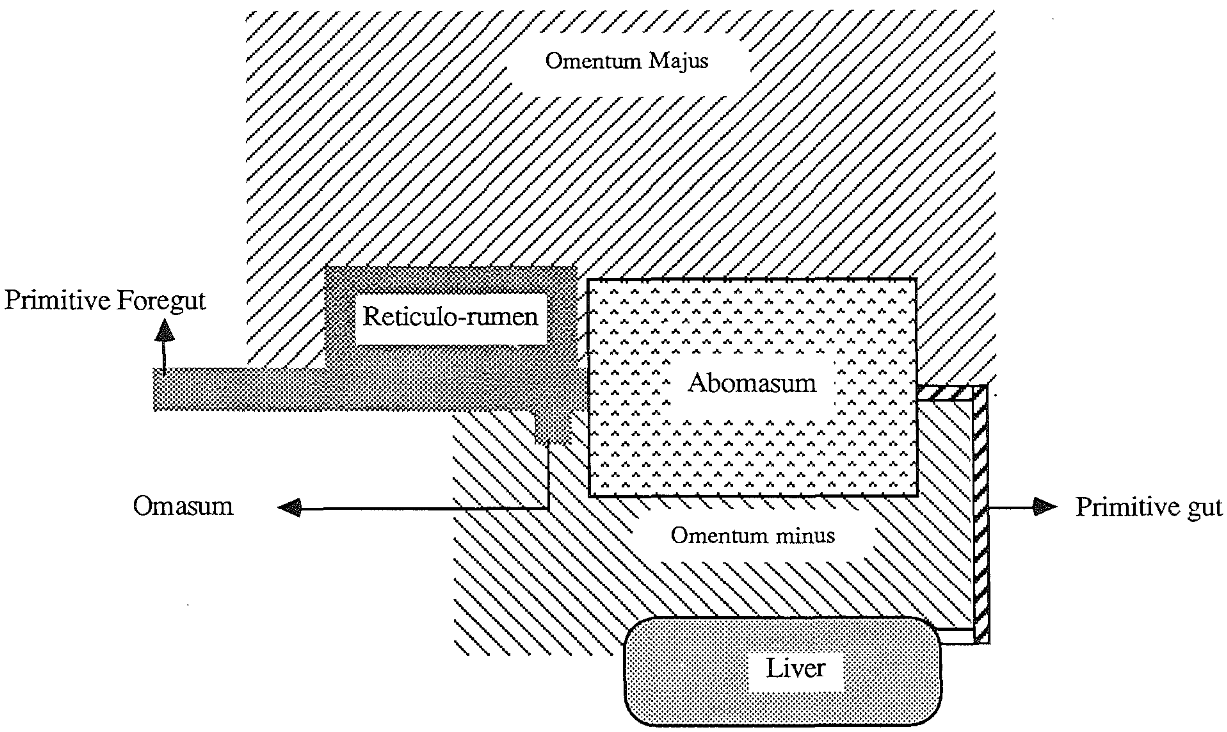
ANDRE AUGUST LOUIS MATHILDE WEYNS
GEBOREN TE BONN

ADDENDUM PART I

CATTLE			
	Belgium	W-Europe	World
Total number (x 1000)	3092	99.048	1.268.934
Total milk production (1000 MT)	3.781	142.439	458.023
Total meat production (1000 MT)	310	8.968	47.088
Economical significance (10^6 BFR)	39.480 (meat) 51.822 (milk)	+/- 1.500.000 +/- 1.500.000	+/- 4.800.000 +/- 8.000.000
SHEEP			
Total number (x 1000)	165	91.725	1.121.993
Total milk production (1000 MT)	?	2737	8621
Total meat production (1000 MT)	4	1010	8360
Economical significance (10^6 BFR)	?	?	?

Table 1. The economical importance of the principal domestic ruminants.
(MT= metric ton; BFR= Belgian francs)
(Source FAO and Nat. Inst. Statistics)


Dorsal mesenterium
(Omentum Majus)
Gastric primordium
Primitive Foregut
Primitive gut
Ventral mesenterium
(Omentum minus)


Omentum Majus
Primitive Foregut
Reticulo-rumen
Abomasum
Omasum
Primitive gut
Omentum minus
Liver

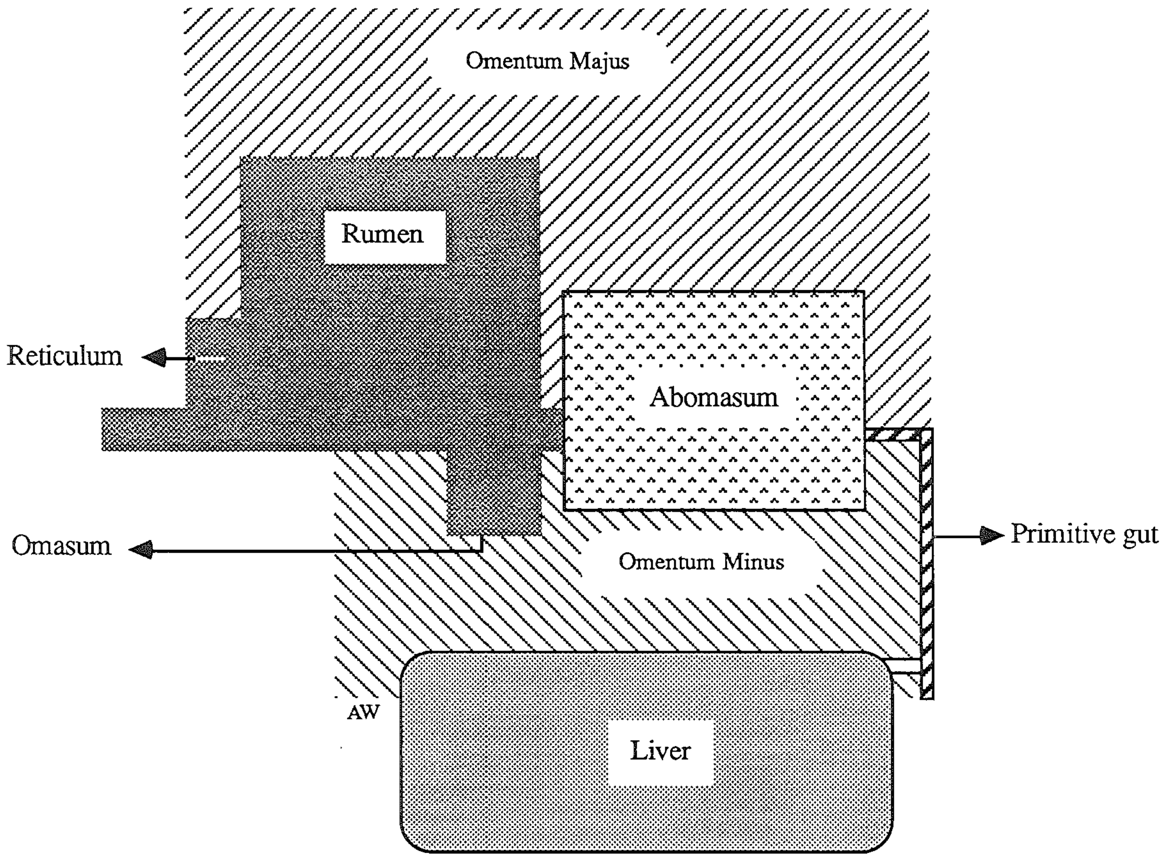


Fig 1. Schematic representation of some early stages in the development of the ruminant stomach.

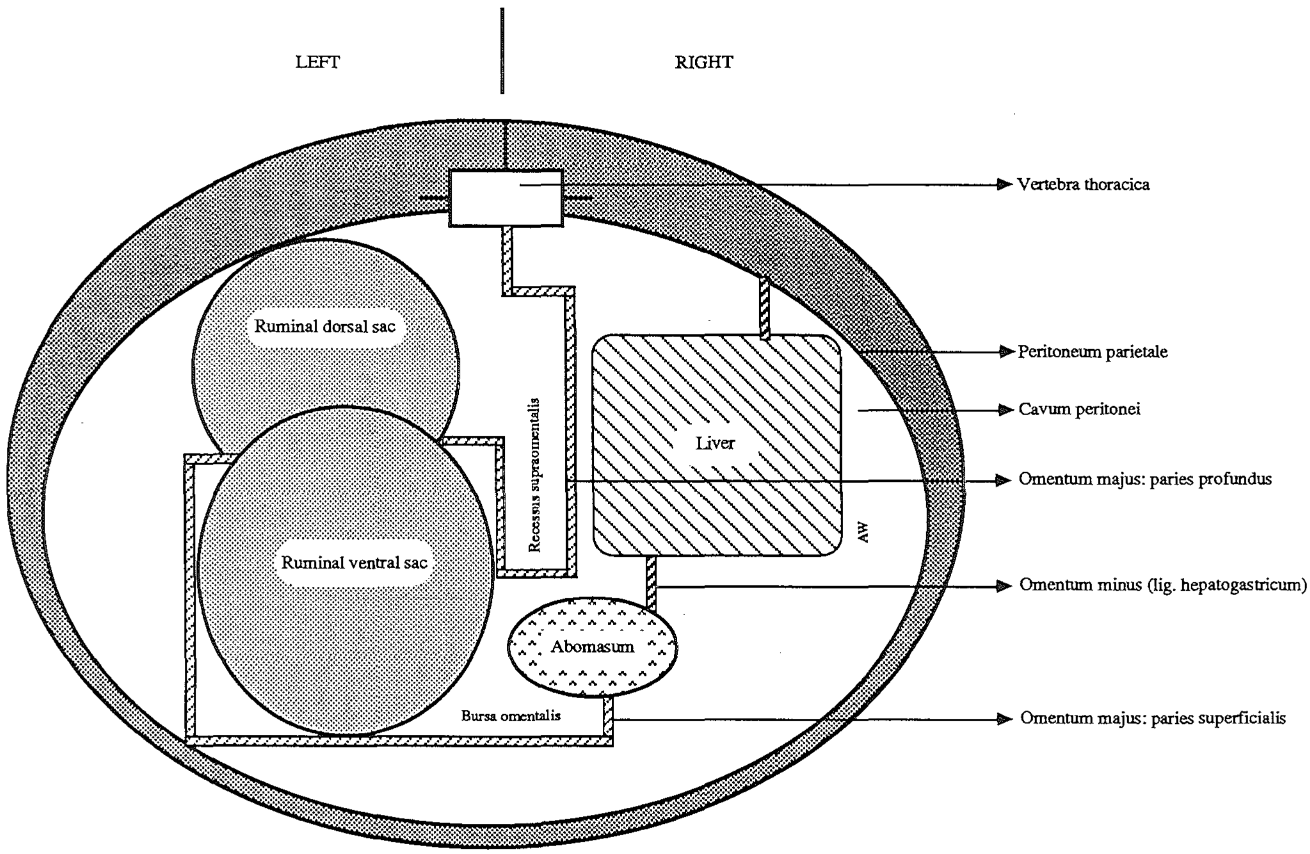
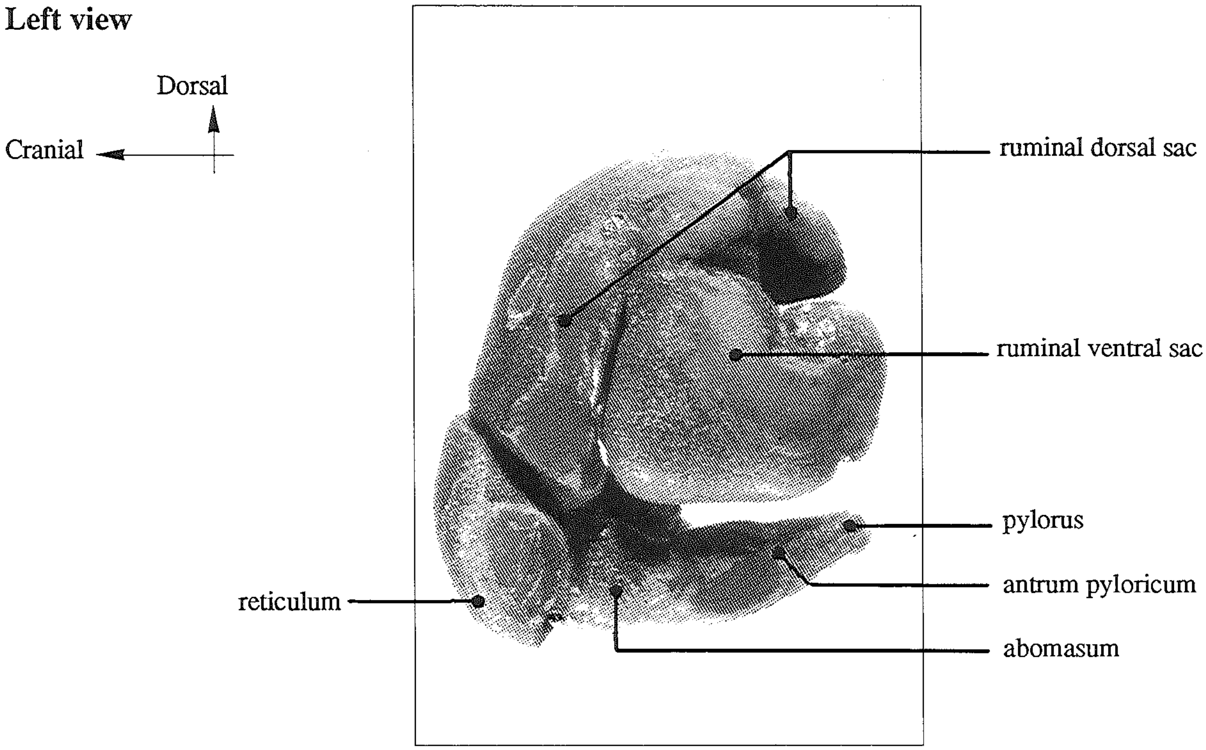


Fig. 2. Schematic representation of the course of the omentum majus in ruminants.



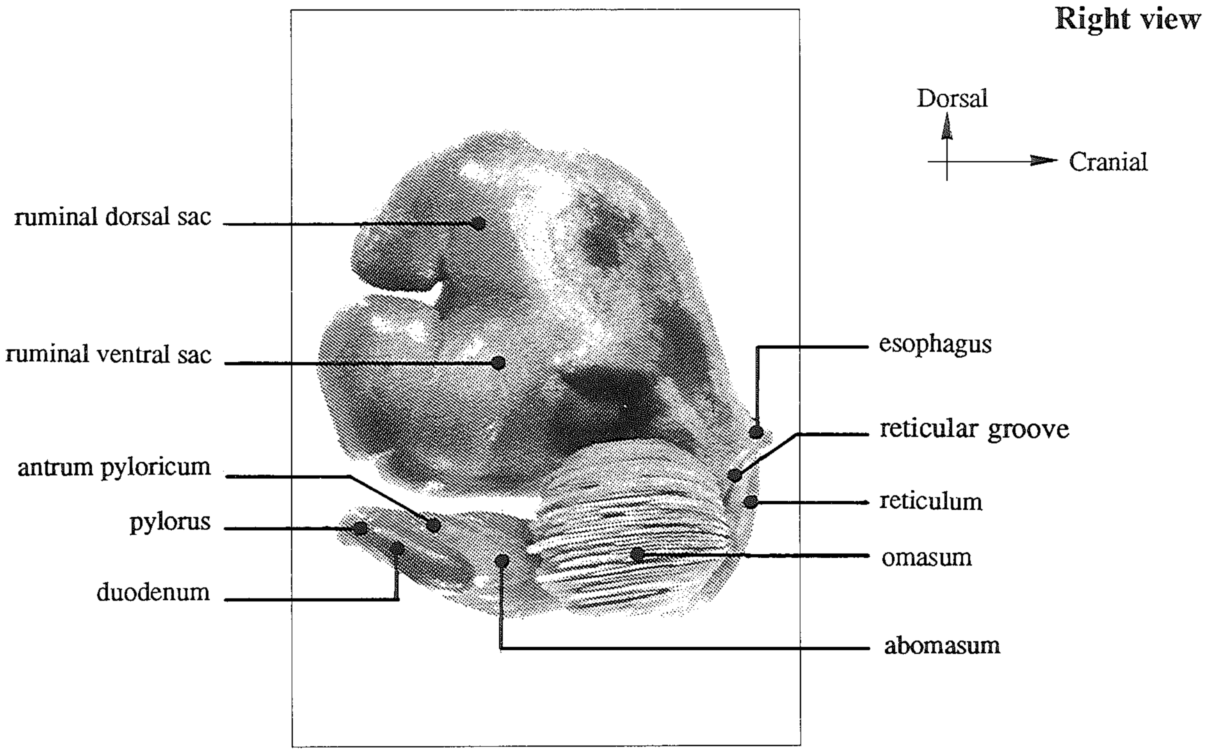


Photo 1. Corrossion cast of the ruminant stomach of a foetal sheep (28 cm). Note the craniodorsal position of the ruminal dorsal sac and the caudoventral position of the ruminal ventral sac. Further caudal outgrowth will bring the ruminal dorsal sac in a dorsal and the ruminant ventral sac in a real ventral position.

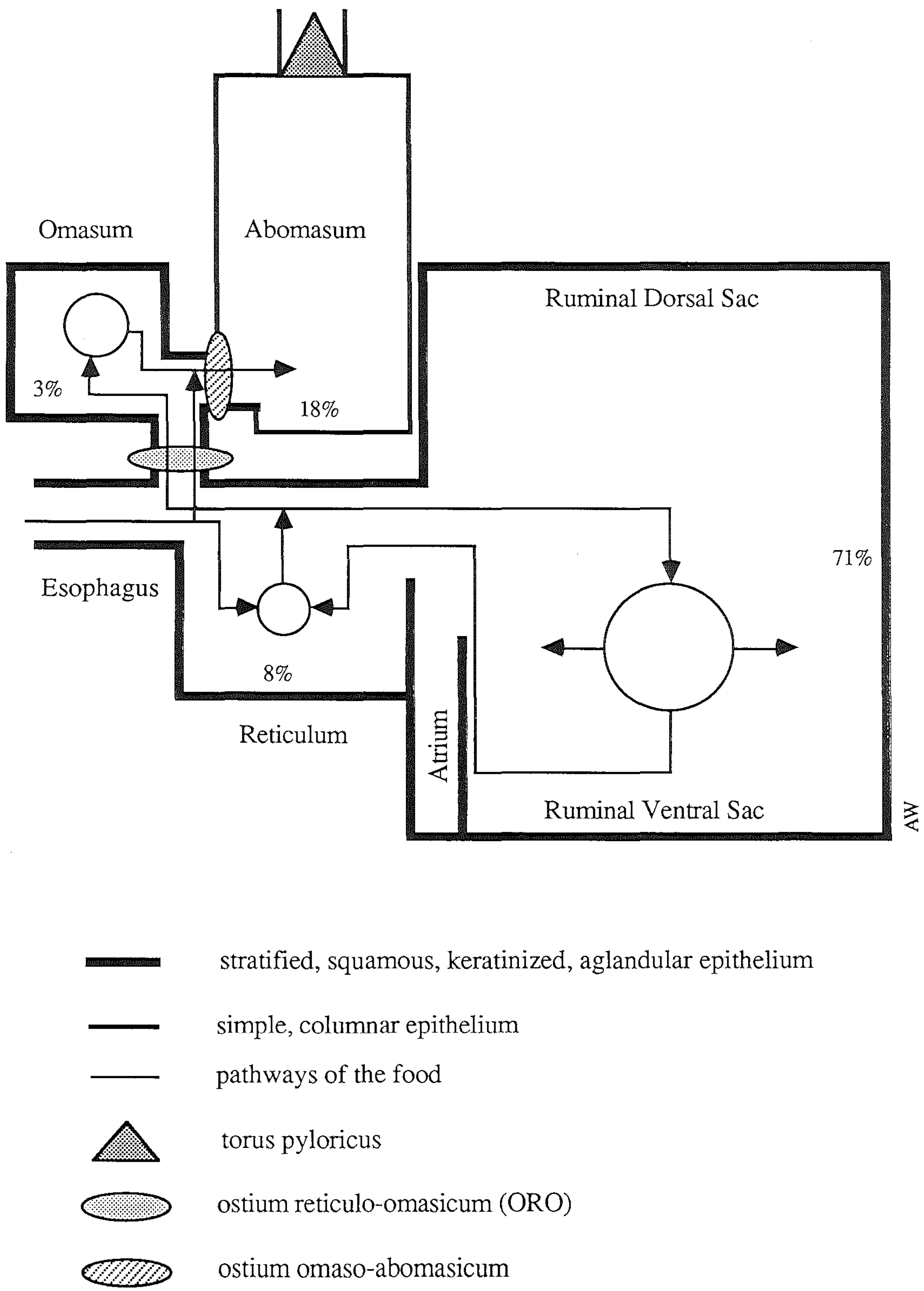


Fig. 3. Schematic representation of the basic anatomical arrangement of the ruminant stomach of the sheep.

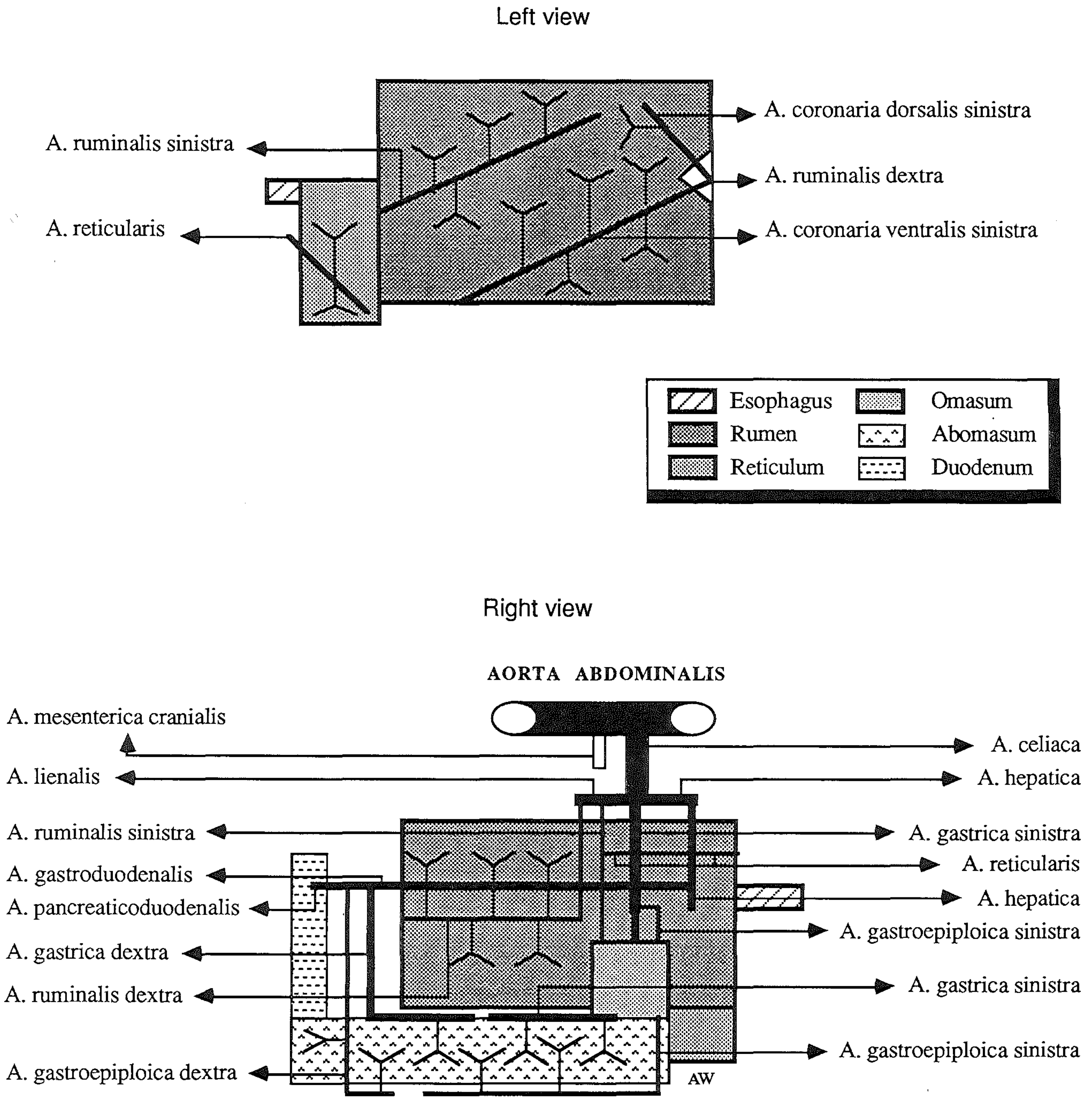


Fig. 4. Schematic representation of the vascularization of the ruminant stomach.

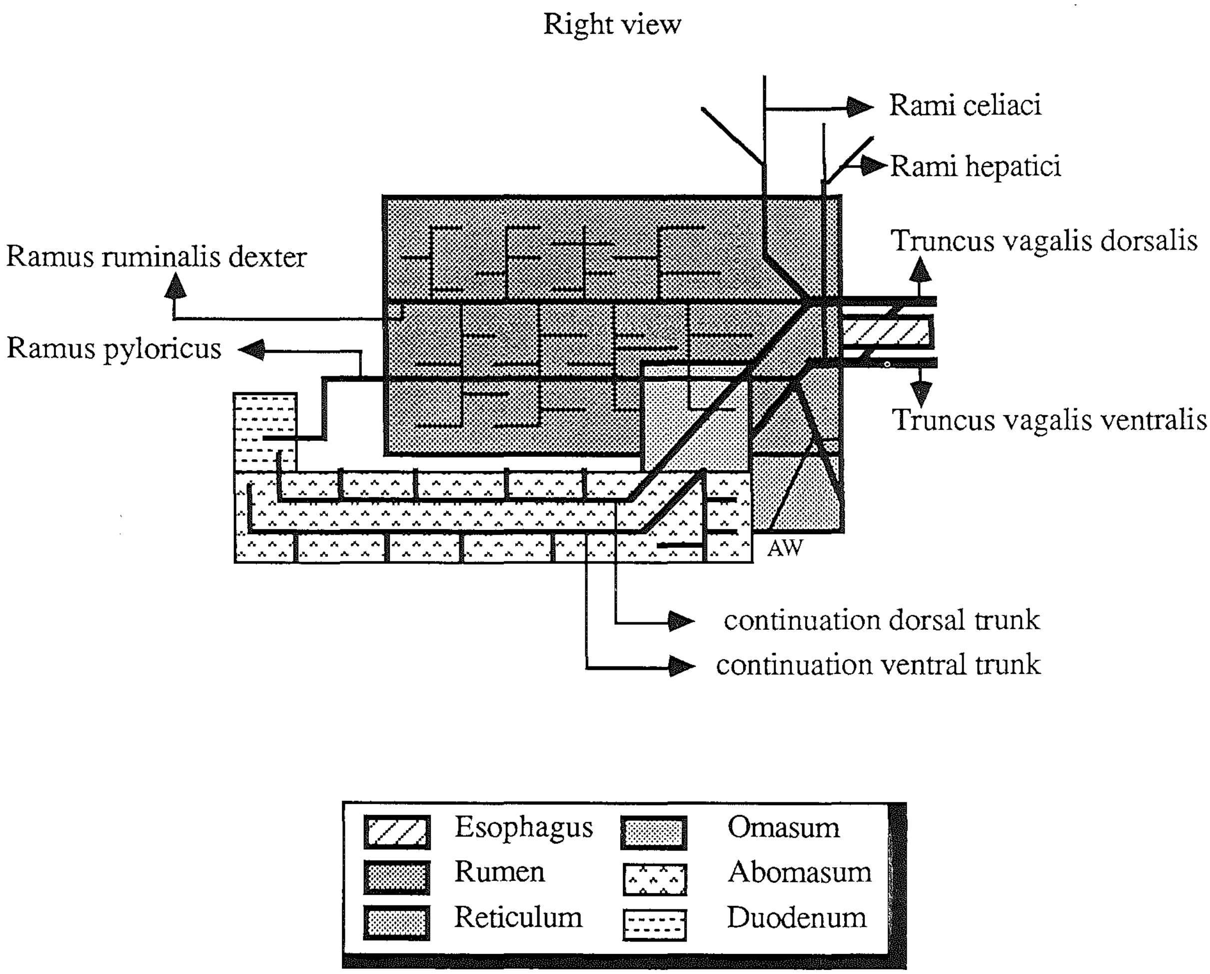


Fig. 5. Schematic representation of the innervation of the ruminant stomach.

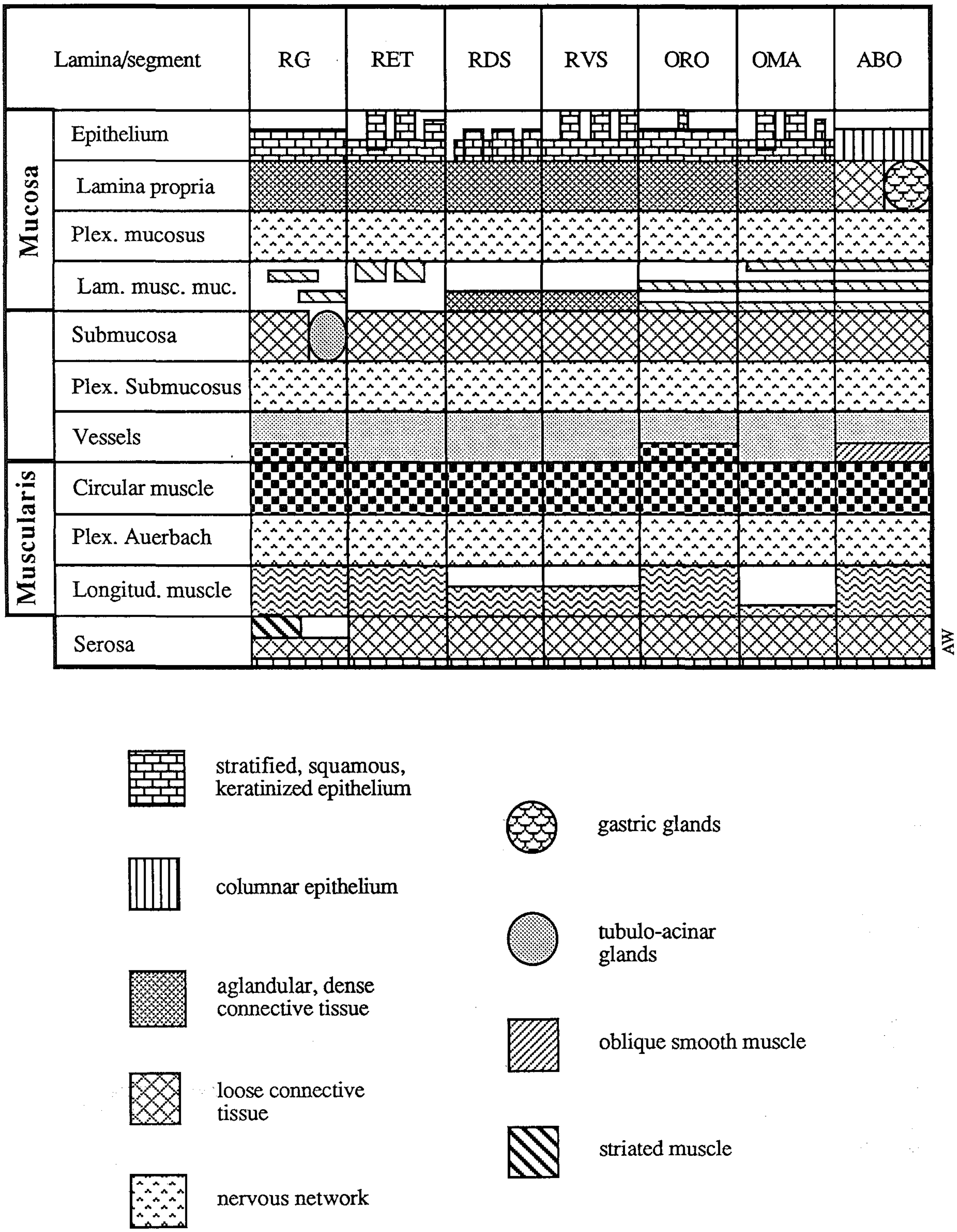


Fig. 6. Schematic representation of the basic microscopic arrangment of the ruminant stomach of the sheep.

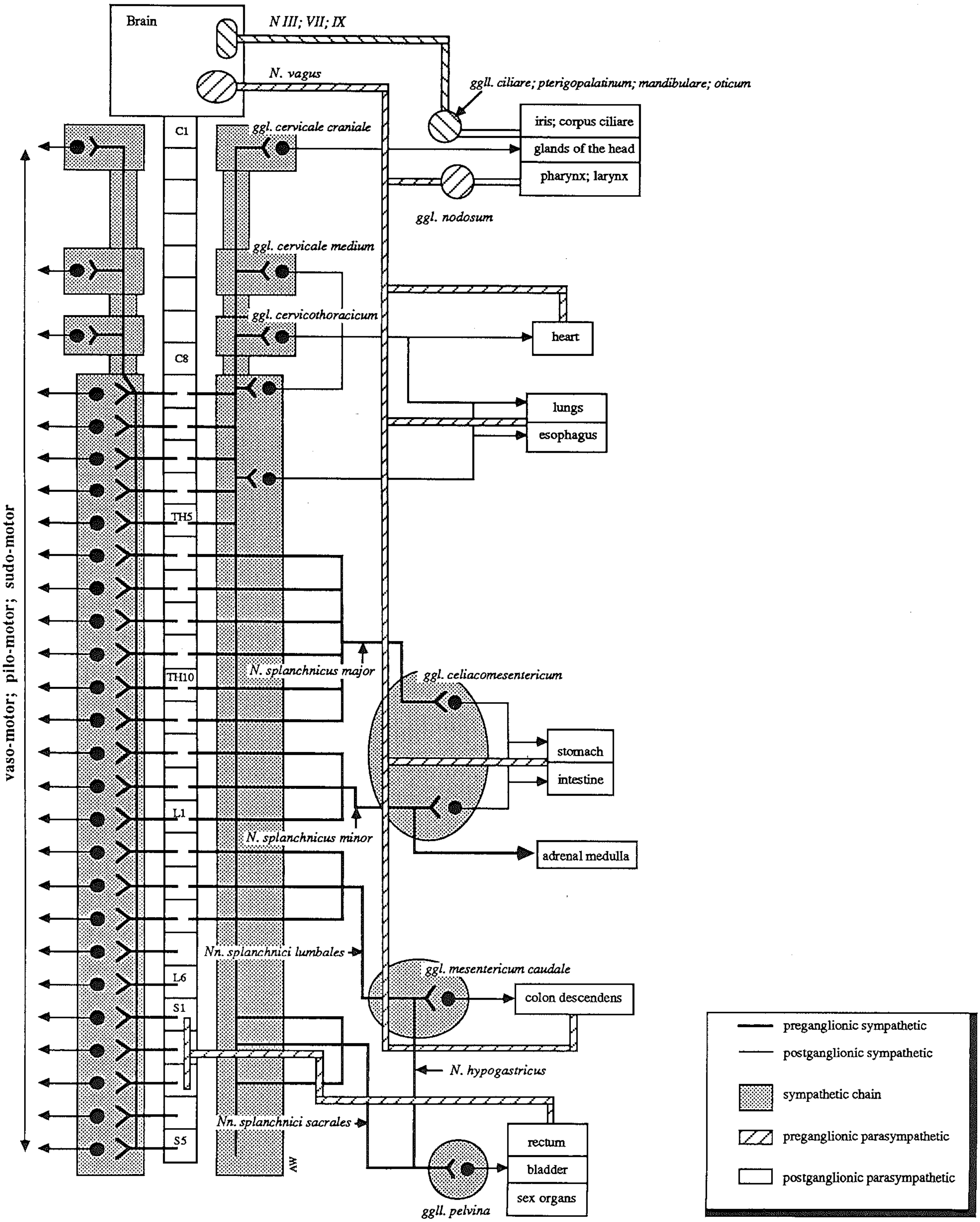


Fig. 7. Schematic representation of the anatomy of the autonomic nervous system.

SEGMENT	NEURONS	SPECIES	REFERENCES
oesophagus			
	2 to 3/ ggl.	rat	758
	1370/ cm2	guinea-pig	382
	1300/ cm2	guinea-pig	517
stomach			
	1100 to 3500/ cm2	monkey	see 239; see 516
cardia	10 to 20/ ggl.	rat	758
	3500/ cm2	guinea-pig	382; 517
	2200/ cm2	guinea-pig	821
	2000/ cm2	rabbit	see 239
corpus	9500/ cm2	guinea-pig	821
	2200/ cm2	rabbit	see 239
pylorus	16250/ cm2	guinea-pig	821
	16500/ cm2	guinea-pig	517
	20000/ cm2	guinea-pig	382; 517
small intestine			
	10600/ cm2	mouse	813
	20 to 30/ ggl.	rat	758
	9400/ cm2	rat	260
	8600/ cm2	guinea-pig	813
	2000 to 3500/ cm2	rabbit	516
	2500/ cm2	sheep	813
	1700 to 2700/ cm2	monkey	see 239; see 516
duodenum			
	6700 to 10000/ cm2	guinea-pig	382; 517; 821; see 665
free edge	2280/ cm2	rabbit	516
mesenteric edge	3500/ cm2	rabbit	516
	12170/ cm2	cat	462
	49081/ cm2	cat	665
	2700/ cm2	monkey	see 239; see 462; see 665
jejunum			
	7200/ cm2	guinea-pig	382
free edge	2088/ cm2	rabbit	516
	1770/ cm2	cat	462
mesenteric edge	2900/ cm2	rabbit	516
	3770/ cm2	cat	462
	2700/ cm2	monkey	see 239; see 562; see 665
ileum			
	2960/ mm2	mouse	729
	1421/ mm2	guinea-pig	728; see 729
	5300/ cm2	guinea-pig	821
	7200/ cm2	guinea-pig	see 256; 382; 517

SEGMENT	NEURONS	SPECIES	REFERENCES
	7500/ cm2	guinea-pig	382
	14200/ cm2	guinea-pig	see 239
free edge	2000/ cm2	rabbit	516
mesenteric edge	2500/ cm2	rabbit	516
	15400/ cm2	cat	665
	7786/ cm2	dog	see 239
	2400/ cm2	monkey	see 239; see 462; see 665
ileo-caecal sphincter	7500/ cm2	guinea-pig	382
large intestine			
	15000/ cm2	guinea-pig	256; see 256; 382
	1760 to 2940/ cm2	rabbit	516
	1300 to 3500/ cm2	monkey	see 239
caecum	5021/ mm2	mouse	729
	3700/ cm2	rat	see 239
	929/ mm2	guinea-pig	728; see 729
	20.5/ ggl.	guinea-pig	728
subtaenial	12000/ cm2	guinea-pig	382
intertaenial	4100/ cm2	guinea-pig	517
	4500/ cm2	guinea-pig	382
	9300/ cm2	guinea-pig	see 239
	1760/ cm2	rabbit	516
colon			
	9080/ mm2	mouse	729
	5 to 15 / section	rat	758
	11100/ cm2	rat	see 239
subtaenial	19000/ cm2	guinea-pig	382
intertaenial	15000/ cm2	guinea-pig	382
	12500/ cm2	guinea-pig	821
	14800/ cm2	guinea-pig	517
	35600/ cm2	guinea-pig	see 239
	3557/ mm2	guinea-pig	728; see 729
	3375/ cm2	rabbit	516
rectum			
	18000/ cm2	guinea-pig	382
	15600/ cm2	guinea-pig	821
	16000/ cm2	guinea-pig	517
	2940/ cm2	rabbit	516

Table 2. Neuronal density in Auerbach's plexus in different species.

SEGMENT	NEURONS	SPECIES	REFERENCES
oesophagus	0	rat	758
	0	cat	126
	37-84/ cm2	opossum	126
stomach			
	2 neurons/ ggl.	rat	758
corpus	84/ cm2	cat	126
antrum	18/ cm2	cat	126
small intestine			
	8700/ cm2	mouse	813
	8 neurons/ ggl.	guinea-pig	246
	3000/ cm2	guinea-pig	813
	4500/ cm2	sheep	813
duodenum	5-10 neurons/ ggl.	rat	758
	5831/ cm2	cat	126
	96881/ cm2	cat	665
	1812/ cm2	opossum	126
jejunum	4632/ cm2	cat	126
	2234/ cm2	opossum	126
ileum	1900/ cm2	guinea-pig	see 239
	3600/ cm2	guinea-pig	820
	3191/ cm2	cat	126
	45462/ cm2	cat	665
	1488/ cm2	opossum	126
large intestine			
caecum	10 to 20 neurons/ ggl.	rat	758
	400/ cm2	guinea-pig	see 239
colon	10 to 20 neurons/ ggl.	rat	758
	2300/ cm2	guinea-pig	see 239
	4500/ cm2	guinea-pig	820
	358.7-1275/ cm2	cat	126
	121.2-206.2/ cm2	opossum	126
rectum	143.9/ cm2	cat	126
	61/ cm2	opossum	126

Table 3. Neuronal density in Meissner's plexus in different species.

ADDENDUM PART II

Foetus number	Crown-Rump length (cm)	Estimated age (days)*
43	12	62
44	15	70
24	20	80
25	25,5	95
38	28	100
12	36	119

Table 4. Foetuses used in the immunohistochemical study concerning the intramural neuro-endocrine system in the wall of the ruminant stomach of the sheep.
(* based upon Evans and Sack, 1976 (196))

Preparation of the BUFFERS

PBS buffer

Stock solution A (0.2 M) :
1 liter aqua dest
27.6 g NaH_2PO_4 x 1 H_2O
Stock solution B (0.2 M) :
2 liters aqua dest.
71.2 g NaH_2PO_4 x 2 H_2O

Add to 4880 ml aqua dest:
28.75 ml stock solution A
96.20 ml stock solution B
22.40 g NaCl
Adjust pH of the buffer to 7.4 - 7.6.

Triton Tris-saline buffer (TTBS) (0.01 M)

800 ml aqua dest :
1.2 g Tris (=tris-(hydroxylmethyl) aminomethane)
9 g NaCl
0.04 g sodium ethylmercurithiosalicylate (merthiolate)
Add 1 ml Triton-X-100 (=alkyl phenyl polyethylenglycol)
adjust pH to 7.6 with HCl
bring to 1 liter with aqua dest..
The addition of 1% Triton X-100 in the TSB provides a deeper penetration of the antibodies in the tissue.

Tris Buffer for DAB

Tris stock buffer (0.05 M)
800 ml aqua dest.
60,5 g Tris
adjust pH to 7.6 with HCl
bring to 1 liter with aqua dest.

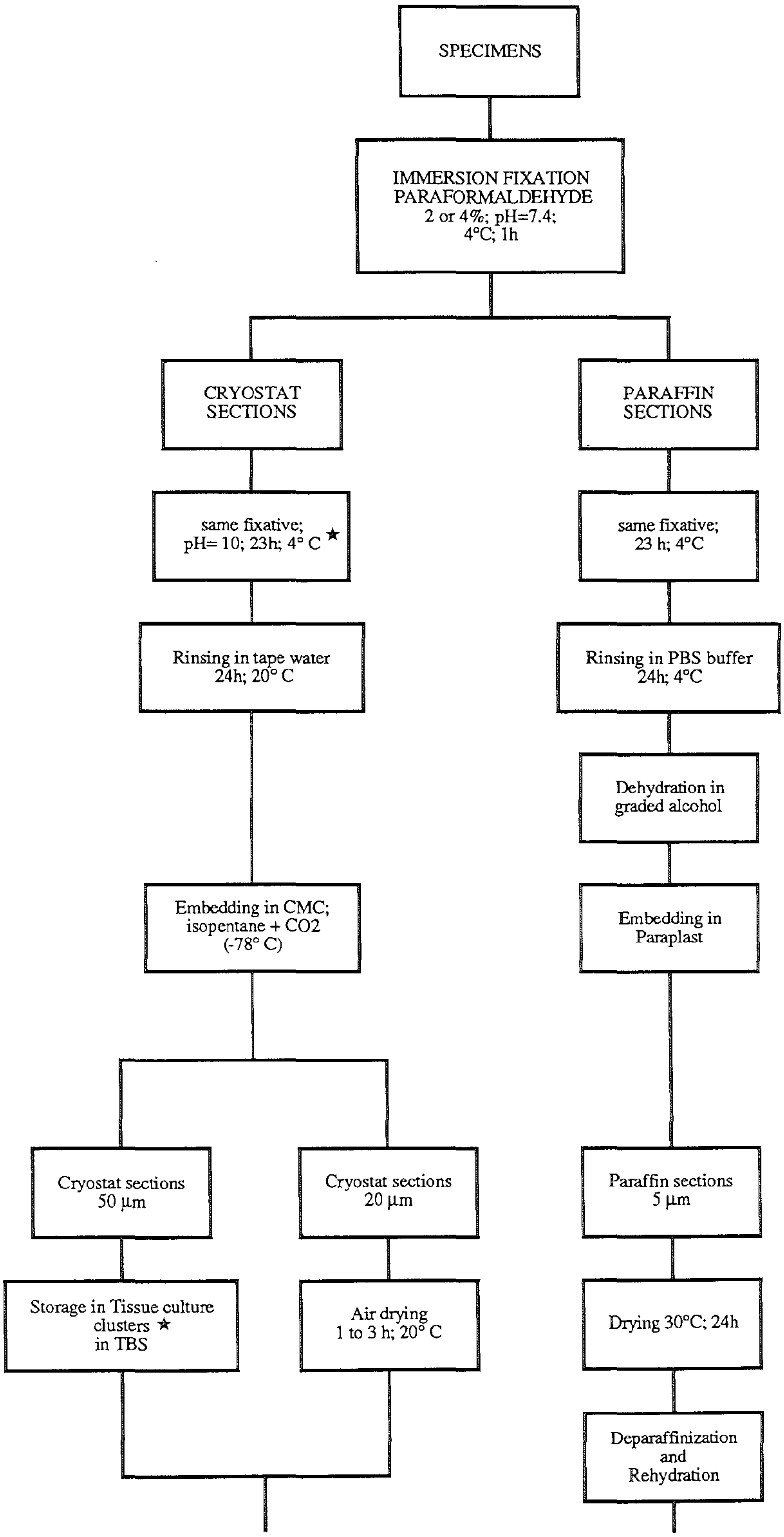
Dissolve in 20 ml Tris stock buffer
2,5 mg DAB (3. 3'-diaminobenzidinetetrahydrochloride)
add immediately before use on the tissue sections
2 ml 0,3% H_2O_2
The DAB solution must be freshly prepared and kept from the light as long as possible.

Preparation of the FIXATIVE

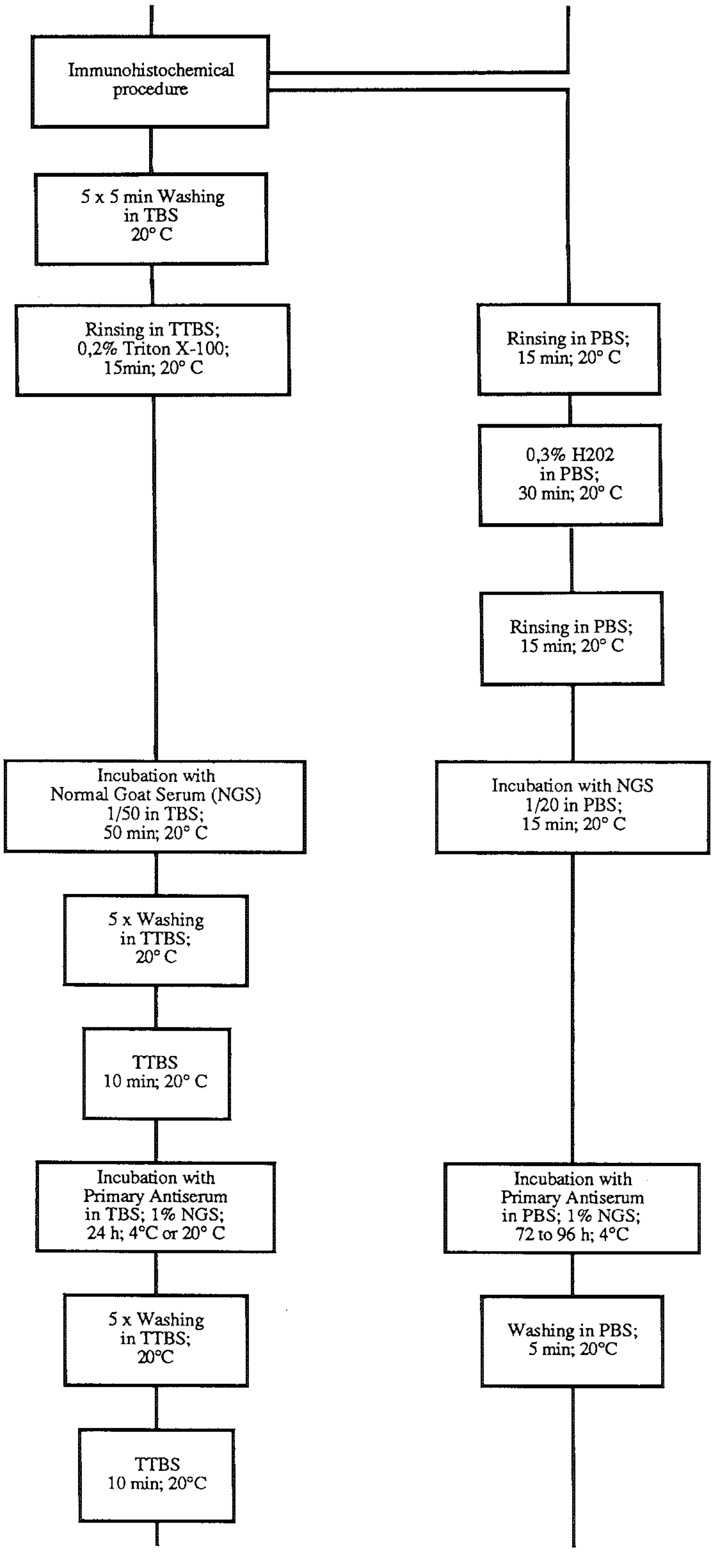
Paraformaldehyde in 0.15 M phosphate buffer

500 ml aqua dest.
9.99 ml phosphoric acid
0.02 g CaCl2 (membrane protection)
adjust the pH to 7.42 with NaOH.
heat the mixture up to 90°C
dissolve 20 or 40 g paraformaldehyde
add 4% NaOH in drops until the solution becomes transparent
bring to 1 liter with aqua dest.

The fixative was freshly prepared.



★ Personal communication Vandesande F., Zoölogical Institute, K.U.Leuven, Belgium.


Immunohistochemical procedure
5 x 5 min Washing in TBS 20° C
Rinsing in TTBS; 0,2% Triton X-100; 15min; 20° C
Incubation with Normal Goat Serum (NGS) 1/50 in TBS; 50 min; 20° C
5 x Washing in TTBS; 20° C
TTBS 10 min; 20° C
Incubation with Primary Antiserum in TBS; 1% NGS; 24 h; 4°C or 20° C
5 x Washing in TTBS; 20°C
TTBS 10 min; 20°C
Rinsing in PBS; 15 min; 20° C
0,3% H202 in PBS; 30 min; 20° C
Rinsing in PBS; 15 min; 20° C
Incubation with NGS 1/20 in PBS; 15 min; 20° C
Incubation with Primary Antiserum in PBS; 1% NGS; 72 to 96 h; 4°C
Washing in PBS; 5 min; 20°C

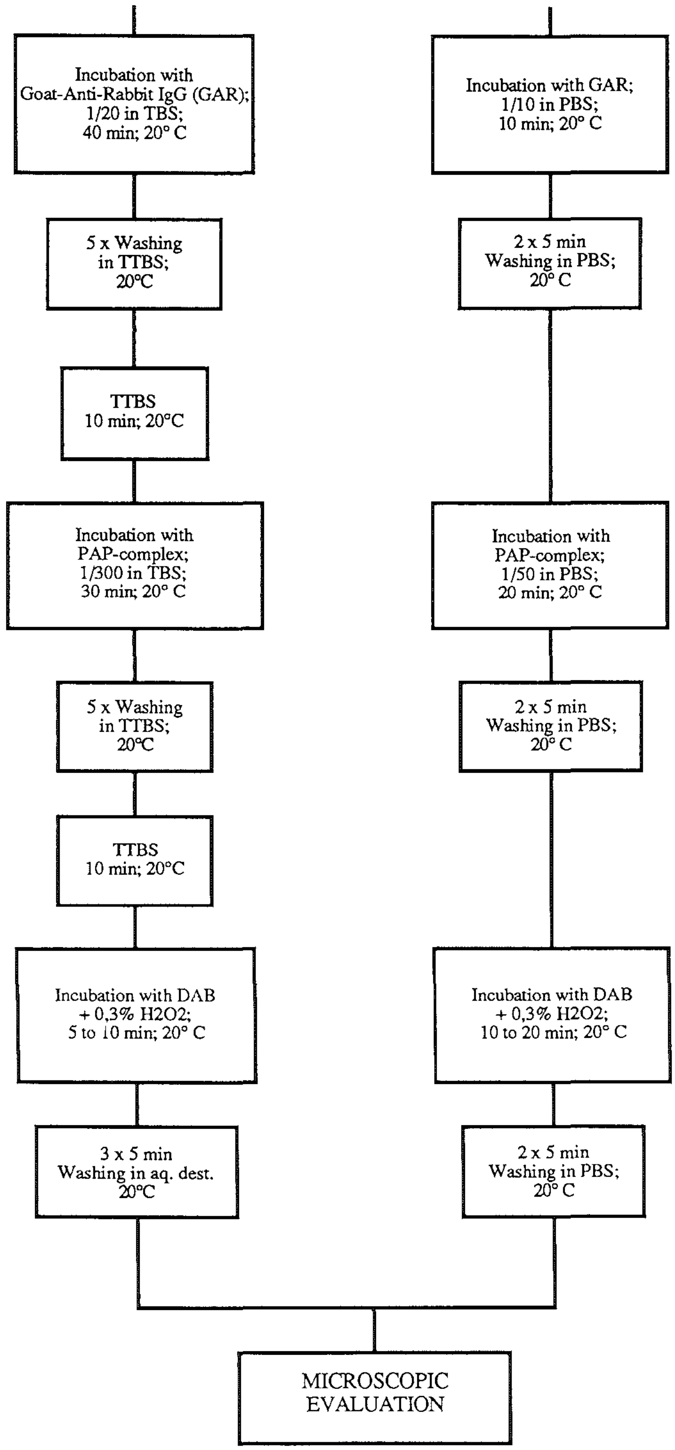


Fig. 8. Schematic representation of the technical protocol used in the immunohistochemical study concerning the intramural neuro-endocrine system in the wall of the ruminant stomach of the sheep.

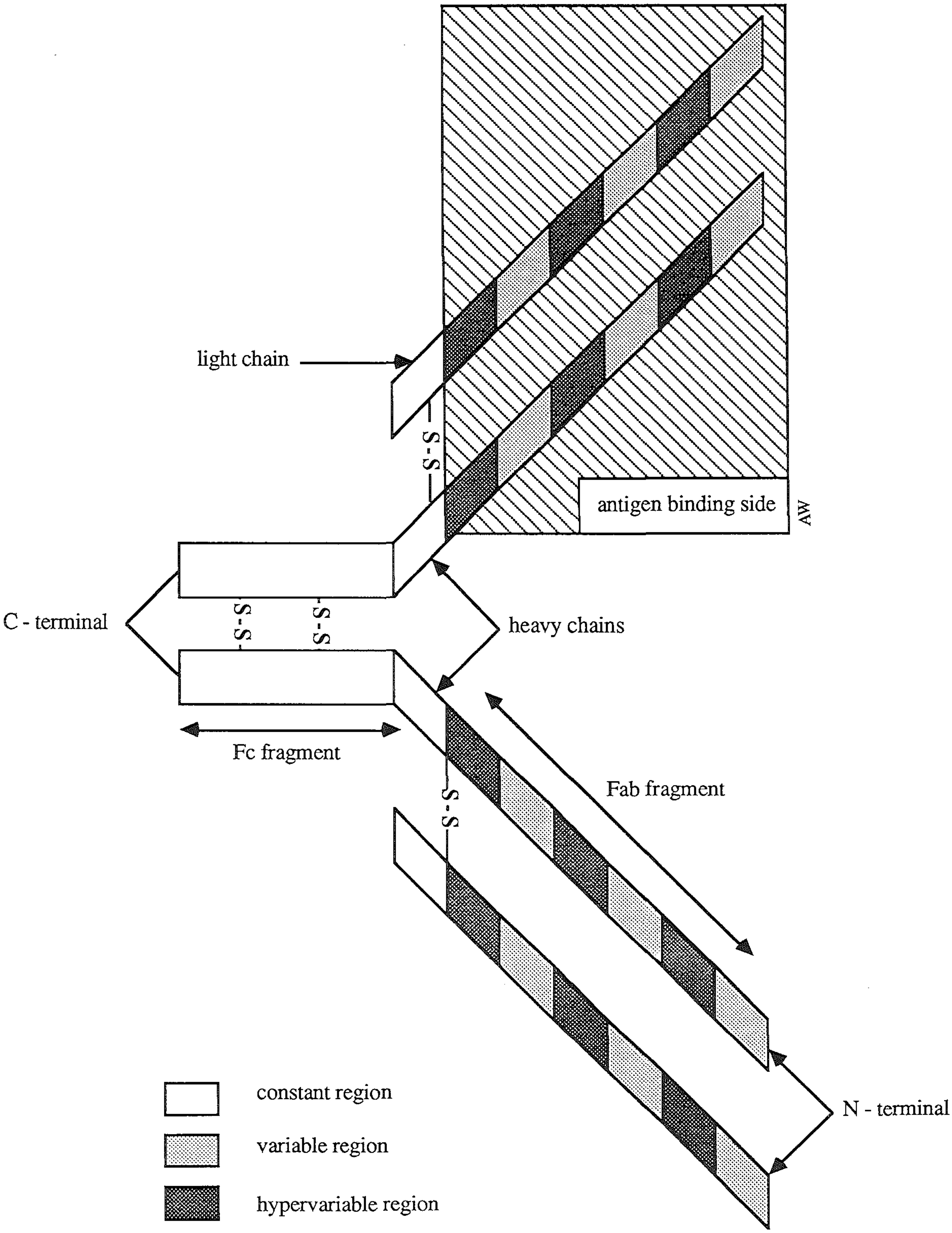


Fig. 9. Schematic representation of the structure of an immunoglobulin (IgG).

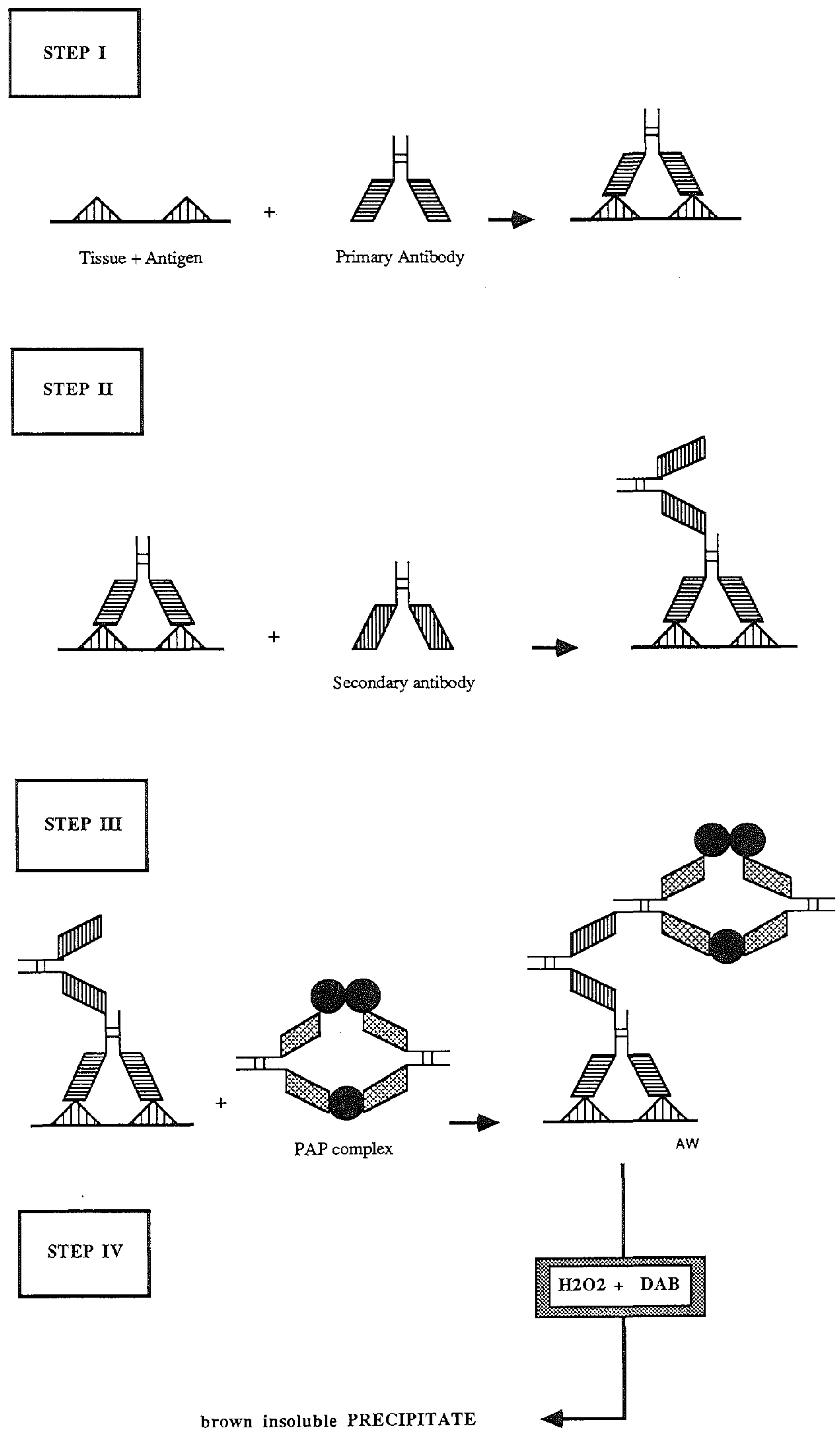


Fig. 10. Schematic representation of the peroxidase-antiperoxidase (PAP) technique.

Photo 2. Reticular groove.

NSE, cryostat section (50 µm), foetus 25 cm. Magn. 29.6 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

5. Isolated groups of smooth muscle cells representing the lamina muscularis mucosae innervated by several NSE-IR nerve fibres
6. Plexus submucosus: NSE-IR nervous network in primary reticular folds
8. Isolated NSE-IR nerve bundle
10. Intramuscular NSE-IR nervous network in the circular muscle layer
11. Plexus Auerbach
13. Intramuscular NSE-IR nervous network in the longitudinal muscle layer
14. Perivascular plexus

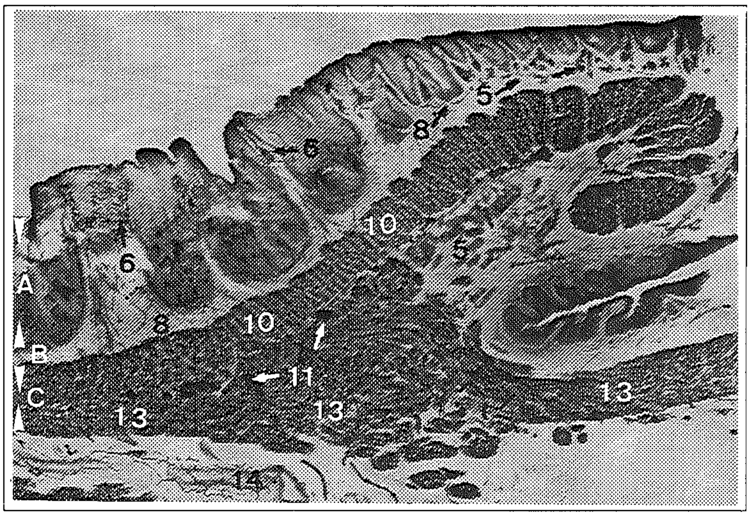
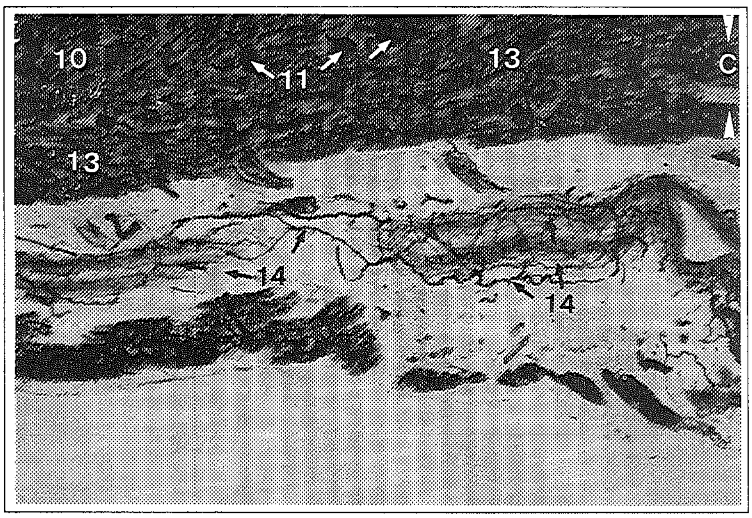


Photo 3. Reticular groove.

NSE, cryostat section (50 µm), foetus 25 cm. Magn. 74 x

C. Tunica Muscularis

10. Intramuscular NSE-IR nervous network in the circular muscle layer
11. Plexus Auerbach
13. Intramuscular NSE-IR nervous network in the longitudinal muscle layer
14. Perivascular plexus



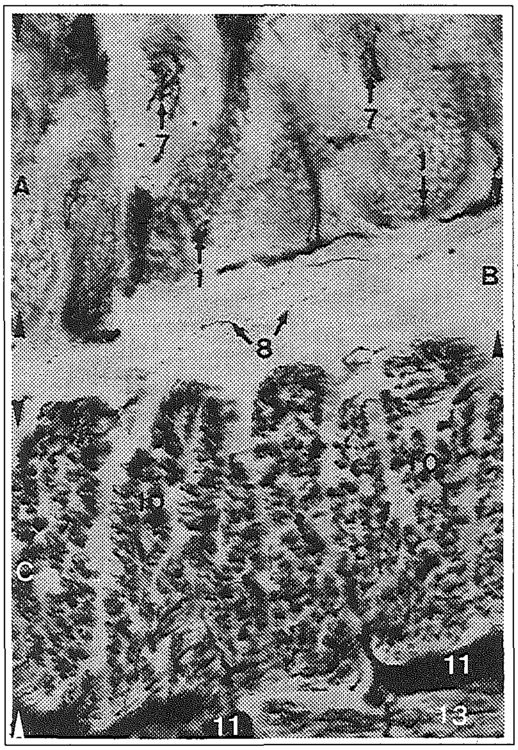


Photo 4. Reticular groove.
NSE, cryostat section (50 µm), foetus 28 cm. Magn. 296 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

1. NSE-IR epithelial cell
7. Plexus submucosus: NSE-IR nervous network in secondary folds
8. Isolated NSE-IR nerve bundle
10. Intramuscular NSE-IR nervous network in the circular muscle layer
11. Plexus Auerbach
13. Intramuscular NSE-IR nervous network in the longitudinal muscle layer

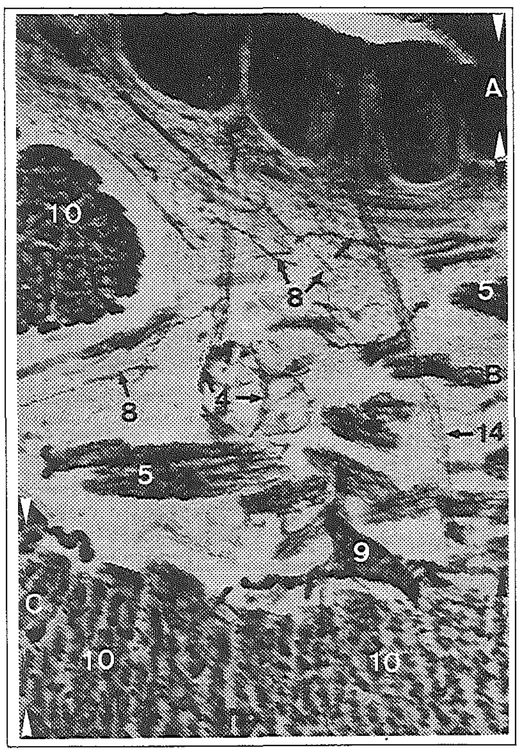


Photo 5. Reticular groove.
NSE, cryostat section (50 µm), foetus 25 cm. Magn. 210 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

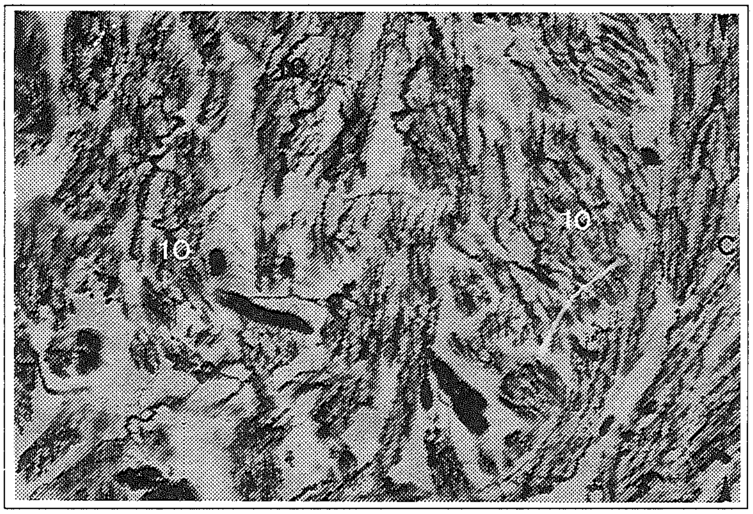
4. Periglandular plexus around the tubulo-acinar glands in the submucosa
5. Parts of the lamina muscularis mucosae innervated by several NSE-IR nerve fibres
8. Isolated NSE-IR nerve bundle
9. Plexus submucosus: ganglion
10. Intramuscular NSE-IR nervous network in the circular muscle layer
14. Perivascular plexus

Photo 6. Reticular groove.

NSE, cryostat section (50 µm), foetus 25 cm.
Magn. 296 x

C. Tunica Muscularis

10. Intramuscular NSE-IR nervous network in the circular muscle layer: large NSE-IR nerve bundles between, smaller NSE-IR nerve fibres within the bundles of smooth muscles cells.



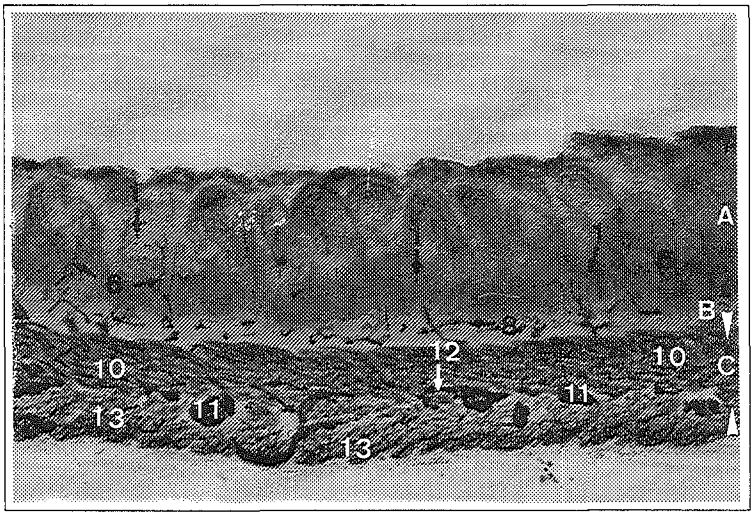


Photo 7. Ruminal Dorsal Sac.

NSE, cryostat section (50 µm), foetus 28 cm. Magn. 52 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

1. NSE-IR epithelial cell
6. Plexus submucosus: NSE-IR nervous network in the ruminal papillae
8. Isolated NSE-IR nerve bundle
10. Intramuscular NSE-IR nervous network in the circular muscle layer
11. Plexus Auerbach
12. Interganglionic nerve bundle
13. Intramuscular NSE-IR nervous network in the longitudinal muscle layer

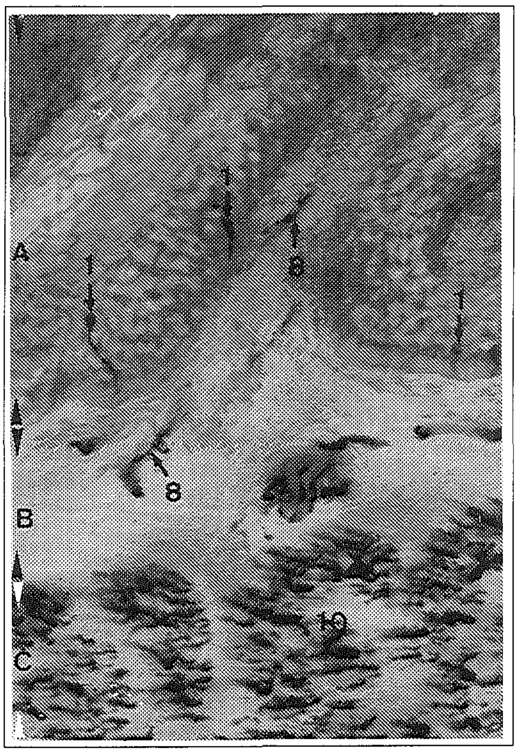


Photo 8. Ruminal Dorsal Sac.

NSE, cryostat section (50 µm), foetus 28 cm. Magn. 583 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

1. NSE-IR epithelial cell with basal process
8. Isolated NSE-IR nerve bundle
10. Intramuscular NSE-IR nervous network in the circular muscle layer

Photo 9. Ruminal Dorsal Sac.
NSE, cryostat section (50 μm), foetus 28 cm. Magn. 474 x

A. Tunica Mucosa
B. Tunica Submucosa

1. NSE-IR epithelial cell
6. Plexus submucosus: NSE-IR nervous network in the ruminal papillae
8. Isolated NSE-IR nerve bundle

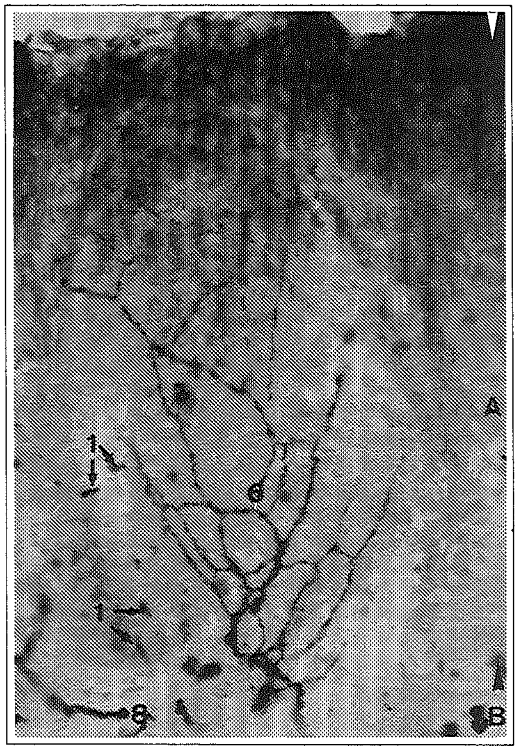
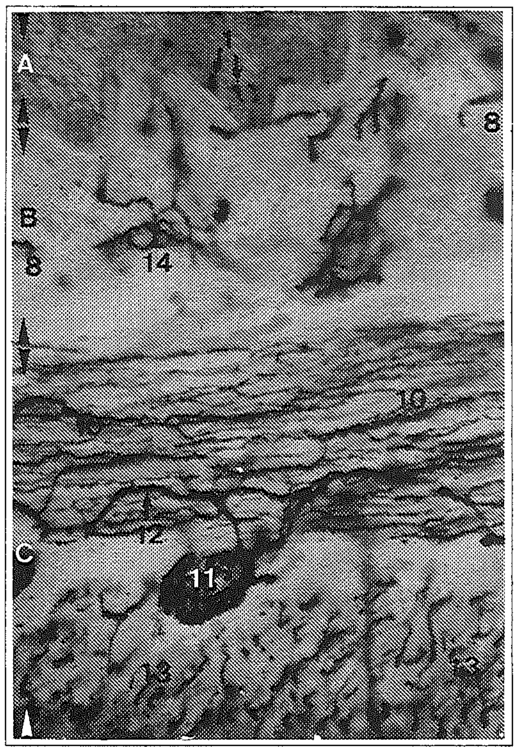


Photo 10. Ruminal Dorsal Sac.
NSE, cryostat section (50 μm), foetus 15 cm. Magn. 647.5 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

1. NSE-IR epithelial cell with basal process
8. Isolated NSE-IR nerve bundle
10. Intramuscular NSE-IR nervous network in the circular muscle layer
11. Plexus Auerbach: note the peripheral arrangement of the NSE-IR nervous elements
12. Interganglionic nerve bundle
13. Intramuscular NSE-IR nervous network in the longitudinal muscle layer
14. Perivascular plexus



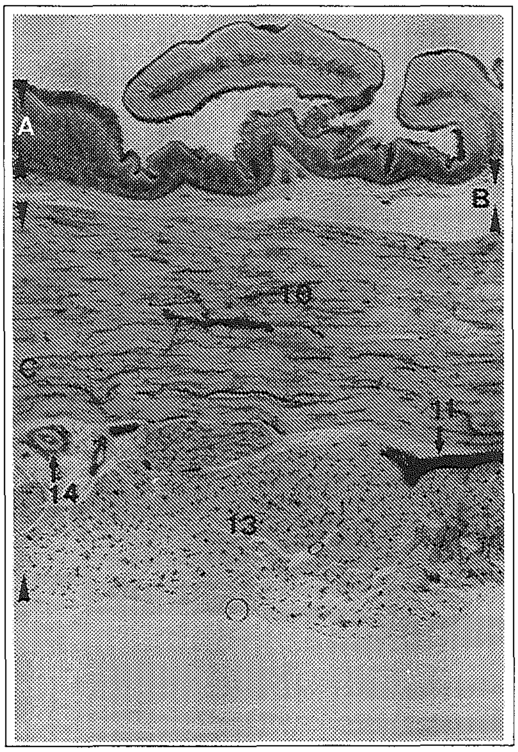


Photo 11. Ruminal Dorsal Sac.

NSE, cryostat section (50 µm), adult sheep. Magn. 81 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

Note the absence of NSE-IR in the epithelium and submucosa

10. Intramuscular NSE-IR nervous network in the circular muscle layer. Large NSE-IR nerve bundles running between the smooth muscle bundles
11. Plexus Auerbach
13. Intramuscular NSE-IR nervous network in the longitudinal muscle layer
14. Perivascular plexus

Photo 12. Ruminal Ventral Sac.

NSE, paraffin section (5 µm), foetus 12 cm.
Magn. 296 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

8. Isolated NSE-IR nerve bundle
10. Intramuscular NSE-IR nervous network in the circular muscle layer
11. Plexus Auerbach
15. Plexus subserosus

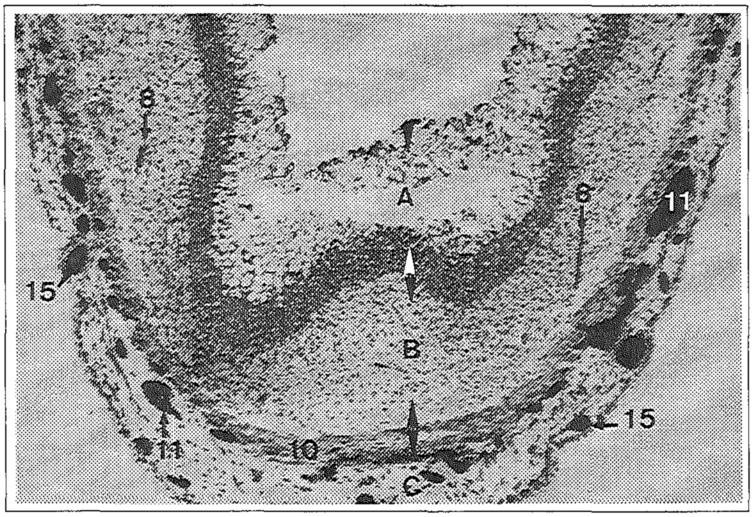
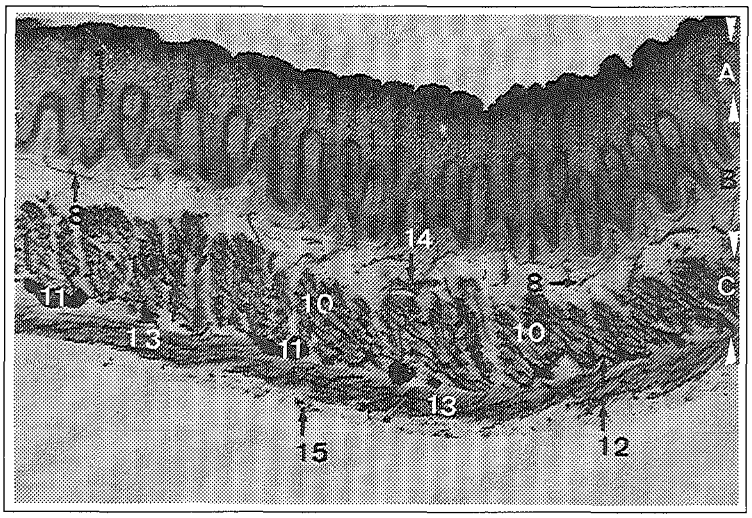


Photo 13. Ruminal Ventral Sac.

NSE, cryostat section (50 µm), foetus 15 cm.
Magn. 133 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

1. NSE-IR epithelial cell
8. Isolated NSE-IR nerve bundle
10. Intramuscular NSE-IR nervous network in the circular muscle layer
11. Plexus Auerbach
12. Interganglionic nerve bundle
13. Intramuscular NSE-IR nervous network in the longitudinal muscle layer
14. Perivascular plexus
15. Plexus subserosus



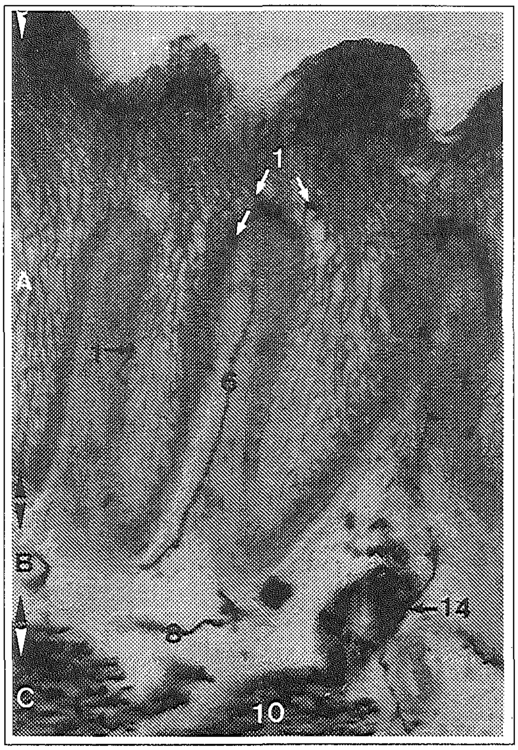


Photo 14. Ruminal Ventral Sac.

NSE, cryostat section (50 µm), foetus 15 cm. Magn. 462.5 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

1. NSE-IR epithelial cell with basal process
6. Plexus submucosus: NSE-IR nerve fibre in the ruminal papillae
8. Isolated NSE-IR nerve bundle
10. Intramuscular NSE-IR nervous network in the circular muscle layer
14. Perivascular plexus

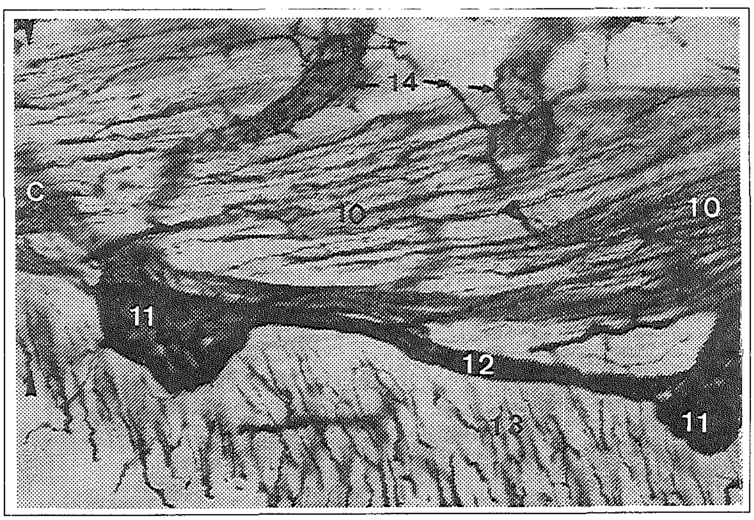


Photo 15. Ruminal Ventral Sac.

NSE, cryostat section (50 µm), foetus 28 cm. Magn. 296 x

C. Tunica Muscularis

10. Intramuscular NSE-IR nervous network in the circular muscle layer
11. Plexus Auerbach. Note NSE-IR neurons.
12. Interganglionic nerve bundle
13. Intramuscular NSE-IR nervous network in the longitudinal muscle layer
14. Perivascular plexus

Photo 16. Reticulum.

NSE, paraffin section (5 μm), foetus 28 cm.
Magn. 296 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

1. NSE-IR epithelial cell
6. Plexus submucosus: NSE-IR nervous network in the primary reticular folds
8. Isolated NSE-IR nerve bundle
10. Intramuscular NSE-IR nervous network in the circular muscle layer
11. Plexus Auerbach
13. Intramuscular NSE-IR nervous network in the longitudinal muscle layer
14. Perivascular plexus
15. Plexus subserosus

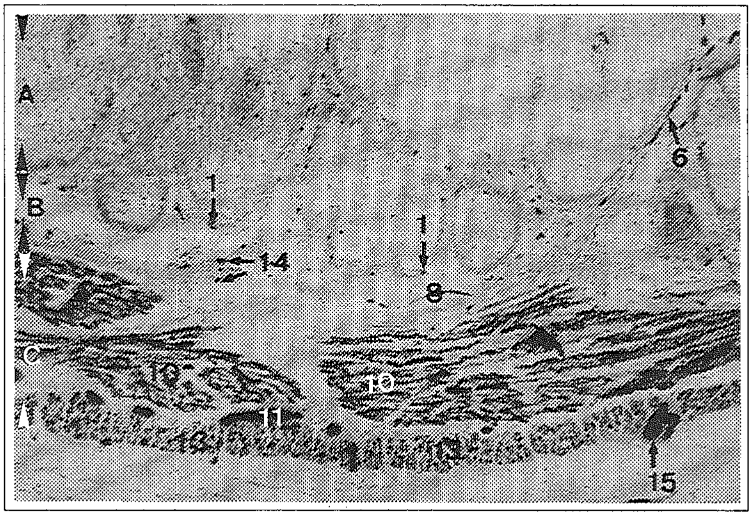
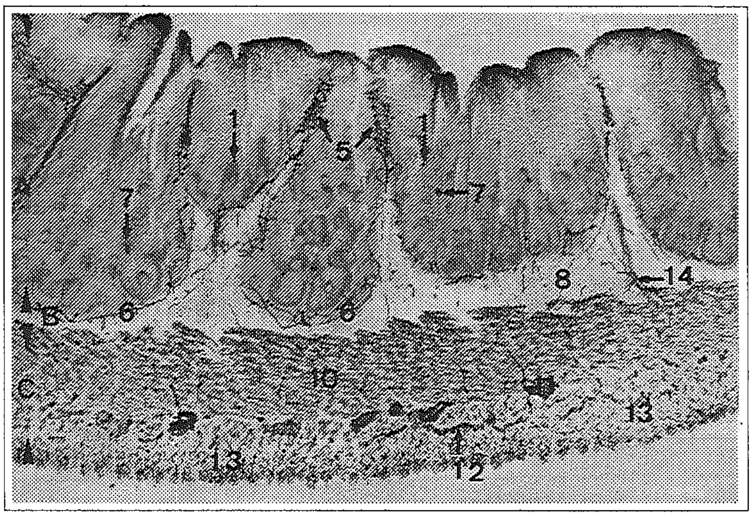


Photo 17. Reticulum.

NSE, cryostat section (50 μm), foetus 25 cm.
Magn. 37 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

1. NSE-IR epithelial cell
5. Lamina muscularis mucosae innervated by several NSE-IR nerve fibres
6. Plexus submucosus: NSE-IR nervous network around and in the primary reticular folds
7. Plexus submucosus: NSE-IR nervous network in the secondary reticular folds
8. Isolated NSE-IR nerve bundle
10. Intramuscular NSE-IR nervous network in the circular muscle layer
11. Plexus Auerbach
12. Interganglionic nerve bundle
13. Intramuscular NSE-IR nervous network in the longitudinal muscle layer
14. Perivascular plexus



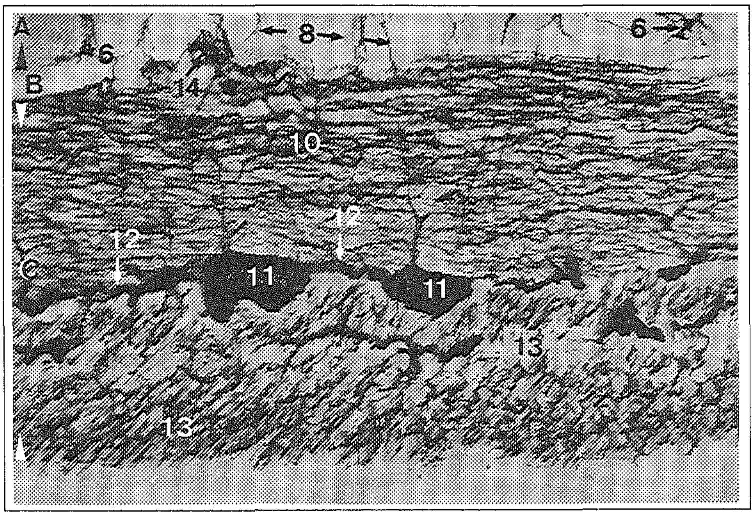


Photo 18. Reticulum.

NSE, cryostat section (50 µm), foetus 25 cm. Magn. 96 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

6. Plexus submucosus: NSE-IR nervous network at the onset of the primary reticular folds
8. Isolated NSE-IR nerve bundle
10. Intramuscular NSE-IR nervous network in the circular muscle layer. Large NSE-IR nerve bundles between, smaller NSE-IR nerve bundles within the smooth muscle bundles.
11. Plexus Auerbach
12. Interganglionic nerve bundle
13. Intramuscular NSE-IR nervous network in the longitudinal muscle layer
14. Perivascular plexus

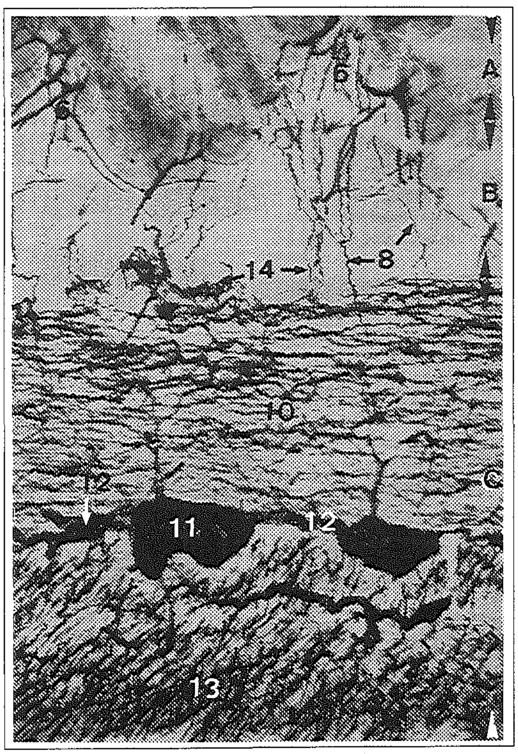


Photo 19. Reticulum.

NSE, cryostat section (50 µm), foetus 25 cm. Magn. 210 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

6. Plexus submucosus: NSE-IR nervous network at the onset of the primary reticular folds
8. Isolated NSE-IR nerve bundle
10. Intramuscular NSE-IR nervous network in the circular muscle layer. Some fibres pierce trough the circular muscle layer and contact the submucous plexus
11. Plexus Auerbach
12. Interganglionic nerve bundle
13. Intramuscular NSE-IR nervous network in the longitudinal muscle layer
14. Perivascular plexus

Photo 20. Reticulum.

NSE, cryostat section (50 µm), foetus 25 cm. Magn. 373 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

1. NSE-IR epithelial cell
6. Plexus submucosus: NSE-IR nervous network at the onset of the primary folds
8. Isolated NSE-IR nerve bundle
9. Plexus submucosus: ganglion
10. Intramuscular NSE-IR nervous network in the circular muscle layer
14. Perivascular plexus

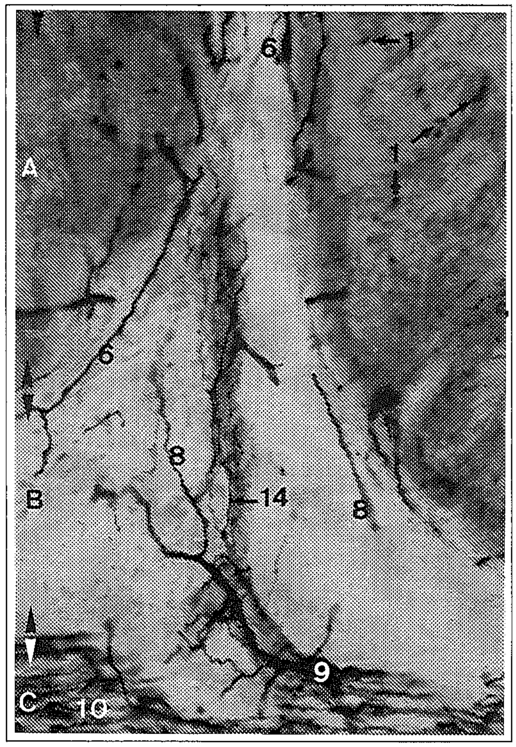
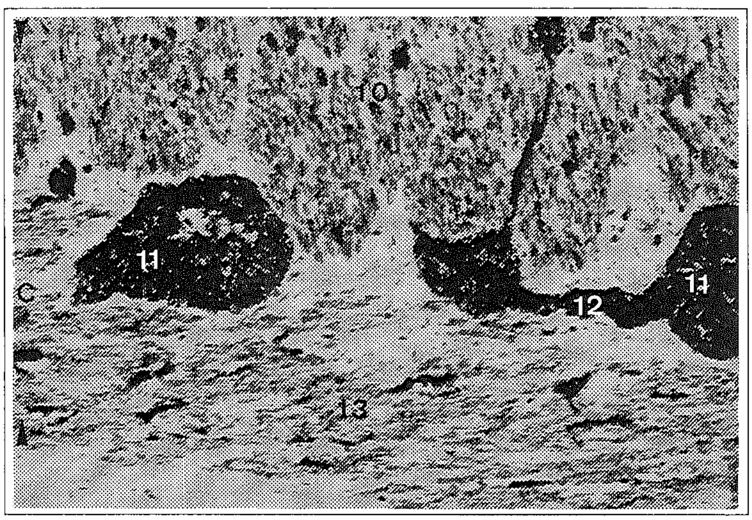


Photo 21. Reticulum.

NSE, paraffin section (5 µm), foetus 28 cm.
Magn. 583 x

C. Tunica Muscularis

10. Intramuscular NSE-IR nervous network in the circular muscle layer. Large NSE-IR nerve bundles between, smaller NSE-IR nerve bundles within the smooth muscle bundles.
11. Plexus Auerbach. A large NSE-IR nerve bundle leaves the ganglion and pierces into the circular muscle layer.
12. Interganglionic nerve bundle
13. Intramuscular NSE-IR nervous network in the longitudinal muscle layer



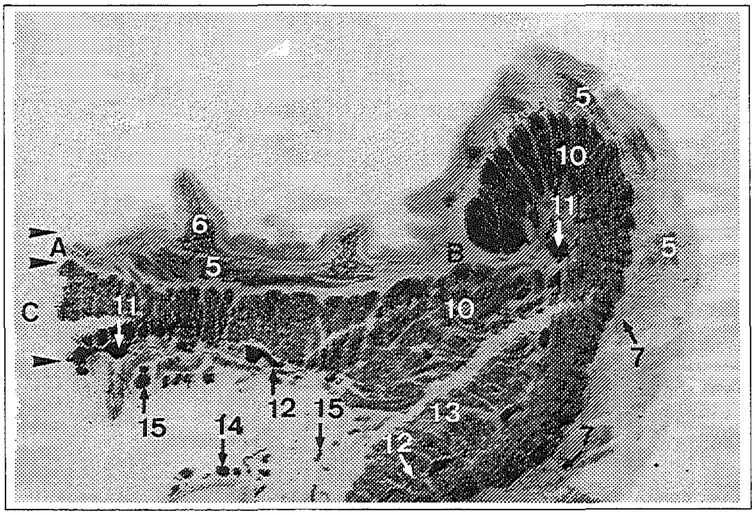


Photo 22. Ostium reticulo-omasicum.

NSE, cryostat section (50 μm), foetus 28 cm.
Magn. 23 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

5. Parts of the lamina muscularis mucosae innervated by several NSE-IR nerve fibres
6. Plexus submucosus: dense NSE-IR nervous network in the papillae unguiculiformes
7. Plexus submucosus: NSE-IR nervous network at the onset of the primary reticular folds
10. Intramuscular NSE-IR nervous network in the circular muscle layer
11. Plexus Auerbach
12. Interganglionic nerve bundle
13. Intramuscular NSE-IR nervous network in the longitudinal muscle layer
14. Peri- and paravascular plexus
15. Plexus subserosus

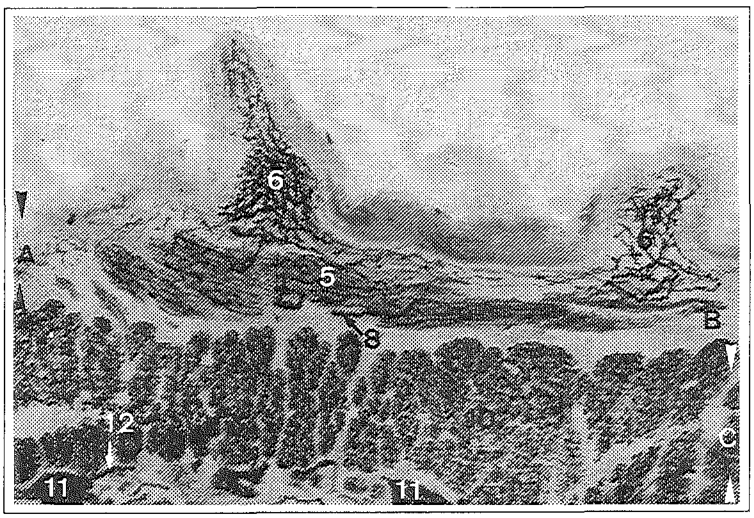


Photo 23. Ostium reticulo-omasicum.

NSE, cryostat section (50 μm), foetus 28 cm.
Magn. 60 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

5. Parts of the lamina muscularis mucosae innervated by several NSE-IR nerve fibres
6. Plexus submucosus: NSE-IR nervous network in the papillae unguiculiformes
8. Isolated NSE-IR nerve bundle
10. Intramuscular NSE-IR nervous network in the circular muscle layer
11. Plexus Auerbach
12. Interganglionic nerve bundle

Photo 24. Ostium reticulo-omasicum.
NSE, cryostat section (50 µm), foetus 28 cm. Magn. 355 x

A. Tunica Mucosa
B. Tunica Submucosa

5. Part of the lamina muscularis mucosae innervated by several NSE-IR nerve fibres
6. Plexus submucosus: very dense NSE-IR nervous network in a papilla unguiculiformis

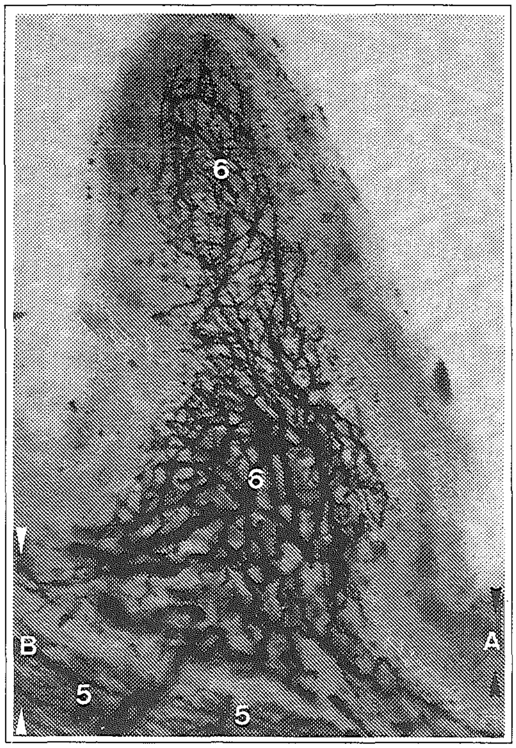
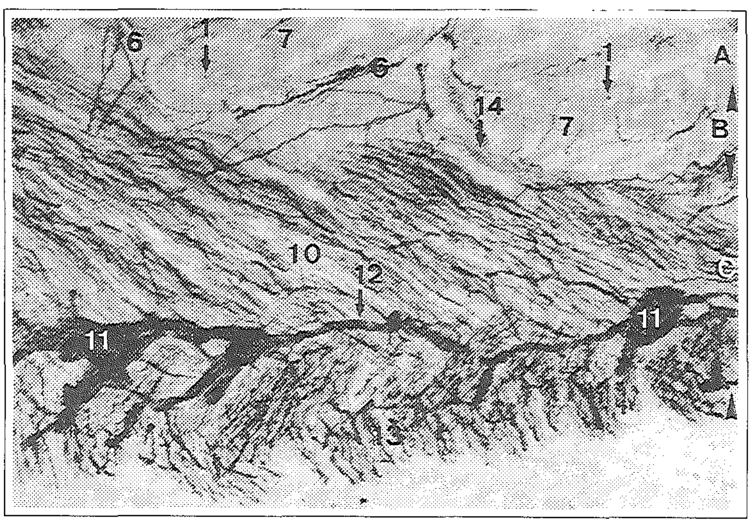


Photo 25. Ostium reticulo-omasicum
(reticular side of the ostium)
NSE, cryostat section (50 µm), foetus 28 cm.
Magn. 93 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

1. NSE-IR epithelial cell
6. Plexus submucosus: NSE-IR nervous network in the primary reticular fold
7. Plexus submucosus: NSE-IR nervous network in the secondary reticular folds
10. Intramuscular NSE-IR nervous network in the circular muscle layer
11. Plexus Auerbach
12. Interganglionic nerve bundle
13. Intramuscular NSE-IR nervous network in the longitudinal muscle layer
14. Perivascular plexus



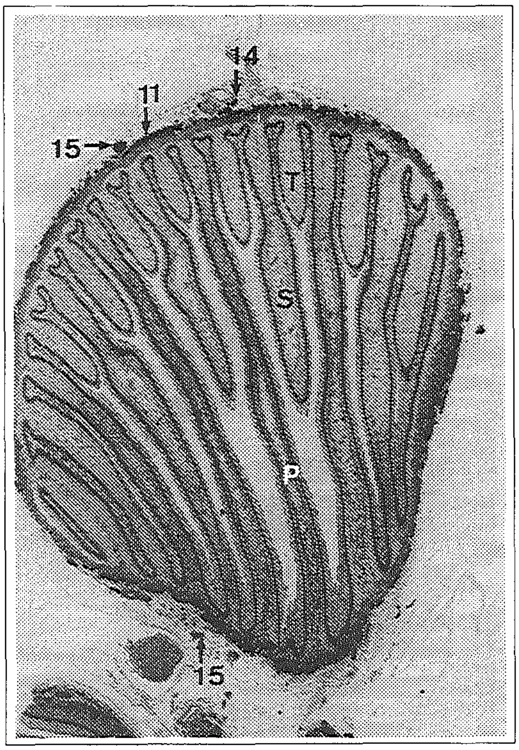


Photo 26. Omasum.

NSE, paraffin section (5 µm), counterstain 1% cresyl violet, foetus 12 cm. Magn. 66,6 x

P. Primary leaf
S. Secondary leaf
T. Tertiary leaf

11. Plexus Auerbach
14. Perivascular plexus
15. Plexus subserosus

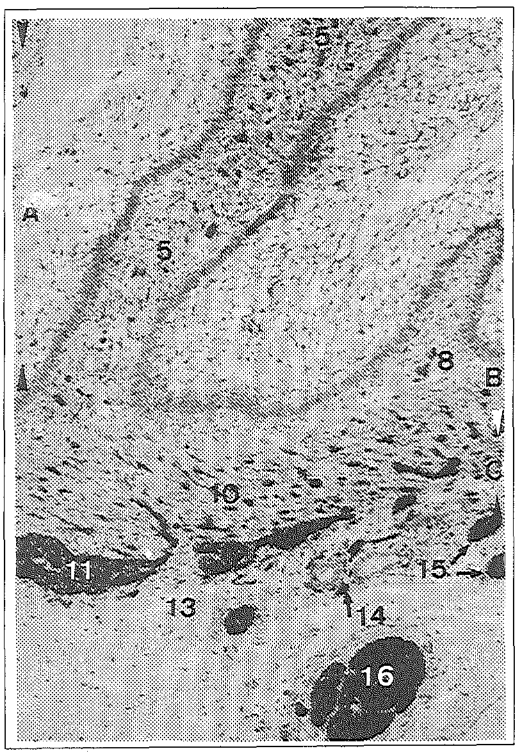


Photo 27. Omasum.

NSE, paraffin section (5 µm), counterstain 1% cresyl violet, foetus 19,5 cm. Magn. 296 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

5. Lamina muscularis mucosae and the extension of the circular muscle layer innervated by several NSE-IR nerve fibres
8. Isolated delicate NSE-IR nerve fibre
10. Intramuscular NSE-IR nervous network in the circular muscle layer
11. Plexus Auerbach
13. Note the "absence" of the longitudinal muscle layer
14. Perivascular plexus
15. Plexus subserosus
16. Continuation of the truncus vagalis dorsalis

Photo 28. Omasum:
longitudinal section through a primary omasal leaf.
NSE, paraffin section (5 µm), counterstain 1% cresyl violet, foetus 15 cm. Magn. 462,5 x

A. Tunica Mucosa
B. Tunica Submucosa

5. Lamina muscularis mucosae and the extension of the circular muscle layer innervated by several NSE-IR nerve fibres

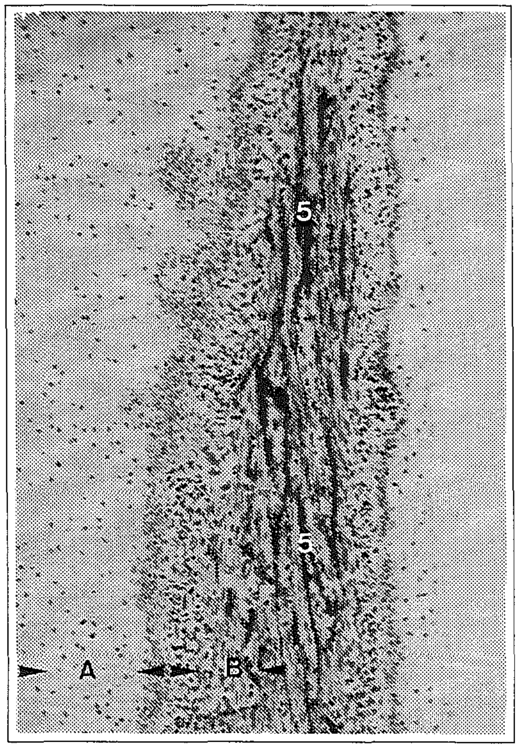


Photo 29. Omasum.
NSE, paraffin section (5 µm), counterstain 1% cresyl violet, foetus 19,5 cm. Magn. 509 x

A. Tunica Mucosa
B. Muscular core in the centre of the leaf

2. Lamina propria. Note the virtual absence of NSE-IR nerve fibres
5. Lamina muscularis mucosae and the extension of the circular muscle layer innervated by several NSE-IR nerve fibres

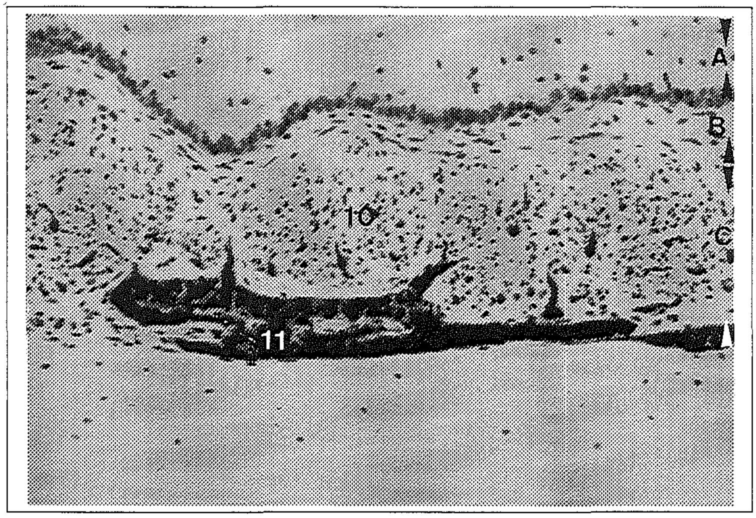


Photo 30. Omasum.

NSE, paraffin section (5 µm), counterstain 1% cresyl violet, foetus 15 cm. Magn. 647,5 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

10. Intramuscular NSE-IR nervous network in the circular muscle layer
11. Plexus Auerbach. Large NSE-IR nerve fibres branch off from the ganglion and penetrate the the muscular coat.

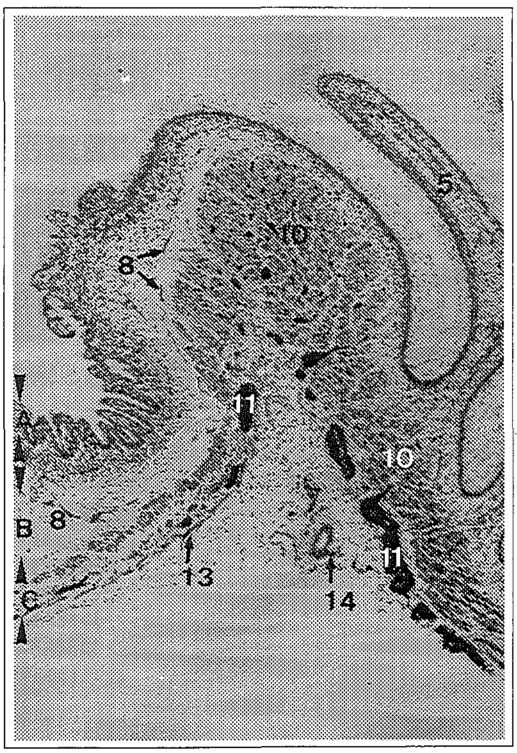


Photo 31. Ostium omasum-abomasicum.

NSE, paraffin section (5 µm), counterstain 1% cresyl violet, foetus 12 cm. Magn. 170 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

5. Lamina muscularis mucosae and the extension of the circular muscle layer innervated by several NSE-IR nerve fibres
8. Isolated NSE-IR nerve fibre on the abomasal side
10. Intramuscular NSE-IR nervous network in the circular muscle layer. Note the increased number of NSE-IR nerve fibers at the level of the ostium.
11. Plexus Auerbach
13. Intramuscular NSE-IR nervous network in the longitudinal muscle layer
14. Perivascular plexus

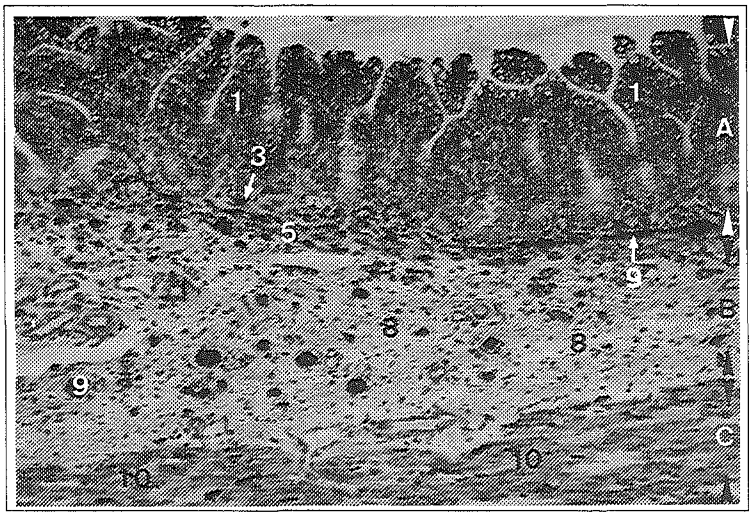


Photo 32. Abomasum.
NSE, paraffin section (5 µm), counterstain
1% cresyl violet, foetus 28 cm. Magn. 462,5 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

1. NSE-IR epithelial cell
3. Plexus mucosus: ganglion between the basis of the glands and the lamina muscularis mucosae
5. Lamina muscularis mucosae innervated by NSE-IR nerve fibres
8. Isolated NSE-IR nerve bundle
9. Plexus submucosus: ganglion
10. Intramuscular NSE-IR nervous network in the circular muscle layer

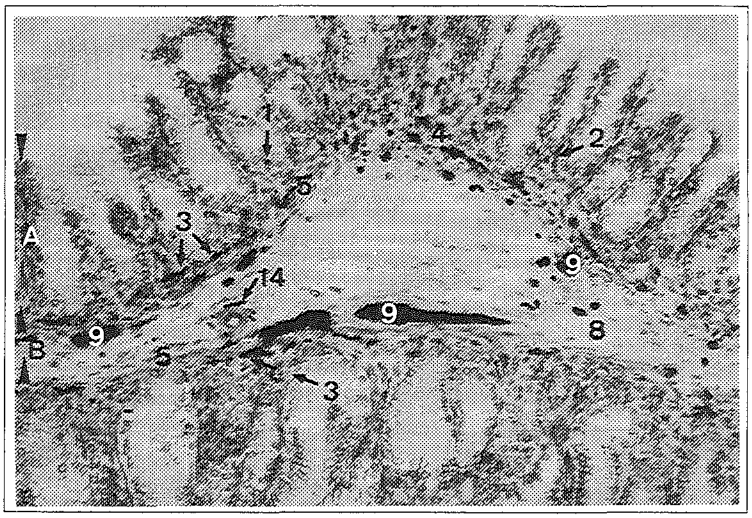


Photo 33. Abomasum.
NSE, paraffin section (5 µm), counterstain
1% cresyl violet, foetus 25,5 cm. Magn. 592 x

A. Tunica Mucosa
B. Tunica Submucosa

1. NSE-IR epithelial cell
2. Plexus mucosus: fibres in lamina propria
3. Plexus mucosus: ganglion between the basis of the glands and the lamina muscularis mucosae
4. Plexus mucosus: periglandular plexus
5. Lamina muscularis mucosae innervated by several NSE-IR nerve fibres
8. Isolated NSE-IR nerve bundle
9. Plexus submucosus: ganglion
14. Perivascular plexus

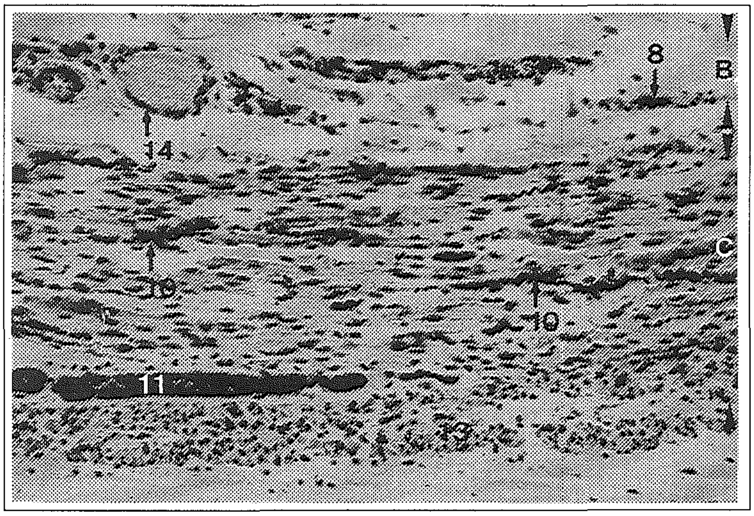


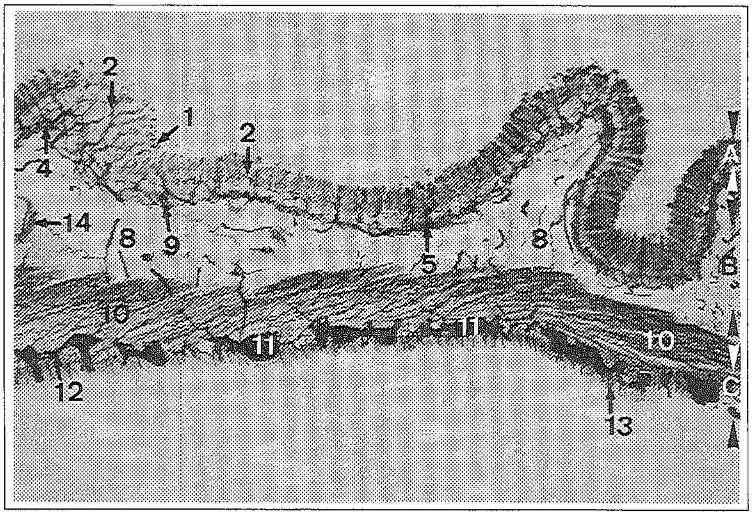
Photo 34. Abomasum.

NSE, paraffin section (5 µm), counterstain 1% cresyl violet, foetus 36 cm. Magn. 583 x

B. Tunica Submucosa
C. Tunica Muscularis

8. Isolated NSE-IR nerve bundle
10. Intramuscular NSE-IR nervous network in the circular muscle layer
11. Plexus Auerbach
13. Intramuscular NSE-IR nervous network in the longitudinal muscle layer
14. Perivascular plexus

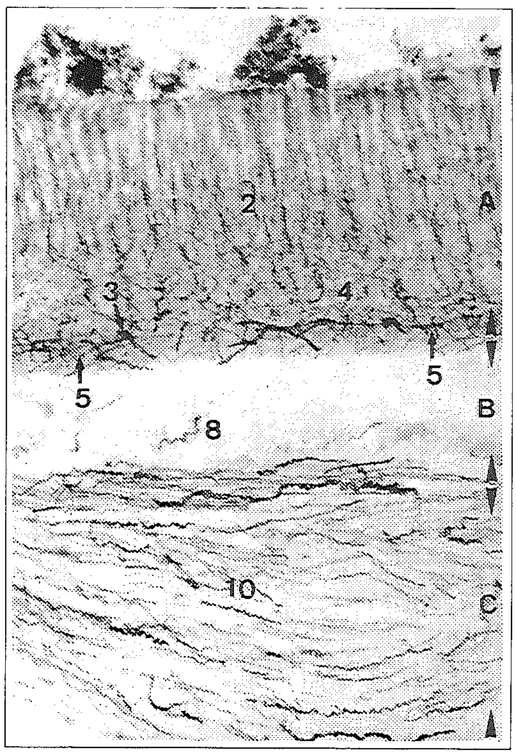
Photo 35. Antrum Pyloricum.
NSE, cryostat section (50 µm), foetus 25 cm.
Magn. 33 x



A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

1. NSE-IR epithelial cell
2. Plexus mucosus: NSE-IR fibres in lamina propria
4. Plexus mucosus: periglandular plexus
5. Lamina muscularis mucosae innervated by several NSE-IR nerve fibres
8. Isolated NSE-IR nerve bundle
9. Plexus submucosus: ganglion
10. Intramuscular NSE-IR nervous network in the circular muscle layer
11. Plexus Auerbach
12. Interganglionic nerve bundle
13. Intramuscular NSE-IR nervous network in the longitudinal muscle layer
14. Perivascular plexus

Photo 36. Antrum Pyloricum.
NSE, cryostat section (50 µm), foetus 25 cm. Magn. 74 x



A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

2. Plexus mucosus: NSE-IR fibres in lamina propria
3. Plexus mucosus: ganglion between the basis of the glands and the lamina muscularis mucosae
4. Plexus mucosus: periglandular plexus
5. Lamina muscularis mucosae innervated by several NSE-IR nerve fibres
8. Isolated NSE-IR nerve bundle
10. Intramuscular NSE-IR nervous network in the circular muscle layer

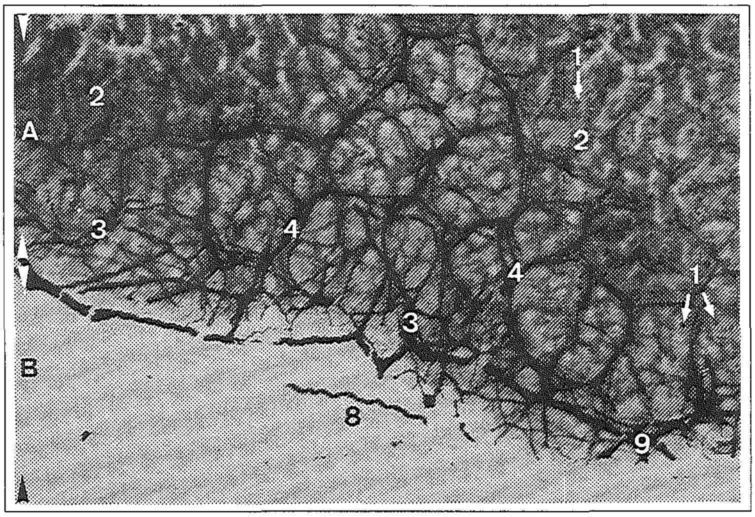


Photo 37. Antrum Pyloricum.

NSE, cryostat section (50 μm), foetus 25 cm.
Magn. 210 x

A. Tunica Mucosa
B. Tunica Submucosa

1. NSE-IR epithelial cell
2. Plexus mucosus: NSE-IR fibres in lamina propria
3. Plexus mucosus: ganglion between the basis of the glands and the lamina muscularis mucosae
4. Plexus mucosus: periglandular plexus
8. Isolated NSE-IR nerve bundle. Note submucous NSE-IR nerve bundle making connecting the plexus submucosus and the plexus mucosus
9. Plexus submucosus: ganglion

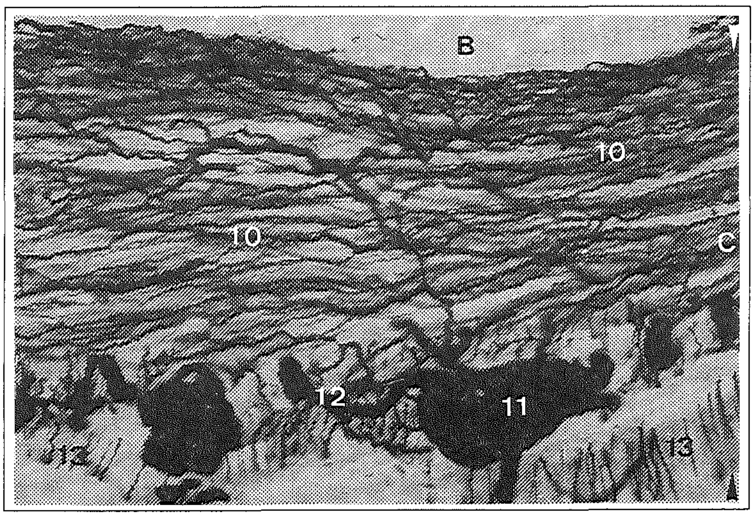


Photo 38. Antrum Pyloricum.

NSE, cryostat section (50 μm), foetus 25 cm.
Magn. 355 x

B. Tunica Submucosa
C. Tunica Muscularis

10. Intramuscular NSE-IR nervous network in the circular muscle layer
11. Plexus Auerbach. Note large NSE-IR nerve fibres leaving the ganglion and entering the muscular coat
12. Interganglionic nerve bundle
13. Intramuscular NSE-IR nervous network in the longitudinal muscle layer

Photo 39. Antrum Pyloricum.
NSE, cryostat section (50 µm), adult sheep. Magn. 237 x

A. Tunica Mucosa
B. Tunica Submucosa

1. NSE-IR epithelial cell
2. Plexus mucosus: NSE-IR fibres in lamina propria. Note association some NSE-IR epithelial cells and some NSE-IR fibres
3. Plexus mucosus: ganglion between the basis of the glands and the lamina muscularis mucosae
4. Plexus mucosus: periglandular plexus
5. Lamina muscularis mucosae innervated by several NSE-IR nerve fibres

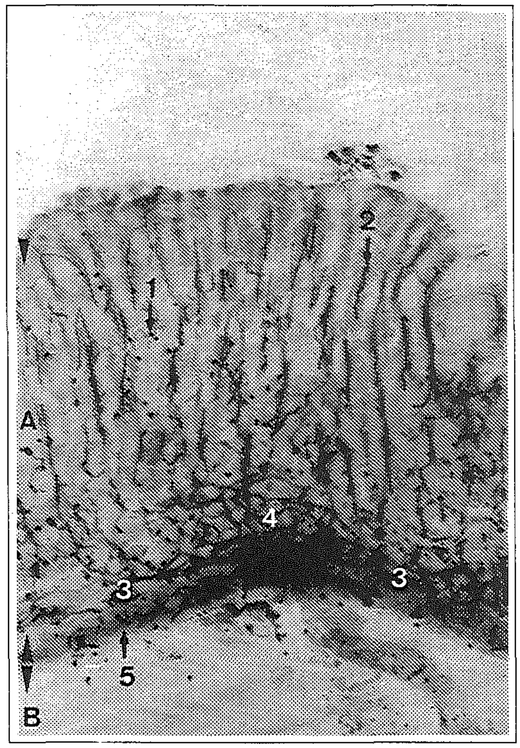
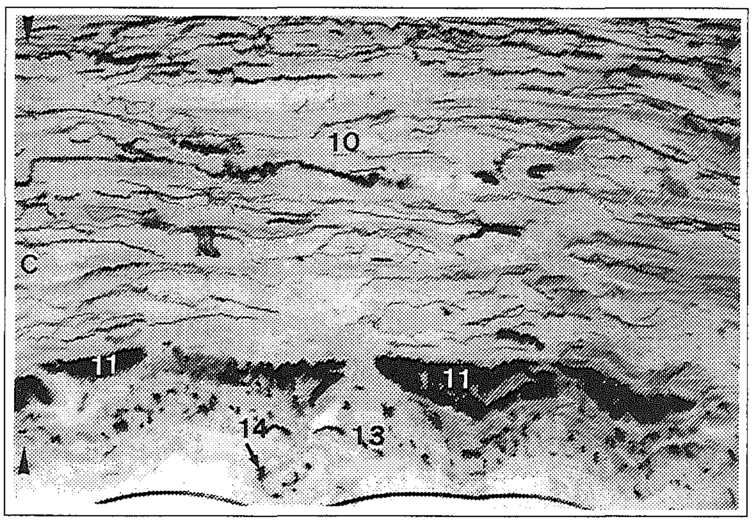


Photo 40. Antrum Pyloricum.
NSE, cryostat section (50 µm), adult sheep.
Magn. 237 x

C. Tunica Muscularis

10. Intramuscular NSE-IR nervous network in the circular muscle layer. Note larger NSE-IR nerve fibres between and smaller NSE-IR nerve fibres within the smooth muscle bundles
11. Plexus Auerbach
13. Intramuscular NSE-IR nervous network in the longitudinal muscle layer
14. Perivascular plexus



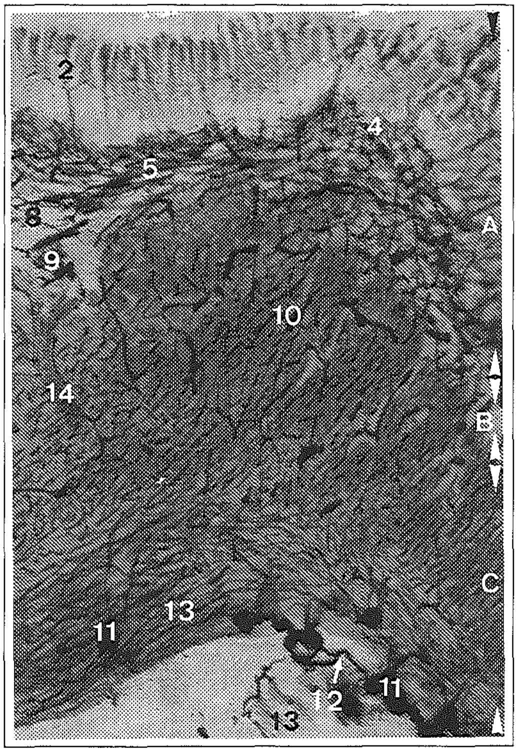


Photo 41. Pylorus.
NSE, cryostat section (50 µm), foetus 25,5 cm. Magn. 163 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

2. Plexus mucosus: NSE-IR fibres in lamina propria
4. Plexus mucosus: periglandular plexus
5. Lamina muscularis mucosae innervated by several NSE-IR nerve fibres
8. Isolated NSE-IR nerve bundle
9. Plexus submucosus: ganglion
10. Very dense intramuscular NSE-IR nervous network in the circular muscle layer the level of the pylorus
11. Plexus Auerbach
12. Interganglionic nerve bundle
13. Intramuscular NSE-IR nervous network in the longitudinal muscle layer
14. Perivascular plexus

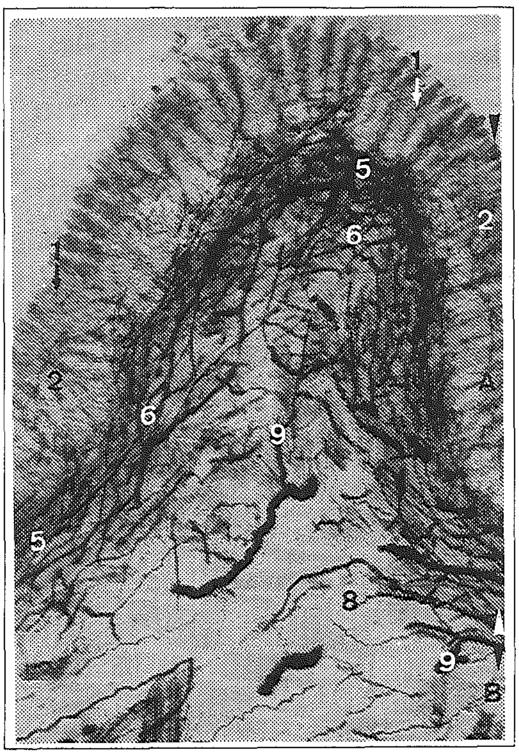


Photo 42. Pylorus.
NSE, cryostat section (50 µm), foetus 25,5 cm. Magn. 163 x

A. Tunica Mucosa
B. Tunica Submucosa

1. NSE-IR epithelial cell
2. Plexus mucosus: NSE-IR fibres in lamina propria
5. Lamina muscularis mucosae innervated by several NSE-IR nerve fibres
6. Plexus submucosus: NSE-IR nervous network
8. Isolated NSE-IR nerve bundle
9. Plexus submucosus: ganglion

Photo 43. Pylorus.
NSE, cryostat section (50 µm), foetus 25,5 cm.
Magn. 296 x

A. Tunica Mucosa
B. Tunica Submucosa

1. NSE-IR epithelial cell
2. Plexus mucosus: NSE-IR fibres in lamina propria
3. Plexus mucosus: ganglion between the basis of the glands and the lamina muscularis mucosae
4. Plexus mucosus: periglandular plexus
5. Lamina muscularis mucosae innervated by several NSE-IR nerve fibres
6. Plexus submucosus: NSE-IR nervous network
8. Isolated NSE-IR nerve bundle
9. Plexus submucosus: ganglion

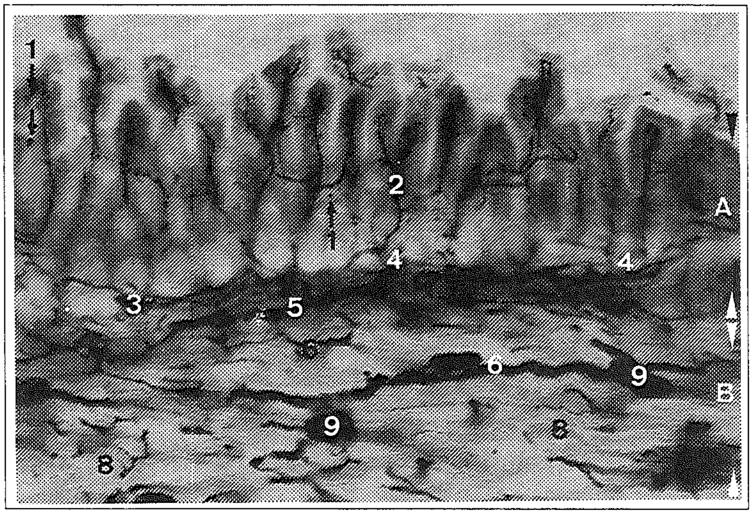
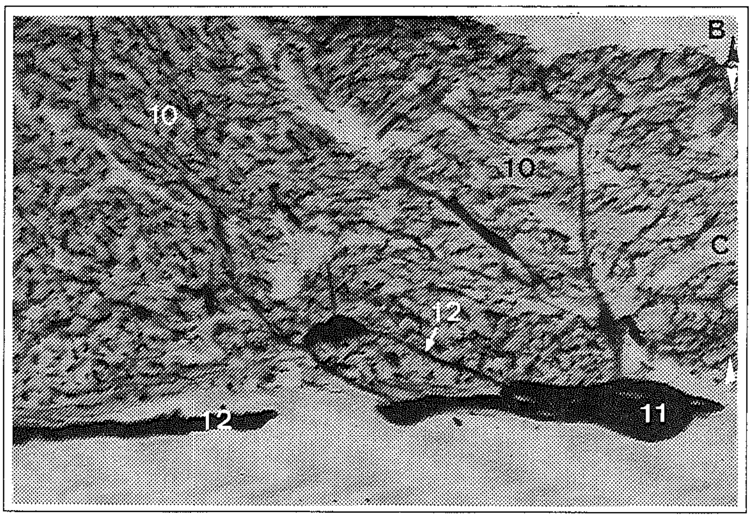


Photo 44. Pylorus.
NSE, cryostat section (50 µm), foetus 25,5 cm.
Magn. 222 x

B. Tunica Submucosa
C. Tunica Muscularis

10. Intramuscular NSE-IR nervous network in the circular muscle layer
11. Plexus Auerbach. Note large nerve bundles leaving the ganglion and penetrating the muscular coat
12. Interganglionic nerve bundle



Forestomach

				E	Pr	M	S	C	A	L	SS
RG	foetus	Gr 1	PS	0	0	0	1	3	4	2	2
			CS	/	/	/	/	/	/	/	/
		Gr 2	PS	0	0	1	1	3	4	2	2
			CS	1	1	2	2	4	5	2	2
		Gr 3	PS	/	/	/	/	/	/	/	/
			CS	2	1	3	2	4	5	3	2
	adult		PS	0	1	1	1	3	3	2	0
			CS	0	1	2	2	4	5	3	0
RET	foetus	Gr 1	PS	0	0	0	0.6	3	4	2	0.6
			CS	/	/	/	/	/	/	/	/
		Gr 2	PS	0.3	0	0.3	1.3	3	4	2	1.3
			CS	1	1	2	2	4	5	3	0
		Gr 3	PS	0	0	0.6	1.3	3.3	4	2	1
			CS	2	1	3	2	4	5	3	0
	adult		PS	0	0.5	1	1	3	4	2	0
			CS	0	1	2	1	4	5	3	0
RDS	foetus	Gr 1	PS	0	0	0	1	3	4	2	0
			CS	/	/	/	/	/	/	/	/
		Gr 2	PS	0	0	0	1	3	4	2	2
			CS	1	0	0	1	4	5	3	0
		Gr 3	PS	0	0	0	1	3	4	2	1
			CS	2	0	0	1	4	5	3	0
	adult		PS	0	0	0	1	3	4	2	0.5
			CS	0	0	0	1	4	5	3	1
RVS	foetus	Gr 1	PS	0	0	0	1	3.5	4	2	1
			CS	/	/	/	/	/	/	/	/
		Gr 2	PS	0	0	0	1	3	4	2	2
			CS	2	0	0	2	4	5	3	1
		Gr 3	PS	0	0	0	1	3	4	2	1
			CS	2	0	0	2	4	5	3	0
	adult		PS	0	0	0	1	3	4	2	0
			CS	0	1	0	2	4	5	3	1
ORO	foetus	Gr 1	PS	/	/	/	/	/	/	/	/
			CS	/	/	/	/	/	/	/	/
		Gr 2	PS	/	/	/	/	/	/	/	/
			CS	0	0	2	2	4	5	3	2
		Gr 3	PS	/	/	/	/	/	/	/	/
			CS	0	0	2	2	4	5	3	2
	adult		PS	0	0	1	1.5	3	4	2	0
			CS	0	1	2	2	4	5	3	0
OMA	foetus	Gr 1	PS	0	0	1.5	1	3	4	0.2	2
			CS	/	/	/	/	/	/	/	/
		Gr 2	PS	0	0	2	1	3	4	0.6	2
			CS	/	/	/	/	/	/	/	/
		Gr 3	PS	0.3	0.2	2	0.5	3	4	1.3	2
			CS	/	/	/	/	/	/	/	/
	adult		PS	0	1	2	1	3	4	1	1
			CS	0	1	3	2	4	5	2	0

Glandular Stomach											
				E	Pr	M	S	C	A	L	SS
ABO	foetus	Gr 1	PS	0.5	1.5	0.5	2	2.5	4	1	2
			CS	/	/	/	/	/	/	/	/
		Gr 2	PS	0	2	1	2	3	4	0.5	1
			CS	2	3	2	2.5	4	5	3	0
		Gr 3	PS	0	2	1.5	2	3	4	2	1.5
			CS	2	3	2	2.5	4	5	3	0
	adult		PS	0	2	2	1.5	3	4	2	0
			CS	1	3	3	3	4	5	3	0
AP	foetus	Gr 1	PS	1	1	1	2	2.5	4	1.5	2
			CS	/	/	/	/	/	/	/	/
		Gr 2	PS	0	1	1	2	2	4	2	2
			CS	2	3	2	2.5	4	5	3	0
		Gr 3	PS	0	2	1	1	3	4	2	2
			CS	2	3	2	2.5	4	5	3	0
	adult		PS	0	2	2	3	3	4	2	1
			CS	0	2	3	3	4	5	3	0
PYL	foetus	Gr 1	PS	0	2	1	2	3	4	2	2
			CS	/	/	/	/	/	/	/	/
		Gr 2	PS	0	1	1	2	3	4	2	2
			CS	0	3	2	3	4	5	3	0
		Gr 3	PS	0	1.5	1	2	3	4	2	1
			CS	2	3	2	2.5	4	5	3	0
	adult		PS	0	2	3	3	3	4	2	0.5
			CS	2	2.5	3	3	4	5	3	0

A: Auerbach; C: circular muscle layer; CS: cryostat section; E: epithelium; Gr: group (=2 foetuses); L: longitudinal muscle layer; M: muscularis mucosae; Pr: propria mucosae; PS: paraffin section; S: submucosa; SS: subserosa.
/: not performed; 0: no NSE-IR; 5: numerous NSE-IR structures showing an intense NSE-IR.

Table 5. Distribution pattern of the NSE-IR in the wall of the ruminant stomach of the sheep.

ADDENDUM PART III

MATERIAL and METHODS

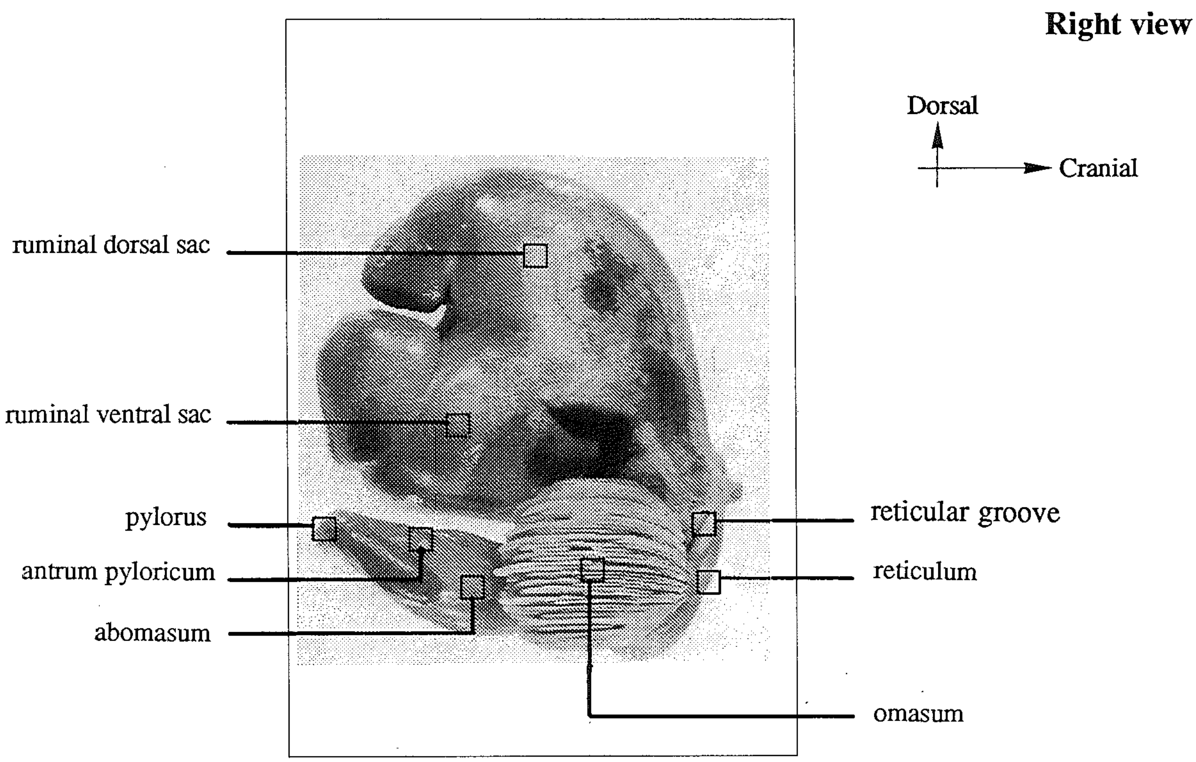


Photo 45. The different segments of the ruminant stomach (foetal sheep) used in this part of the study

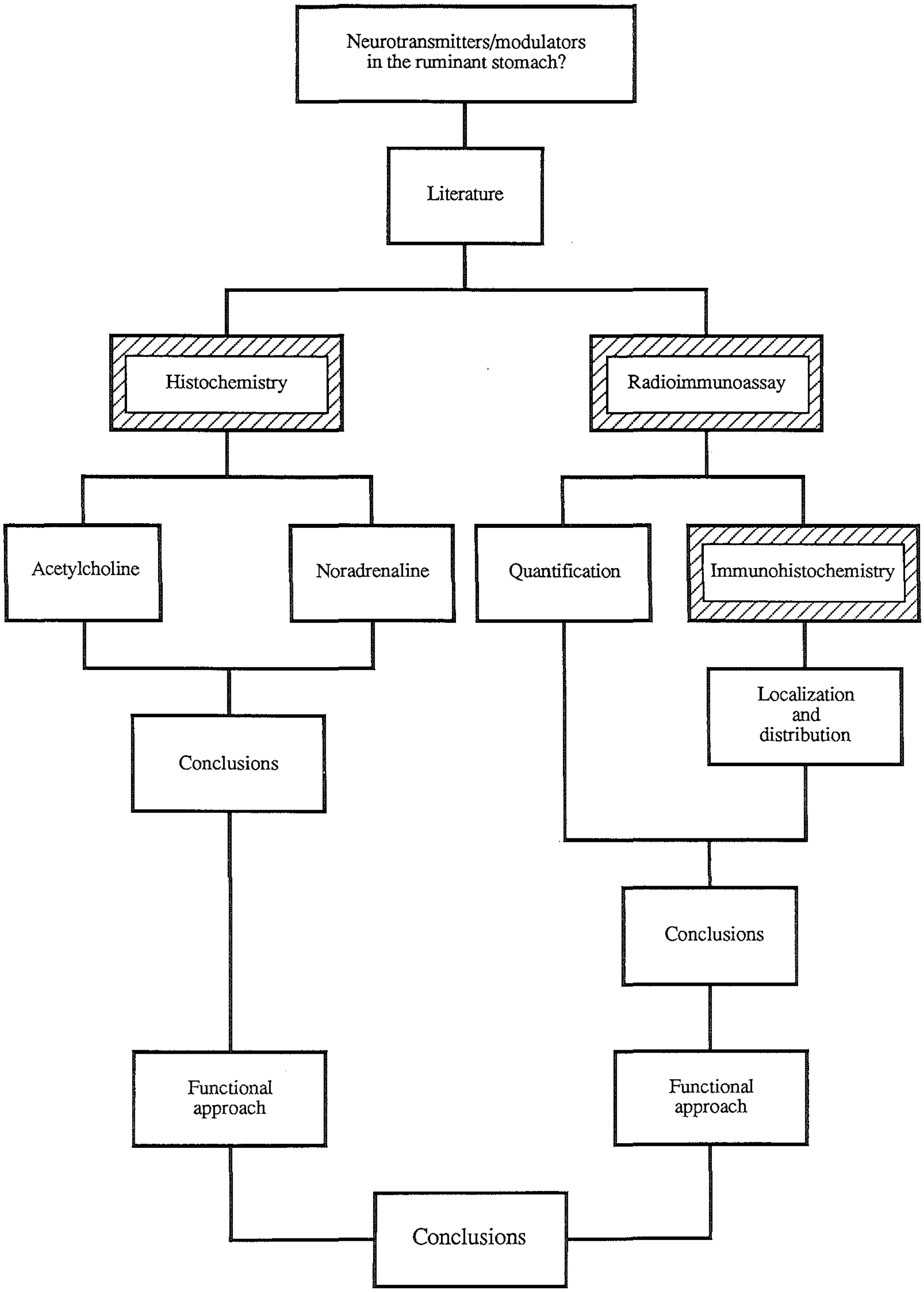


Fig. 11. Schematic representation of the methodological approach used in the study concerning the presence, distribution and functional significance of some neurotransmitters/modulators in the ruminant stomach of the sheep.

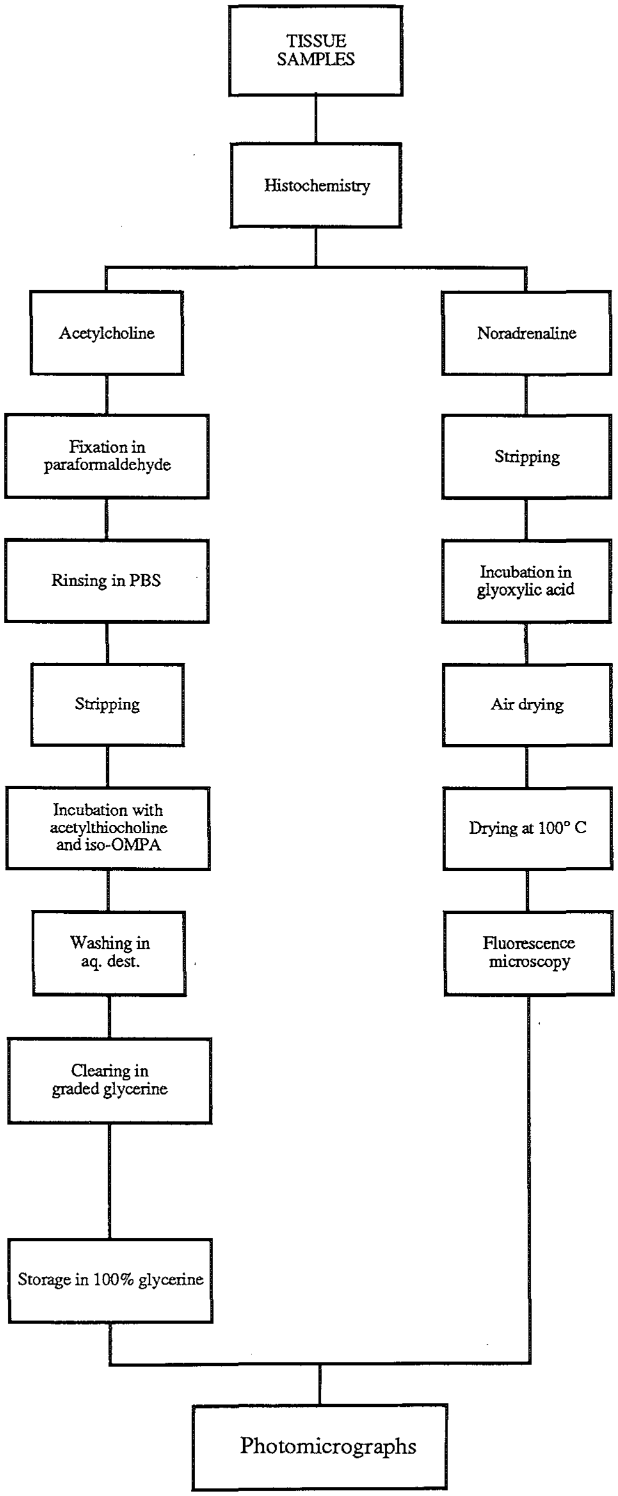


Fig. 12. Schematic representation of the histochemical approach used in the study concerning the presence, distribution and functional significance of some neurotransmitters/modulators in the ruminant stomach of the sheep.

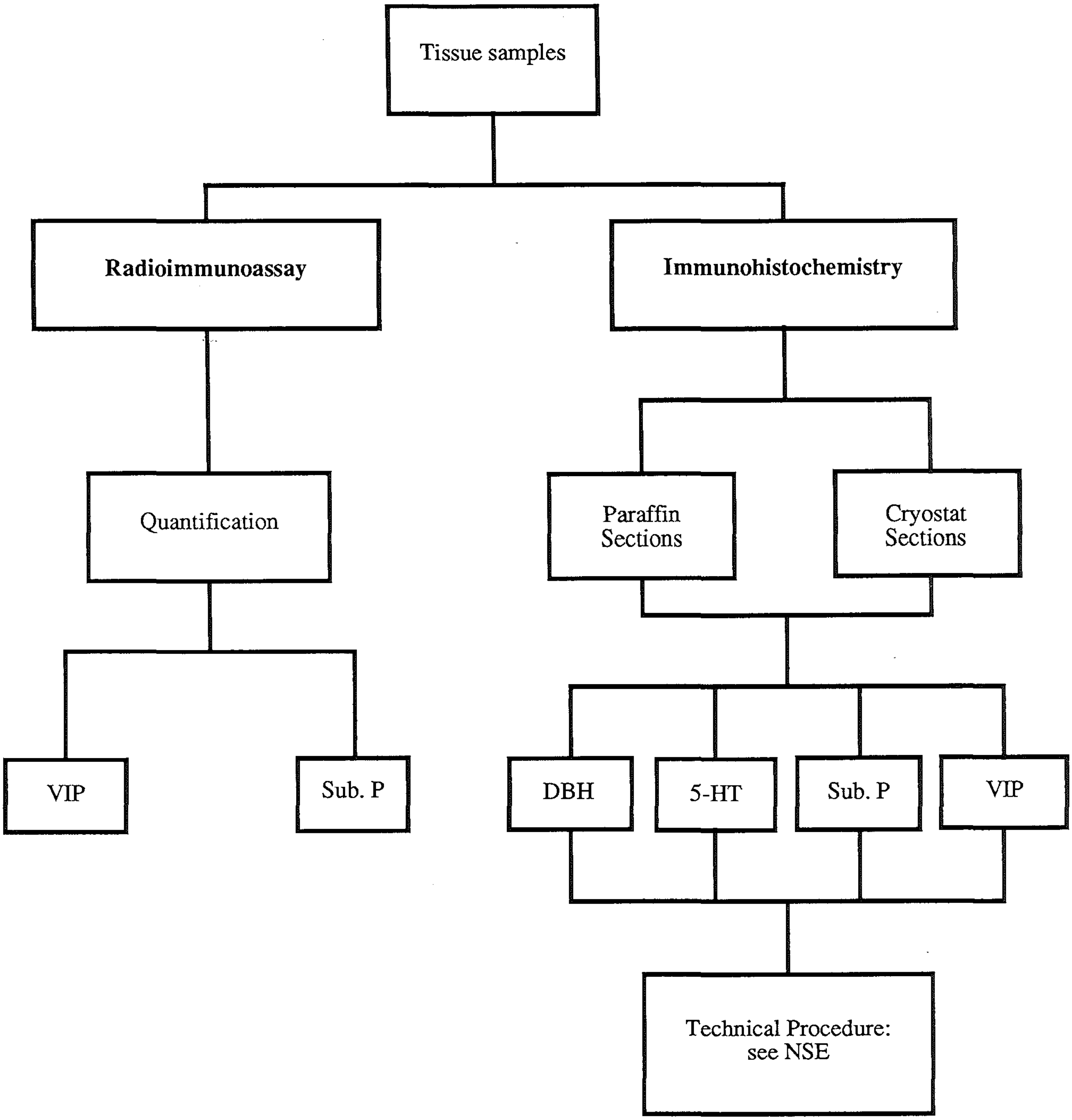


Fig. 13. Schematic representation of the immunological approach used in the study concerning the presence, distribution and functional significance of some neurotransmitters/modulators in the ruminant stomach of the sheep.

PRIMARY ANTISERUM	ANTIGEN source/ ANTISERUM source	DILUTION	
		Paraffin sections	Cryostat sections
NSE	bovine / rabbit	1/1000	1/5000
DBH*	bovine / goat	-	1/8000
5-HT*	5-HT / rabbit	1/1000	-
VIP	porcine / rabbit	1/2500	1/10.000
Sub. P*	Sub. P / rabbit	1/1000	1/10.000

* kind gift of Dr. A. A. J. Verhofstad

Table 6. Antisera used in the immunohistochemical study concerning the enteric nervous system in the ruminant stomach of the sheep.

RESULTS

ACETYLCHOLINE (ACh)

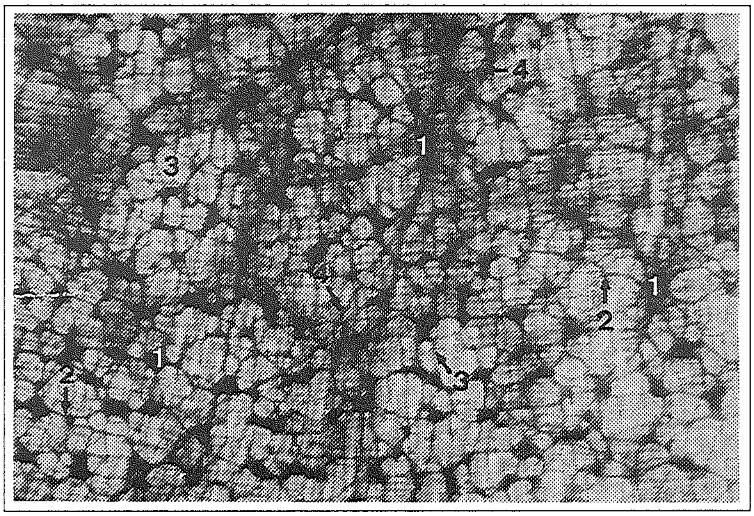


Photo 46. Reticulum.
AChE, whole mount preparation, foetus 18 cm.
Magn.73 x

1. Ganglion
2. Internodal strands constituting together with the ganglia the primary plexus
3. Interlaching AChE + nervous network forming the secondary and tertiary plexus
4. Branch of the truncus vagalis dorsalis

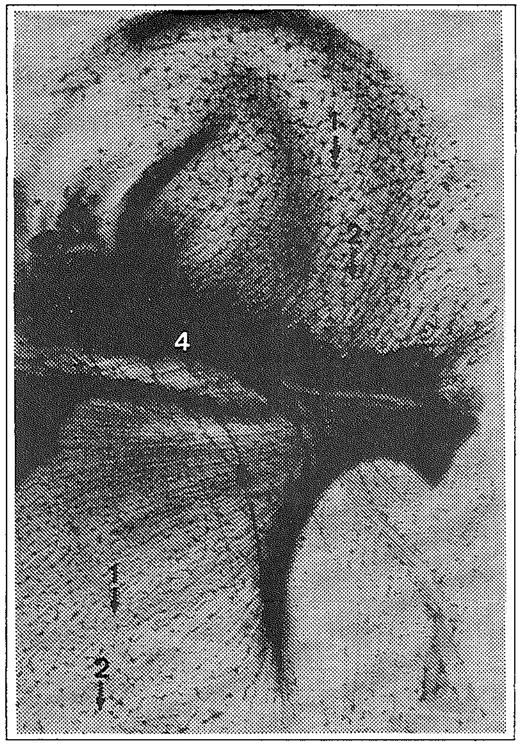


Photo 47. Rumen.
AChE, whole mount preparation, foetus 18 cm. Magn.18 x

1. Ganglion
2. Internodal strands constituting together with the ganglia the primary plexus
4. Truncus vagalis dorsalis running in the sulcus longitudinalis ruminis
5. Branches of the truncus vagalis dorsalis ending on myenteric ganglia

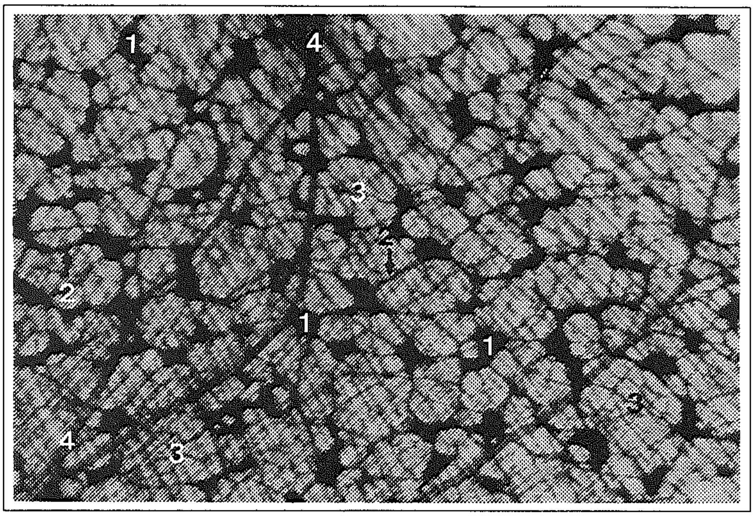


Photo 48. Ruminal Dorsal Sac.
AChE, whole mount preparation, foetus 18 cm.
Magn.80 x

1. Ganglion
2. Internodal strands constituting together with the ganglia the primary plexus
3. Interlaching AChE + nervous network forming the secondary and tertiary plexus
4. Branch of the truncus vagalis dorsalis

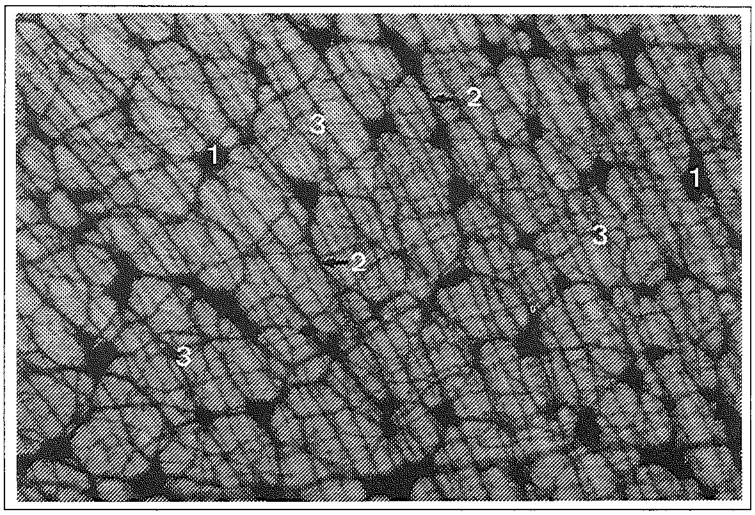


Photo 49. Ruminal Ventral Sac.
AChE, whole mount preparation, foetus 18 cm.
Magn.116,5 x

1. Ganglion
2. Internodal strands constituting together with the ganglia the primary plexus
3. Interlaching AChE + nervous network forming the secondary and tertiary plexus

Photo 50. Omasum.
AChE, whole mount preparation, foetus 18 cm.
Magn.73 x

1. Ganglion
2. Internodal strands constituting together with the ganglia the primary plexus
3. Interlaching AChE + nervous network forming the secondary and tertiary plexus
4. Branch of the truncus vagalis dorsalis

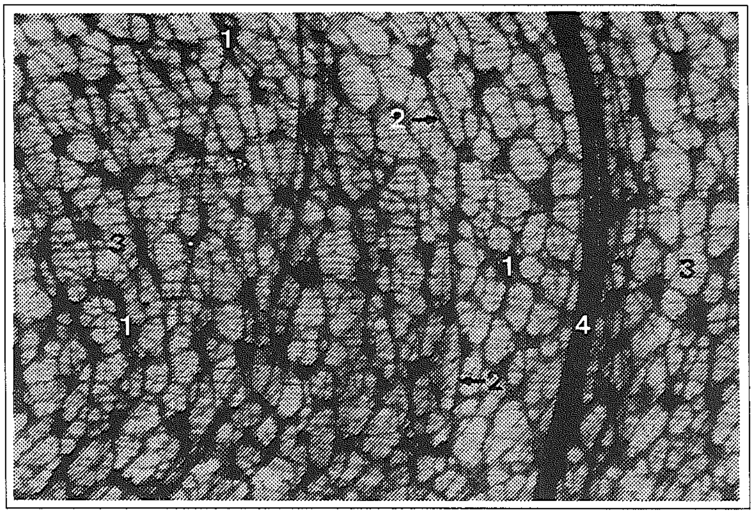
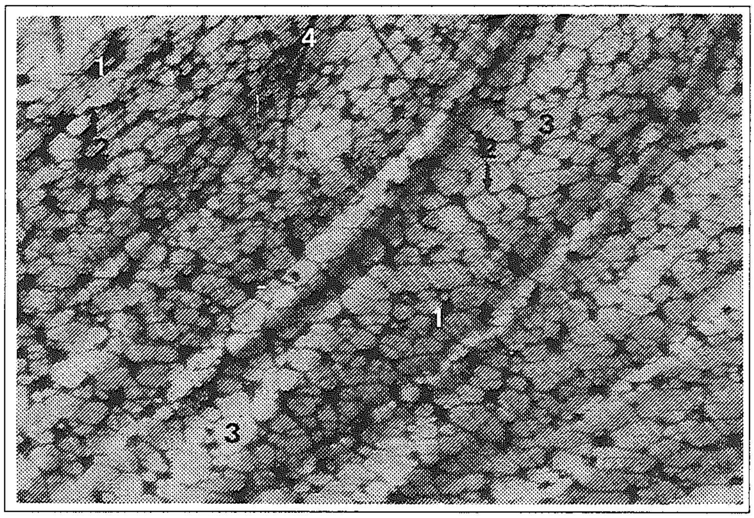


Photo 51. Abomasum.
AChE, whole mount preparation, foetus 18 cm.
Magn.45,5 x

1. Ganglion
2. Internodal strands constituting together with the ganglia the primary plexus
3. Interlaching AChE + nervous network forming the secondary and tertiary plexus
4. Branches of the truncus vagalis dorsalis ending on myenteric ganglia



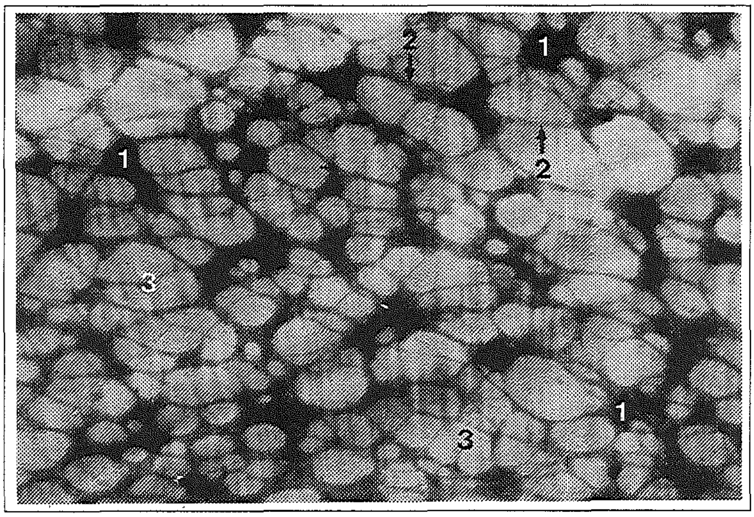


Photo 52. Abomasum.
AChE, whole mount preparation, foetus 18 cm.
Magn.116,5 x

1. Ganglion
2. Internodal strands constituting together with the ganglia the primary plexus
3. Interlaching AChE + nervous network forming the secondary and tertiary plexus

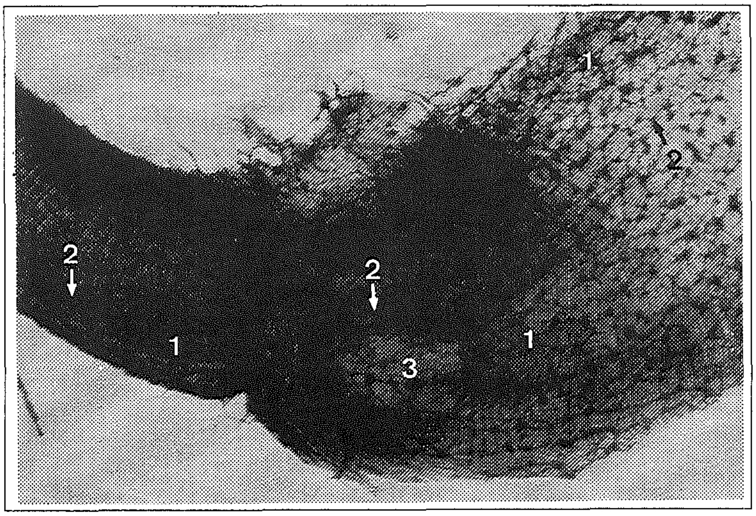


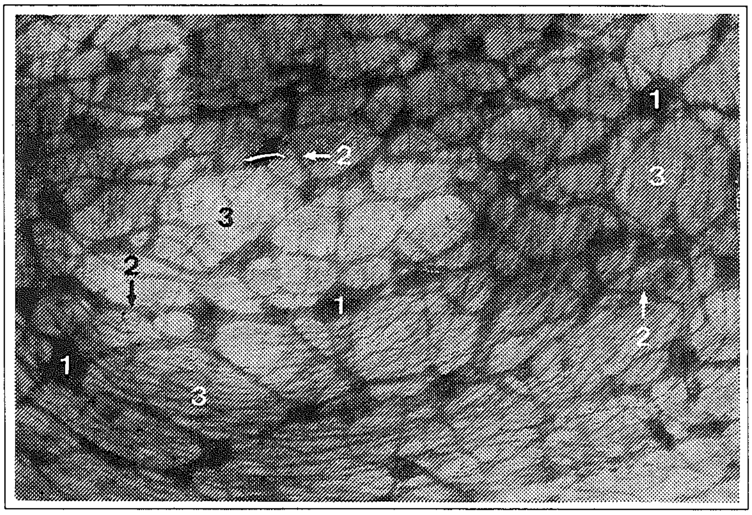
Photo 53. Antrum pyloricum, Pylorus and Duodenum.
AChE, whole mount preparation, foetus 18 cm.
Magn.36 x

1. Ganglion
2. Internodal strands constituting together with the ganglia the primary plexus
3. Interlaching AChE + nervous network forming the secondary and tertiary plexus

Note diffferences in the morphology of the meshwork along the different segments

Photo 54. Pylorus.
AChE, whole mount preparation, foetus 18 cm.
Magn.116,5 x

1. Ganglion
2. Internodal strands constituting together with the ganglia the primary plexus
3. Interlaching AChE + nervous network forming the secondary and tertiary plexus



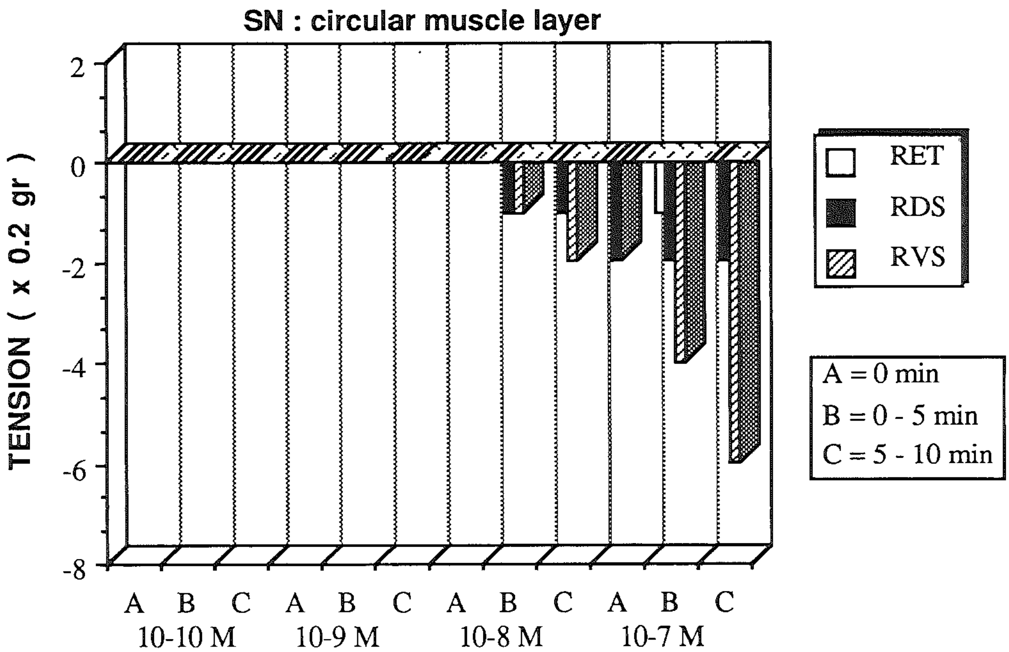


Fig. 14. Graphic representation of the in vitro effect of sodium nitroprusside (SN) on the circular muscle layer of the RET; RDS and RVS.

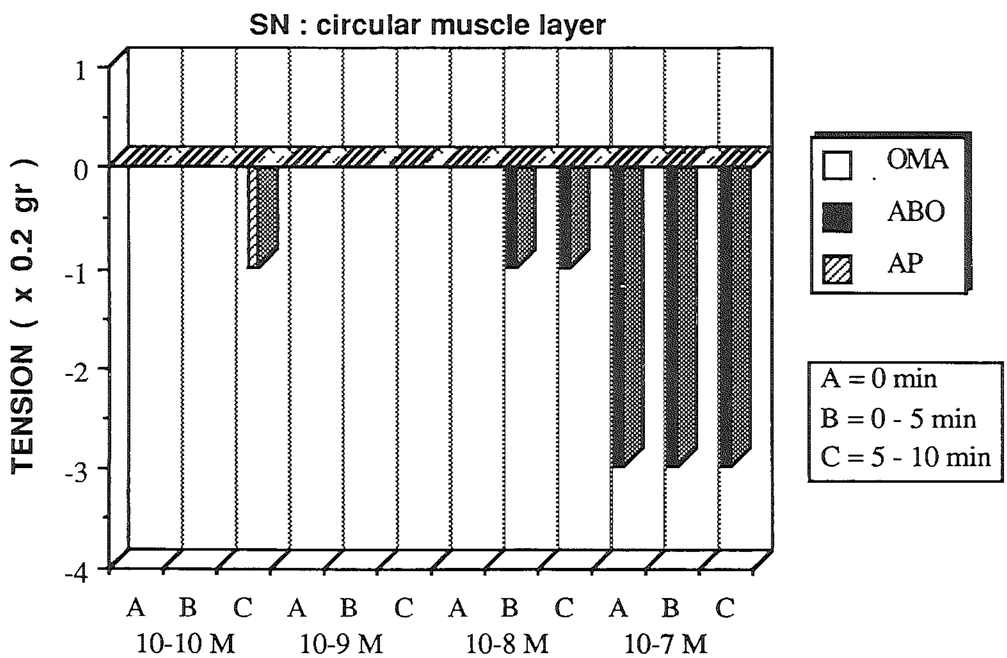


Fig. 15. Graphic representation of the in vitro effect of sodium nitroprusside (SN) on the circular muscle layer of the OMA; ABO and AP.

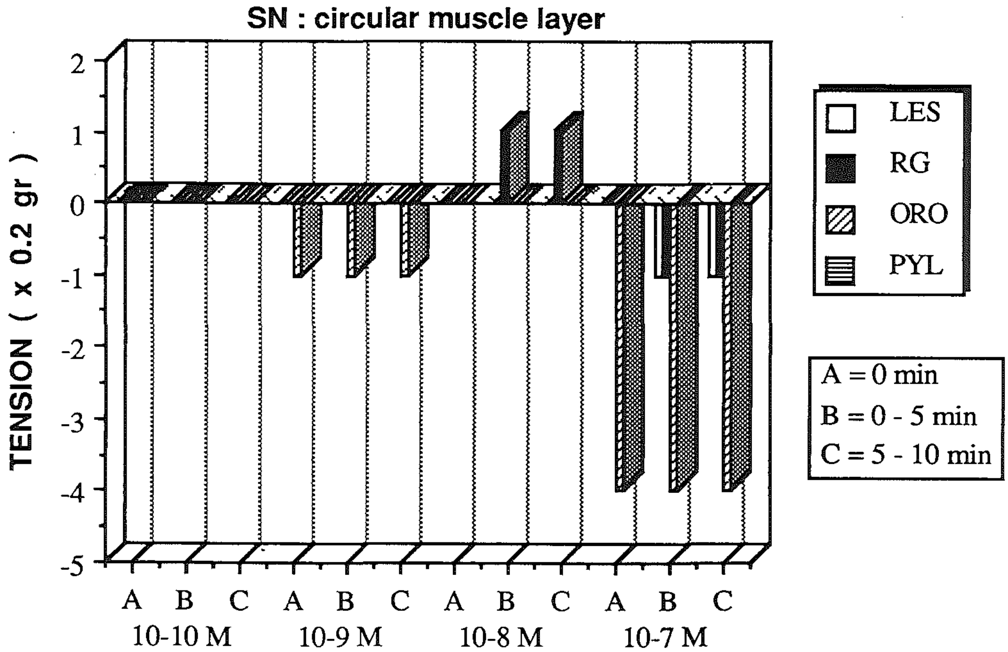


Fig. 16. Graphic representation of the in vitro effect of sodium nitroprusside (SN) on the circular muscle layer of the sphincters: LES; RG; ORO and PYL.

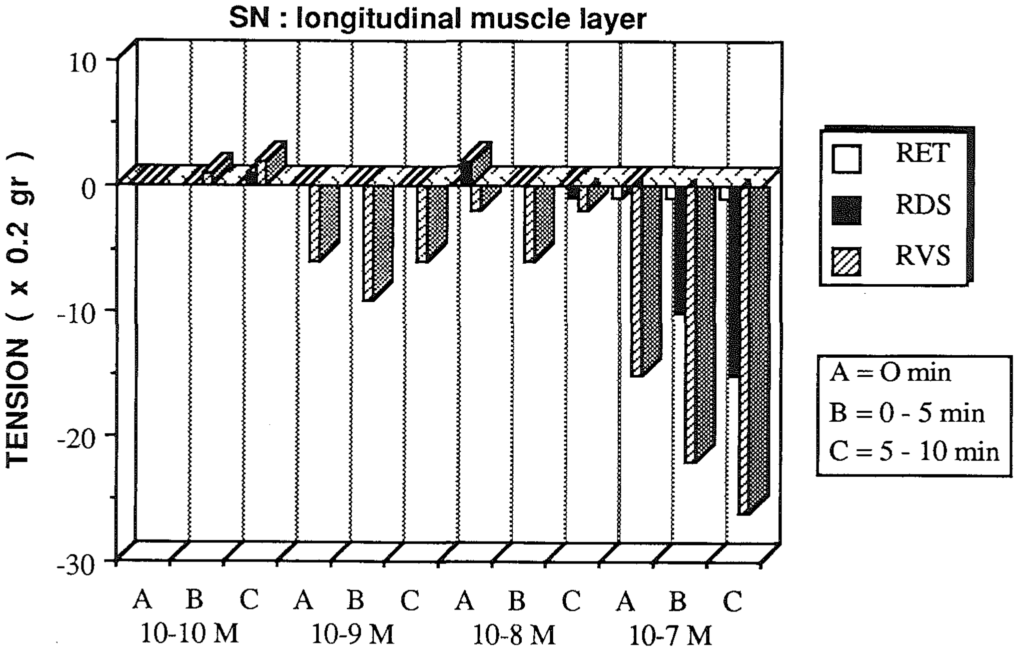


Fig. 17. Graphic representation of the in vitro effect of sodium nitroprusside (SN) on the longitudinal muscle layer of the RET; RDS and RVS.

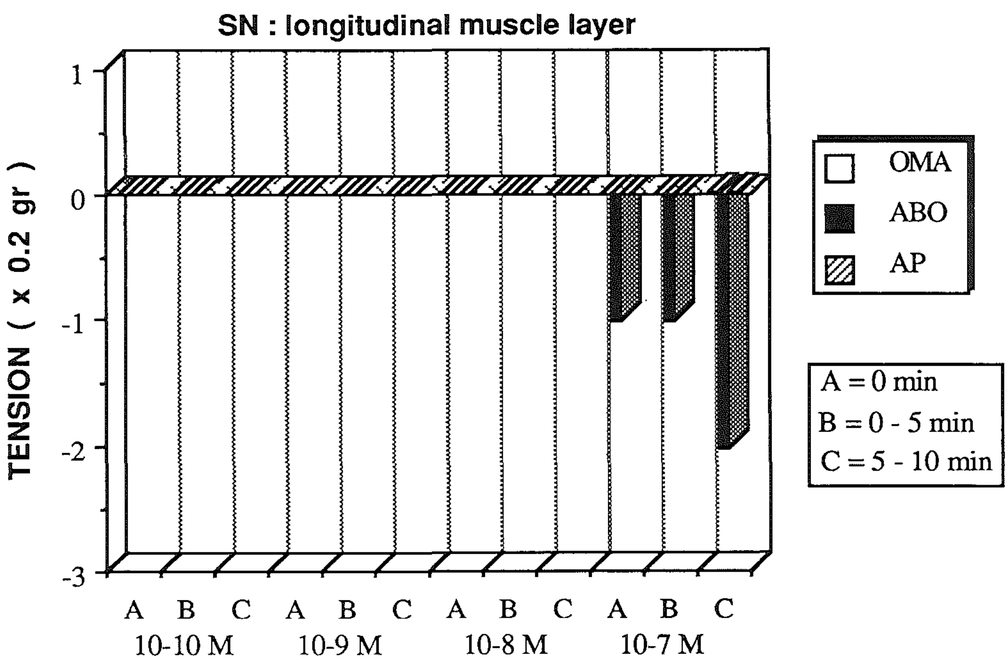


Fig. 18. Graphic representation of the in vitro effect of sodium nitroprusside (SN) on the longitudinal muscle layer of the OMA; ABO and AP.

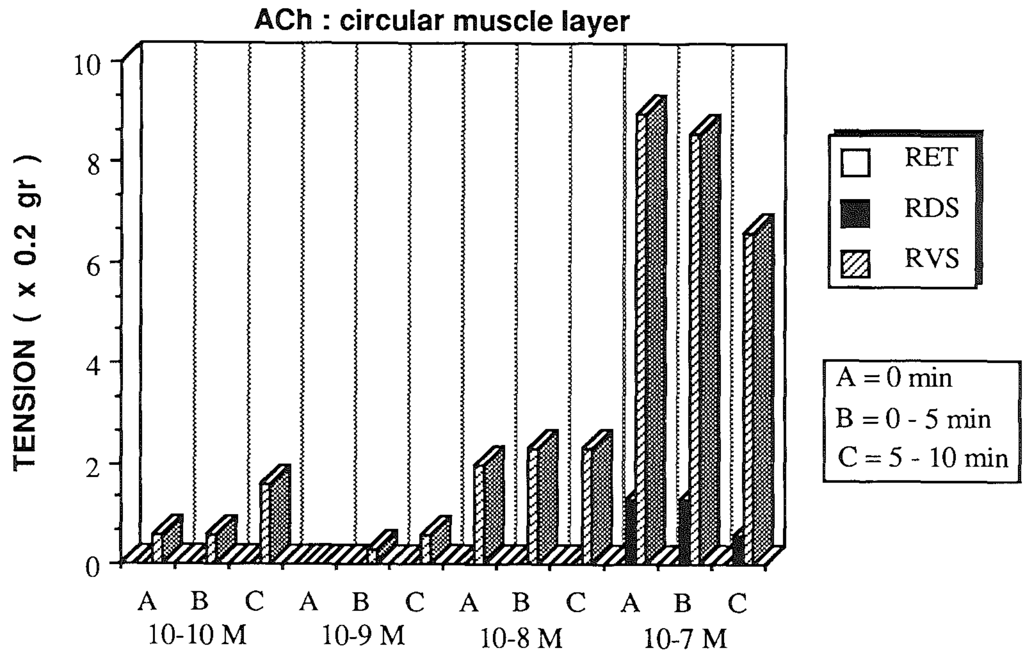


Fig. 19. Graphic representation of the in vitro effect of acetylcholine (ACh) on the circular muscle layer of the RET; RDS and RVS.

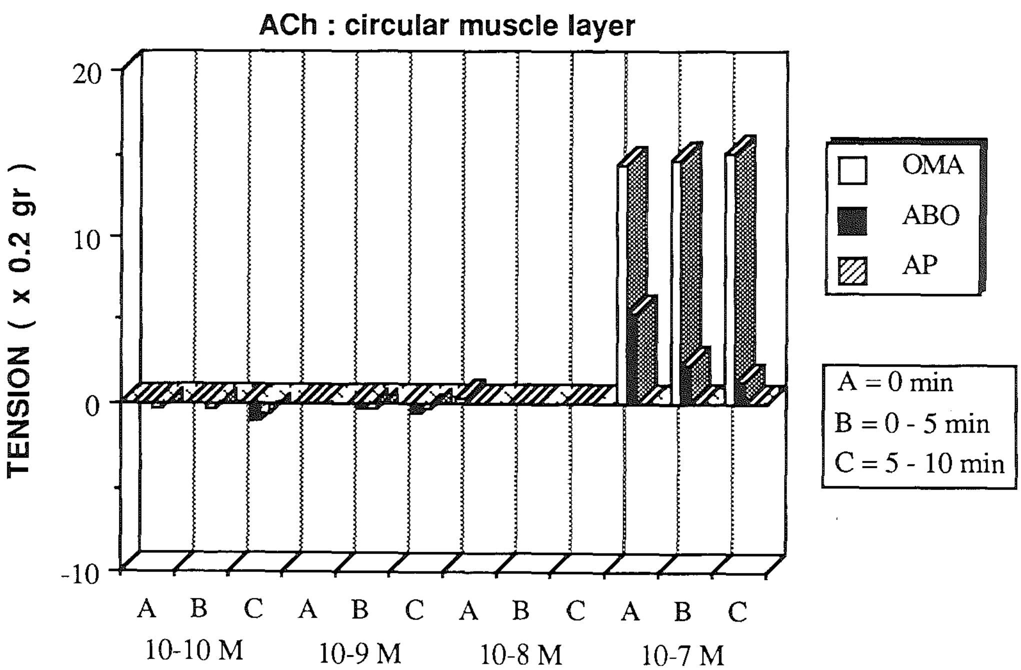


Fig. 20. Graphic representation of the in vitro effect of acetylcholine (ACh) on the circular muscle layer of the OMA; ABO and AP.

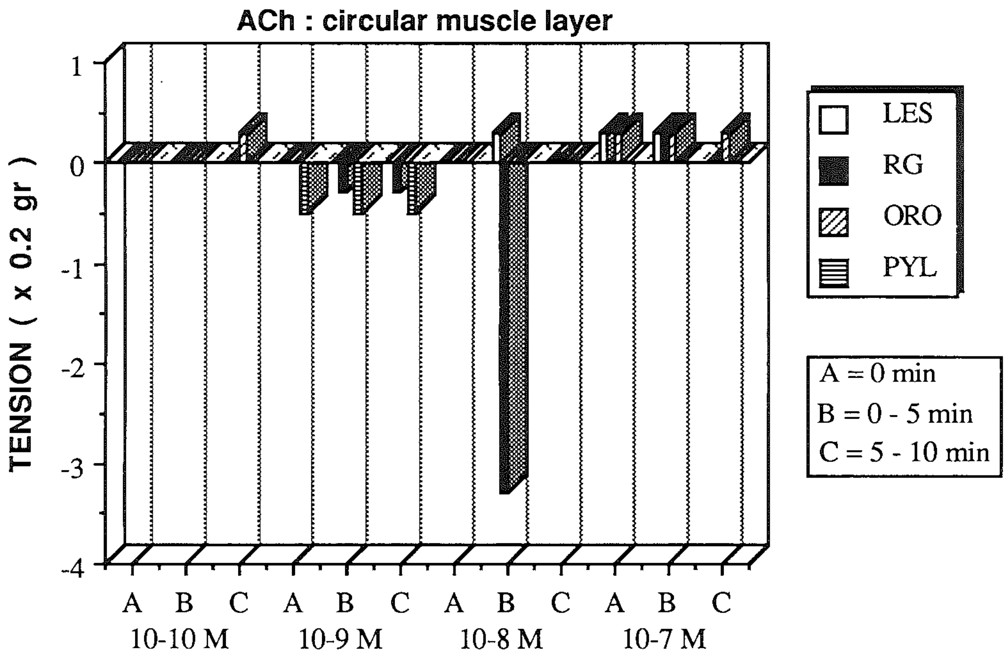


Fig. 21. Graphic representation of the in vitro effect of acetylcholine (ACh) on the circular muscle layer of the sphincters: LES; RG; ORO and PYL.

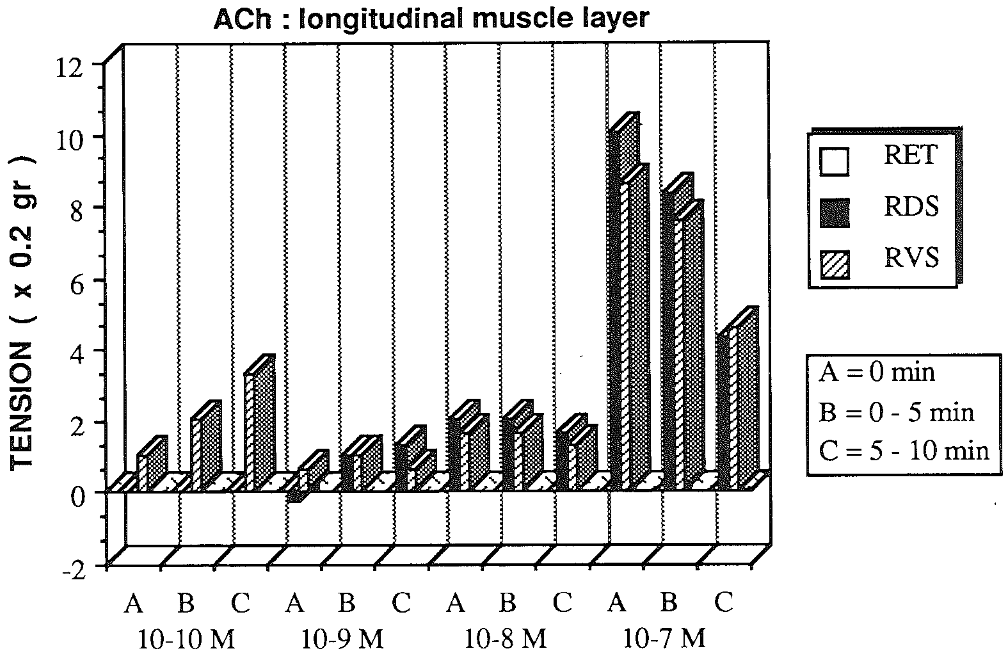


Fig. 22. Graphic representation of the in vitro effect of acetylcholine (ACh) on the longitudinal muscle layer of the RET; RDS and RVS.

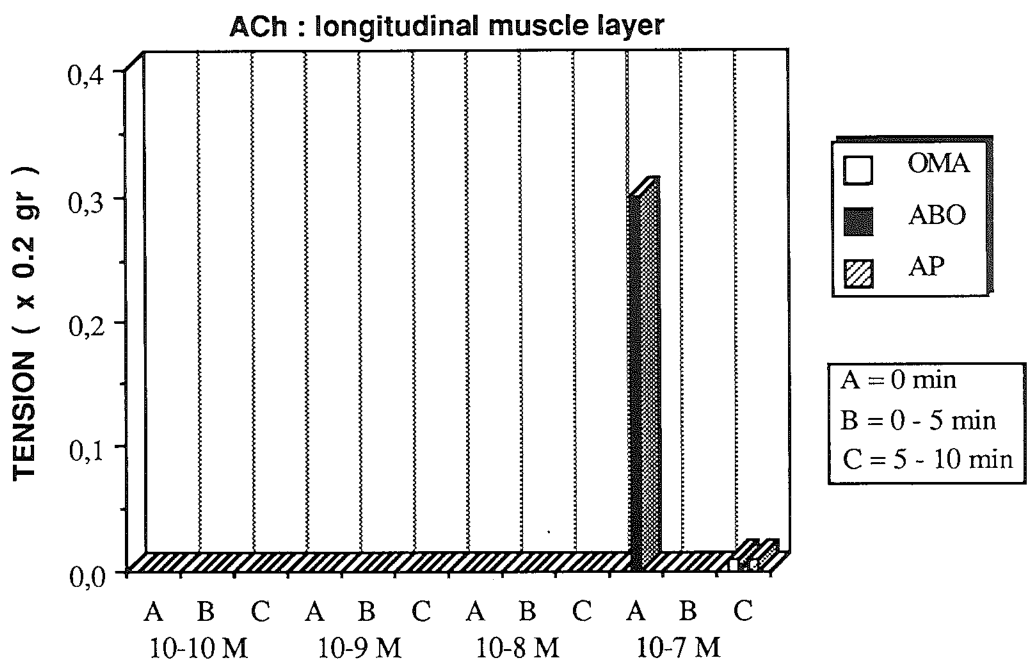


Fig. 23. Graphic representation of the in vitro effect of acetylcholine (ACh) on the longitudinal muscle layer of the OMA; ABO and AP.

NORADRENALINE (NA)

Photo 55. Abomasum
glyoxylic acid-induced fluoresence (GIF), whole mount preparation, adult sheep.
Magn. 284 x

1. non-reactive ganglion cell
2. pericellular noradrenergic network surrounding ganglion cell
3. varicose NA nerve fibre running in the internodal strand

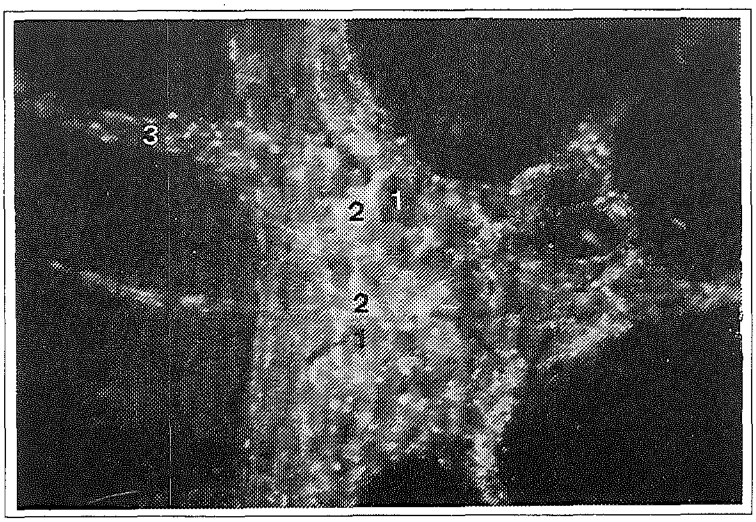
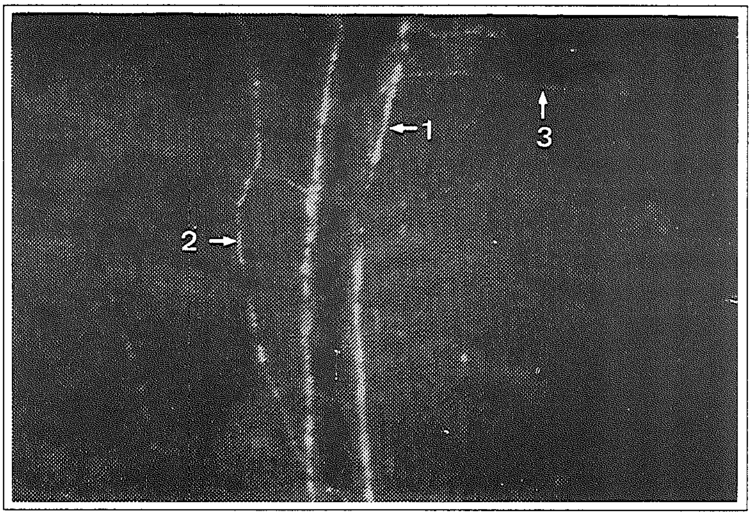


Photo 56. Antrum Pyloricum
glyoxylic acid-induced fluoresence (GIF), whole mount preparation, adult sheep.
Magn. 284 x

1. non-reactive ganglion cell
2. pericellular noradrenergic network surrounding ganglion cell
3. varicose NA nerve fibre running in the internodal strand

Photo 57. Antrum Pyloricum
glyoxylic acid-induced fluoresence (GIF), whole mount preparation, adult sheep.
Magn. 114 x

1. perivascular NA nervous network
2. paravascular nerve fibre
3. isolated NA nerve fibre in the circular muscle layer



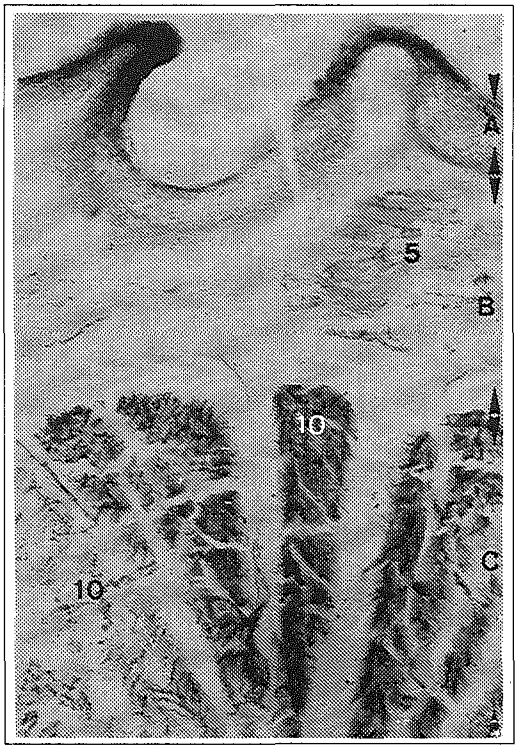


Photo 58. Reticular groove.
DBH, cryostat section (50 µm), foetus 26 cm. Magn.325 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

5. Parts of the lamina muscularis mucosae innervated by several DBH-IR nerve fibres
10. Intramuscular DBH-IR nervous network in the circular muscle layer

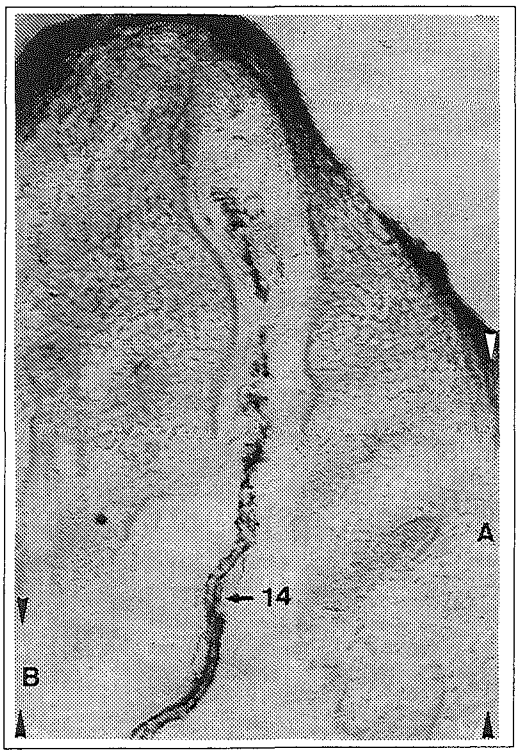


Photo 59. Reticular groove.
DBH, cryostat section (50 µm), foetus 26 cm. Magn.325 x

A. Tunica Mucosa
B. Tunica Submucosa

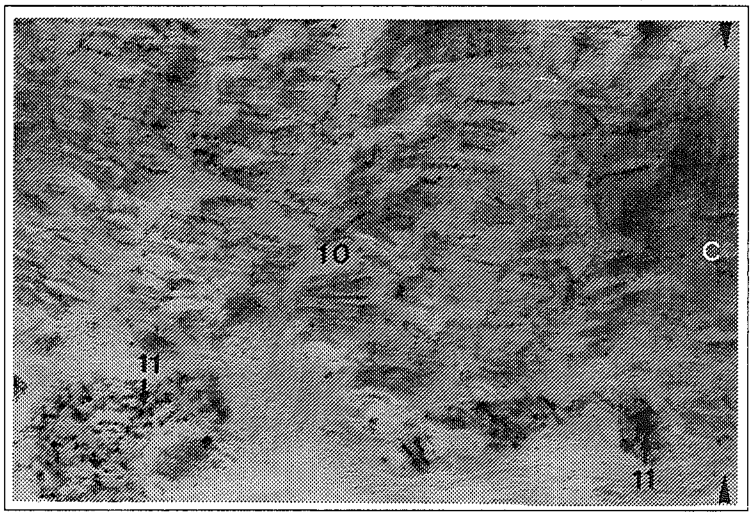
14. Perivascular DBH-IR plexus in a submucosal protrusion

Photo 60. Reticular groove.

DBH, cryostat section (50 µm), foetus 26 cm.
Magn.473 x

C. Tunica Muscularis

10. Intramuscular DBH-IR nervous network in the circular muscle layer
11. Plexus Auerbach: numerous DBH-IR nerve fibres surrounding non-immunoreactive ganglion cells



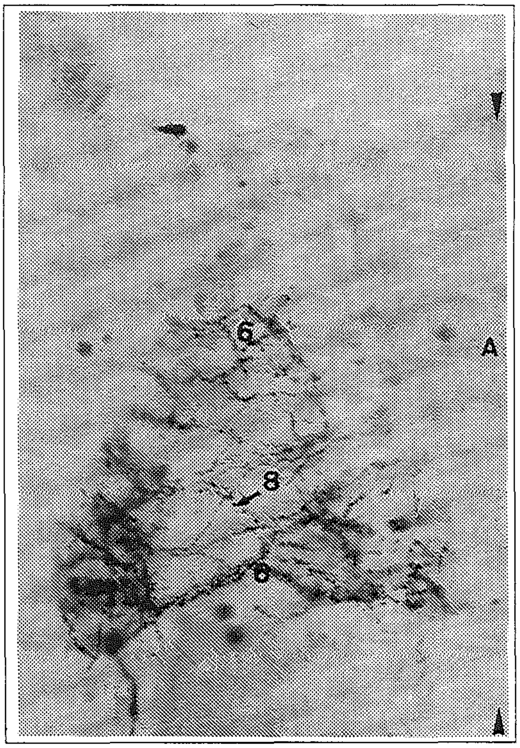


Photo 61. Reticulum.

DBH, cryostat section (50 μm), foetus 26 cm. Magn.473 x

A. Tunica Mucosa

6. Plexus submucosus: DBH-IR nervous network in a primary reticular fold
8. Delicate, varicose DBH-IR nerve fibre

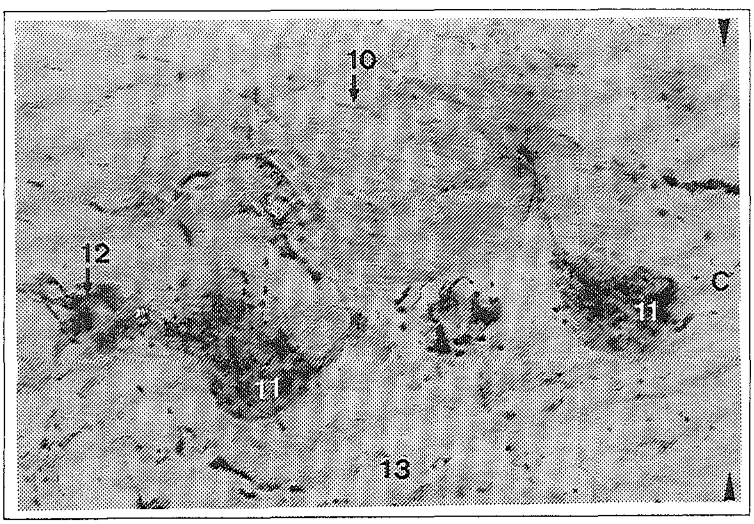


Photo 62. Reticulum.

DBH, cryostat section (50 μm), foetus 26 cm. Magn.473 x

C. Tunica Muscularis

10. Few, isolated, intramuscular DBH-IR nerve fibres in the circular muscle layer
11. Plexus Auerbach: DBH-IR nerve fibres surrounding non-immunoreactive ganglion cells
12. Interganglionic nerve bundle containing DBH-IR nerve fibres
13. Few, isolated, intramuscular DBH-IR nerve fibres in the longitudinal muscle layer

Photo 63. Ruminal Dorsal Sac.
DBH, cryostat section (50 µm), foetus 26 cm. Magn.372 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

6. DBH-IR nerve fibres in the primordium of the ruminal papillae
8. Isolated DBH-IR nerve bundle
10. Intramuscular DBH-IR nerve fibres in the circular muscle layer
11. Plexus Auerbach: DBH-IR nerve fibres surrounding non-immunoreactive ganglion cells
12. Interganglionic nerve bundle containing DBH-IR nerve fibres
13. Intramuscular DBH-IR nerve fibres in the longitudinal muscle layer
14. Perivascular DBH-IR nerve plexus

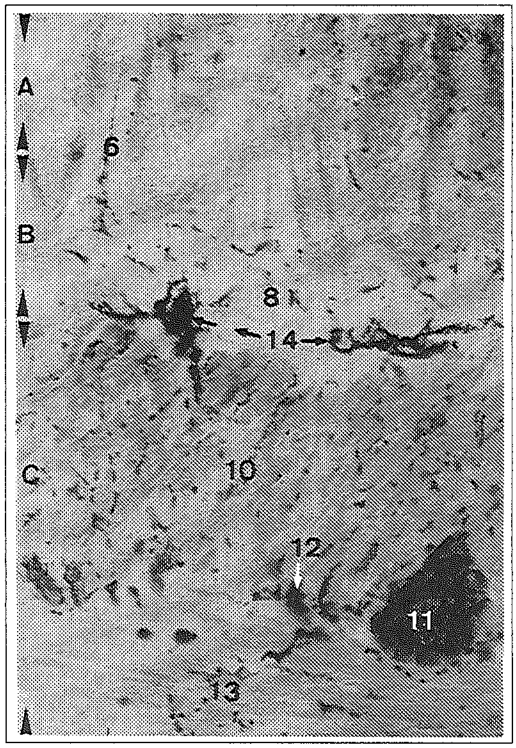
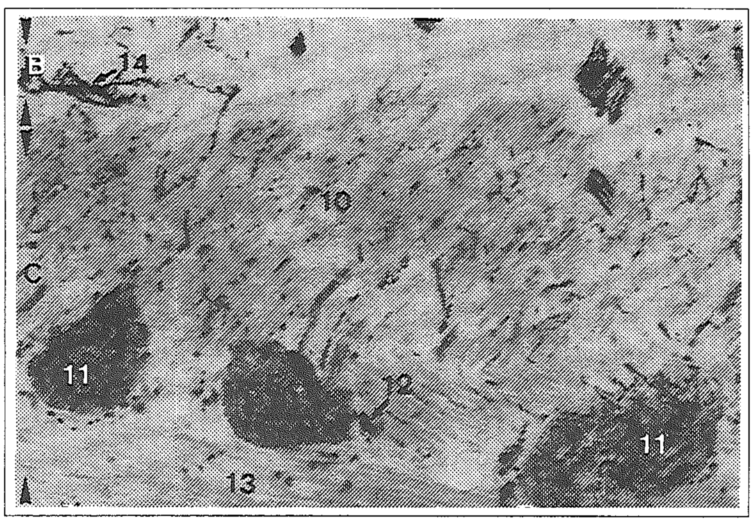


Photo 64. Ruminal Dorsal Sac.
DBH, cryostat section (50 µm), foetus 26 cm.
Magn.372 x

B. Tunica Submucosa
C. Tunica Muscularis

10. Intramuscular DBH-IR nerve fibres in the circular muscle layer
11. Plexus Auerbach: DBH-IR nerve fibres surrounding non-immunoreactive ganglion cells
12. DBH-IR nerve fibres in the nerve bundle leaving the ganglion
13. Intramuscular DBH-IR nerve fibres in the longitudinal muscle layer
14. Perivascular plexus



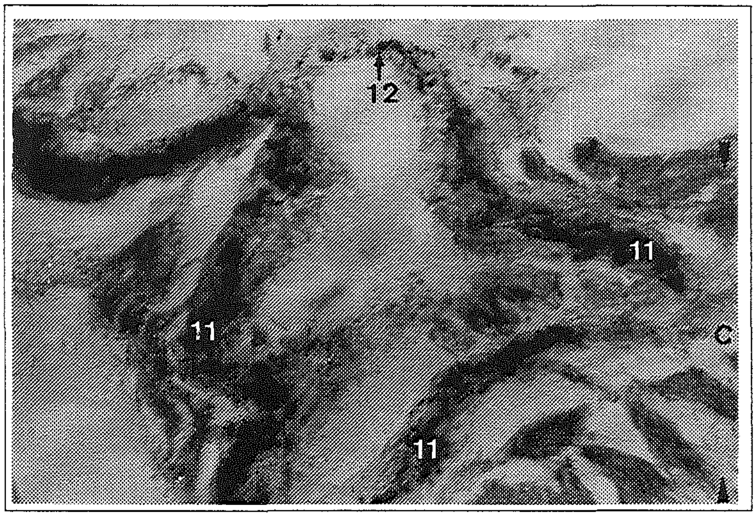


Photo 65. Antrum Pyloricum.

DBH, cryostat section (50 μm), foetus 26 cm.
Magn.925 x

C. Tunica Muscularis

11. Plexus Auerbach: numerous DBH-IR nerve fibres surrounding non-immunoreactive ganglion cells
12. Interganglionic nerve bundle containing DBH-IR nerve fibres

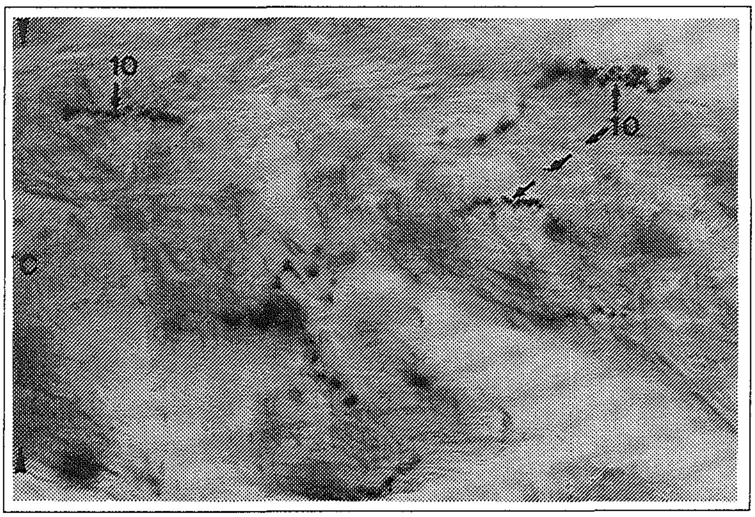


Photo 66. Antrum Pyloricum.

DBH, cryostat section (50 μm), foetus 26 cm.
Magn.1156 x

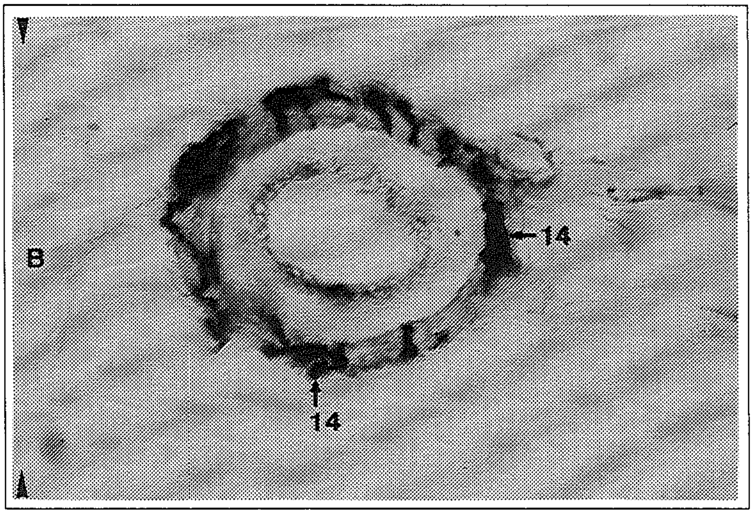
C. Tunica Muscularis

10. Isolated, intramuscular DBH-IR nerve fibres in the circular muscle layer

Photo 67. Antrum Pyloricum.
DBH, cryostat section (50 µm), foetus 26 cm.
Magn.1156 x

B. Tunica Submucosa

14. Dense perivascular DBH-IR nerve plexus



Cryostat sections

Adult sheep	RG	RET	RDS	RVS	OMA	ABO	AP	PYL
mucosa	-	-	-	-	+	+	+	+
submucosa	+	+	+	+	+	+	+	+
circul. muscle layer	+	+	+	+	+	+	+	+
Auerbach	++	++	++	++	++	++	++	++
longit. muscle layer	+	+(+)	+	+	-	+	+	+
Foetus								
mucosa	-	-	-	-	-	+	+	+
submucosa	+	+	+	+	(+)	+	+	+
circul. muscle layer	++	+	+	+	+	+	+	++
Auerbach	++	++	++	++	++	++	++	++
longit. muscle layer	+	++	+	+	-	+	+	++

Table 7. Distribution pattern of DBH-IR in the wall of the ruminant stomach of the sheep.

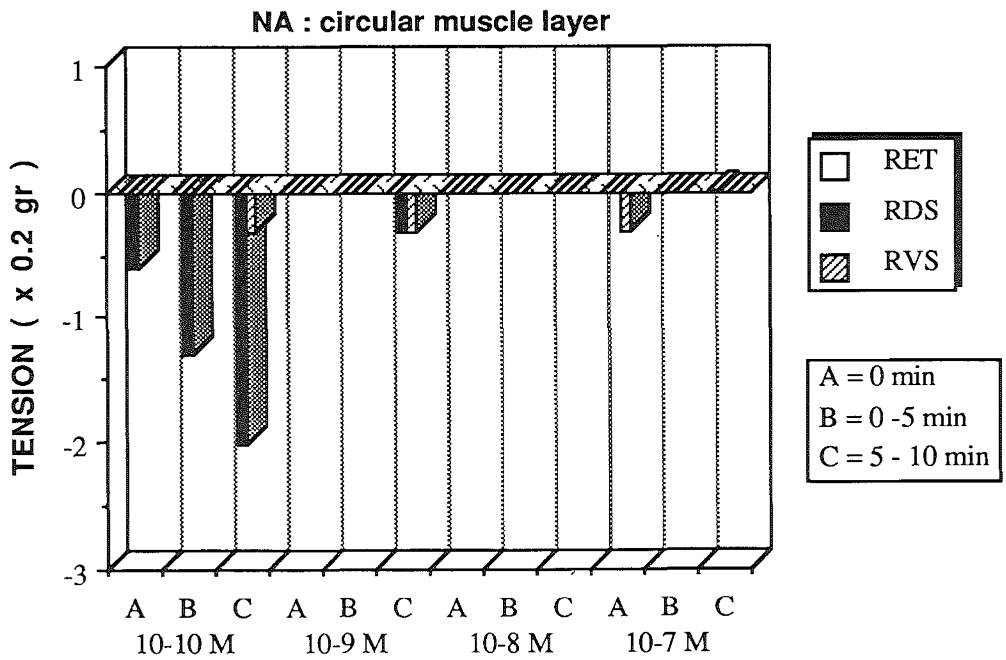


Fig. 24. Graphic representation of the in vitro effect of noradrenaline (NA) on the circular muscle layer of the RET; RDS and RVS.

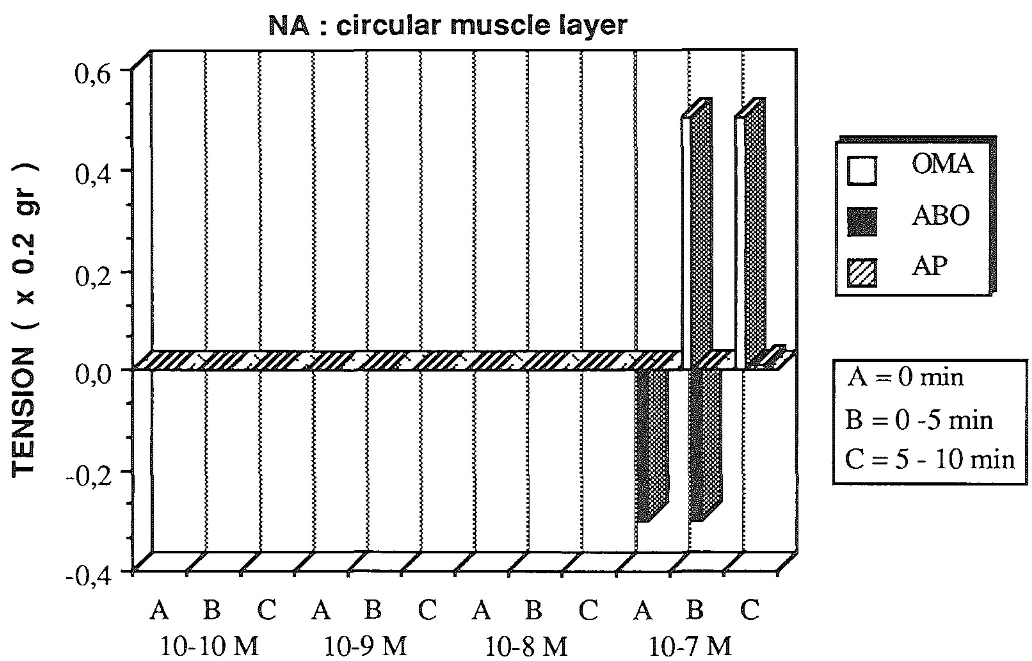


Fig. 25. Graphic representation of the in vitro effect of noradrenaline (NA) on the circular muscle layer of the OMA; ABO and AP.

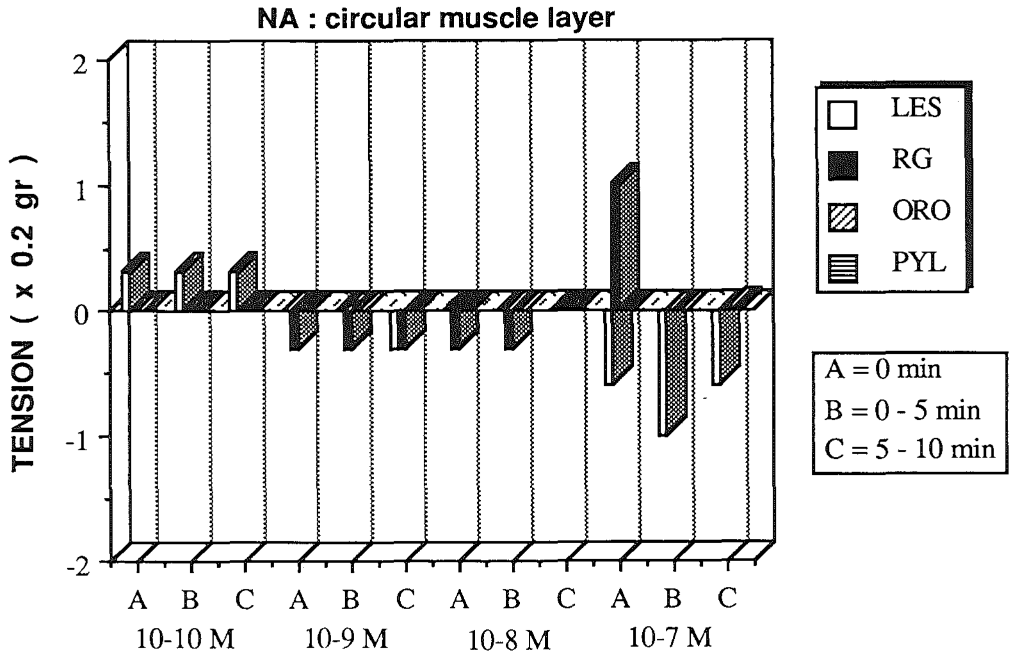


Fig. 26. Graphic representation of the in vitro effect of noradrenaline (NA) on the circular muscle layer of the sphincters: LES; RG; ORO and PYL.

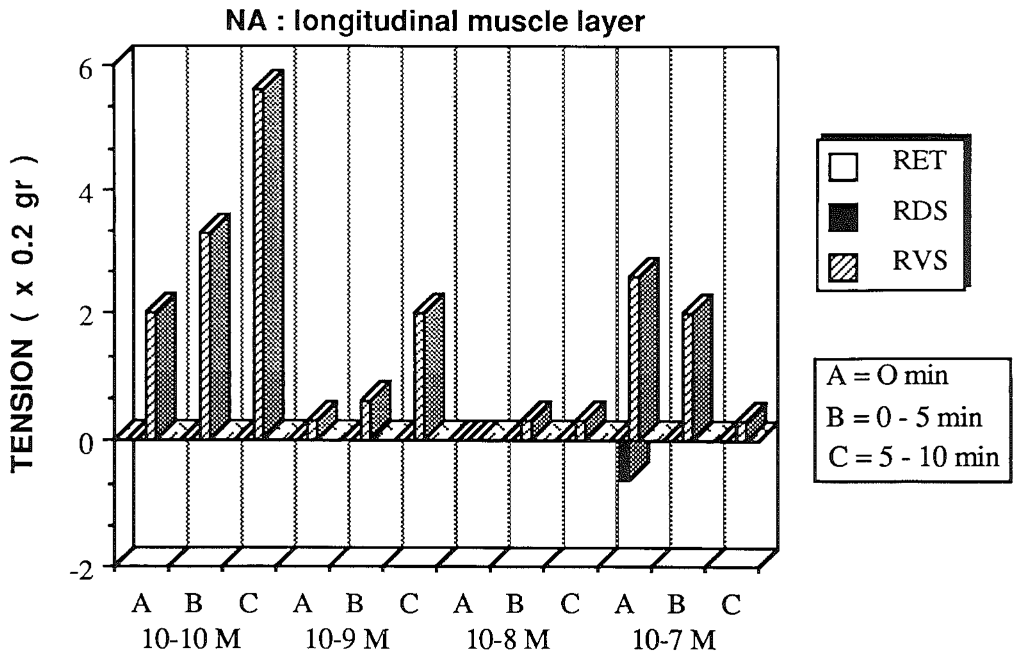


Fig. 27. Graphic representation of the in vitro effect of noradrenaline (NA) on the longitudinal muscle layer of the RET; RDS and RVS.

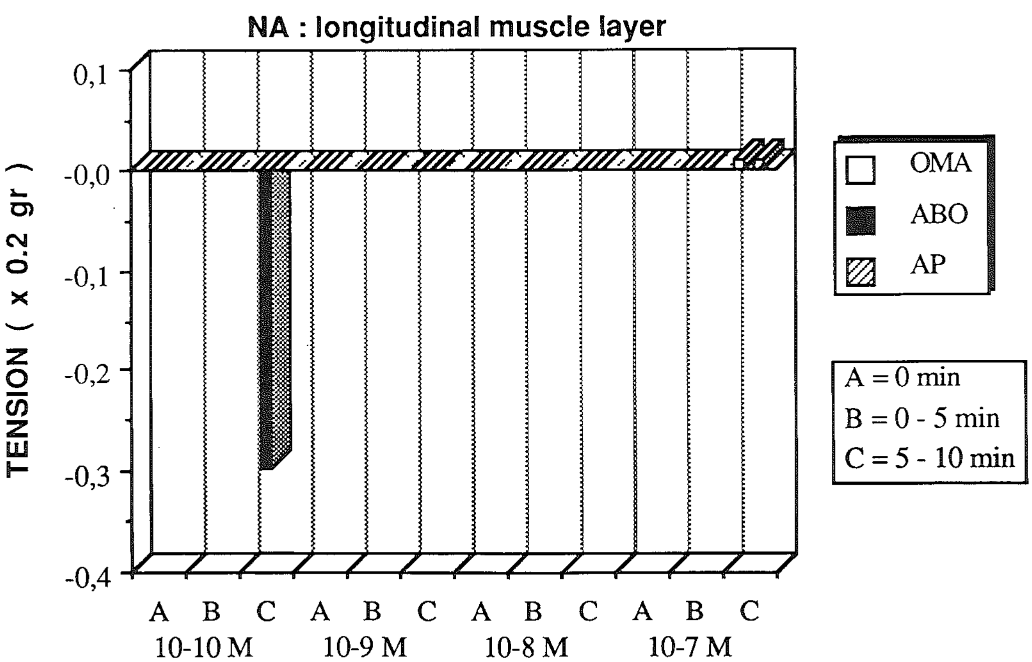


Fig. 28. Graphic representation of the in vitro effect of noradrenaline (NA) on the longitudinal muscle layer of the OMA; ABO and AP.

SEROTONIN (5-HT)

PRESENCE 5-HT in the gut epithelium

Enterochromaffin and enterochromaffin-like cells

SEGMENT	SPECIES	REFERENCES
* oral cavity in association with gustatory epithelia	frog; rabbit	see 545
* esophagus	bullfrog	545
* proventriculus	chicken	156
* stomach; small and large intestine	different species: chicken; mice; rat; guinea-pig; rabbit; cat; pig; horse; man; human foetus	see 110; 112; see 137; see 176; see 299; see 308; see 310; 315; 316; see 422; 433; 464; 465; 468; see 468; see 525; see 529; 550; 576; 594; 595; 596; 597; 598; see 633; 650;743; see 747; see 775; 782; 783; 784; 785
* possible co-storage with:		
- Sub. P - enkephalin - motilin - somatostatin - neurotensin	different species: rat; guinea-pig; cat; pig	19; see 110; see 299; see 310; 337; 433; see 468; see 515; 560; 589; 591; 611; 724; see 724
- histamine in mast cells gut mucosa		see 468
- bombesin	chicken	156
* gastrointestinal and peritoneal mast cells	rat and mice	see 310; see 747
* carcinoid tumours	man	see 134

PRESENCE 5-HT in neural elements

Neurons and nerve fibres

SEGMENT	LOCALIZATION	SPECIES	REFERENCES
* stomach; small and large intestine; gall-bladder	intramural plexuses (mainly myenteric plexus); immunoreactive neurons and nerve fibres	leech; trout mice; rat; guinea-pig; rabbit; cat	140; 176; 241; 276; 283; 288; 290; see 461; 468; see 468; see 659; 747

* intestine (small and large)	enteric neurons (high affinity uptake mechanism for L -tryptophan)	leech; fish lower vertebrates birds rat; guinea-pig other species including man; human foetus	see 110; see 461 see 23; see 110 see 110 see 193; 277; 285; see 468; see 756 see 110; 308; see 567; 681
	myenteric neurons (synthesize 5-HT from L -tryptophan)	guinea-pig; rabbit	181; see 193; 659; see 791
	myenteric neurons small intestine only	toad	23
	intramural plexuses (high affinity uptake mechanism for ^{3}H-5 HT)	guinea-pig rabbit other species	180; 181 743 see 110; see 193; see 310; see 576; see 659
	tryptophan hydroxylase present in muscle layer suggesting the presence of 5-HT neurons	rat	464
	in nerve fibres myenteric plexus; in muscle layer intestine	toad	23
	in myenteric plexus (5-HT stored and released together with serotonin binding protein (SBP))	guinea-pig other species	see 110; 276; 277 see 137; see 281; see 659
	co-existence with Sub. P in enteric neurons	guinea-pig	see 468; see 515
* foetal stomach and intestine	immunoreactive neurons and nerve fibres in both plexuses; immunoreactive fibres in internodal strands; in wall some small mesenteric blood vessels outside intestine	sheep man	817; 818 308
* vagal nerve	serotoninergic system in vagal afferents	cat	271
* (brain)	SBP in central 5-HT neurons	rat	281; see 281; 734; 735

Note
In some species 5-HT localized in mast cells 596

RELEASE 5-HT

Mucosal pool (= entero-endocrine cells)

Stimuli from mucosal side

STIMULUS	REFERENCES
* food intake	92; 213; 226; see 515; 525
* change in intraluminal pH	225; see 422; 423; 424; 426; see 515; 550; see 576; 600; 633
* intraluminal perfusion	see 310
* increase in intraluminal pressure	12; 96; 101; 102; 179; 599; see 600
* peristalsis	99; 100; 101; 102; 747
* hypertonic glucose	179; see 225; 550; 599; 749
* mechanical stimulation	189; see 529
* absorbable fat	747
* application catecholamines; acetylcholine	102; 600; 602
* cholera toxin	561; 562
* mechanical obstruction small bowel	see 747
* autotransplantation small bowel	see 747
* pyloroplasty with or without vagotomy	299; see 747

Note.
small quantities 5-HT continuously released into lumen

| 96; 97; 570

Stimuli from serosal side

STIMULUS	REFERENCES
* transmural electrical stimulation (blocked by tetrodotoxin)	see 576; 600
* scratching serosal surface	101
* vagal nerve stimulation (via vagal adrenergic fibres)	8; 10; 11; 12; 101; 102; see 110; 213; 275; see 310; see 422; 425; 451; 454; 468; see 468; see 525; see 576; 601; see 724; 737; 747; 749
* splanchnic nerve stimulation	12; 101; 102; see 299; see 310; 451; 454; 456; see 468; 549; see 576; 737; 749
* intra-arterial infusion of nicotine; morphine; catecholamines; ACh; motilin	98; 99; 100; 101; 102; 422; 748
* vagotomy	see 749

Intramural neural pool

* electrical stimulation (vagal nerve; myenteric plexus) transmural electrical stimulation.	see 180; see 193; 276; 283; see 576

Note
noradrenaline blocked release of ^{3}H 5-HT from the enteric nervous system through action on alpha receptors

	see 110

EFFECTS OF 5-HT

Motility

EFFECT	SEGMENT	SPECIES	REFERENCES
* contraction smooth muscle	esophagus	guinea-pig	279; 410; see 747
		opossum	see 576
	stomach	rat	272; 468; 732
		cat	468
	jejunum	guinea-pig; rabbit	97; see 422
		dog	see 576
	ileum	guinea-pig	97; see 515
	small intestine	mouse	see 515
		dog	439; 692
		man	see 515; 535
	colon	horse	687
		man	151
by blocking c-AMP inhibiting effects	small intestine	dog	312
direct (smooth muscle) and indirect (neural) excitatory effect	small intestine	dog	98
	colon	man	see 576
direct effect (D-receptors)	esophagus	opossum	see 576
	stomach	cat	468
	duodenum	mouse	178
	Oddi sphincter	cat	see 576
	ileo-caecal sphincter	cat	see 576
indirect			
via cholinergic pathway	esophagus	opossum	see 576
	ileum	guinea-pig	4; see 468; see 576; 747
via induction release Sub. P from myenteric plexus	ileum	guinea-pig	see 52; see 55
	colon	guinea-pig	791
action on 2 separate receptors	fundus and antrum; intestine	guinea-pig; cat	see 468; 537; 579
- nerve cells (M-receptors)	stomach	rat	178; see 541; see 627
- smooth muscle cells (D-receptors)			

followed by relaxation ("fade")	ileum	guinea-pig	375
tachyphylaxis of 5-HT on nerve and direct mediated effects	small intestine; colon	guinea-pig	145
acts indirectly through inhibitory and excitatory neurons (M-receptors)	esophagus duodenum	opossum mouse	see 576 178
* participate in response intestine to morphine and related agents	intestine	dog	100
* regulates MMC	small intestine	dog pig sheep	see 576; 652 652 see 652
* induction short contractions; decreases primary and secondary contractions	forestomach	sheep	653
* inhibition extrinsic reticulo-rumen contractions	forestomach	goat	704
* increases eructation rate; reflex inhibition normal cyclic contraction	forestomach	goat	762
* direct stimulatory action on smooth muscle fibres; participates in genesis spontaneous movements foetal rumen	rumen	bovine foetus	40
* relaxation (receptive relaxation stomach)	fundus and antrum	guinea-pig	see 308; 537; see 576
longitudinal muscle layer	colon	man	151
after 5-HT IV infusion	colon	man	535
* changes in motility stimulation	stomach and intestine	# species including man	194; see 310; 535; 630

hypermotility in carcinoid syndrome	small intestine	man	176; 535
increase volume fluid transport	ileum jejunum	guinea-pig; rabbit	97
depression of motility in carcinoid syndrome (hypomotility)	colon	man	177; 535
decreases motility	stomach and colon	man	535
* modulation peristalsis; involved in descending suppression of vagal excitation	gut	mammals	274
by action on mucosal sensory receptors	jejunum ileum	rabbit guinea-pig	99 97
possible role in initiating peristaltic reflex	ileum	guinea-pig	96; 101; see 310
involved in ascending excitatory neural path-way	distal colon and rectum	guinea-pig	148
inhibition peristalsis due to blockade in the myenteric plexus	ileum	guinea-pig	568
regulation peristalsis	intestine	guinea-pig rabbit # species	see 630 see 630 see 96; 97; see 101; see 194; see 468
neurotransmitter role between sensory and motor neurons in the peristaltic reflex	small intestine	mouse	280
decreases intraluminal pressure threshold for peristaltic reflex	intestine	man	535
* inhibits cholinergic excitatory neurons for smooth muscle	proximal colon	rabbit	402
* prevents presynaptic release ACh in myenteric ganglia	small intestine	guinea-pig	see 567; see 576; 795

* neurotransmitter in intrinsic inhibitory and excitatory enteric neurons	stomach small intestine	 mouse guinea-pig	see 110 178 93; see 180; see 276
* participates in vagal inhibitory pathway			see 276
production of slow EPSP myenteric neurons (type 2/AH)	small intestine	guinea-pig	see 110; 193; see 193; 327; see 327; see 468; see 576; 768; see 768; see 794; 800; 801; 802
* depolarizes cultured myenteric neurons	caecum	guinea-pig	327; see 327
* depolarizes neurons submucous plexus (5-HT neurotransmitter in plexus submucosus)	small intestine colon	guinea-pig	145
* stimulation mucosal afferent nerve endings; excitatory and inhibitory ganglion cells	review		279; see 747
* regulation cholinergic transmission in general	lumbar sympathetic ganglia; sciatic nerve	bullfrog; frog	341
* activates afferent elements of mesenteric nerves in the submucosa	duodenum	rat	559
* neurotransmitter in enteric interneurons	ileum and colon	guinea-pig	145; see 468; see 576; see 659; see 791
* excites intramural neuronal elements	small and large intestine	rat; guinea-pig	see 55; 663
* causes release ACh from myenteric ganglion cells	ileum	guinea-pig	4
* transmitter in NANC inhibitory nerves of the gut; acts on post-ganglionic cholinergic nerve fibres	review		see 659; see 747
involved in contractile action of CCK	colon	guinea-pig	791

* activates specific receptors at intramural parasympathetic ganglion cells	ileum	guinea-pig	93
* inhibition synaptic transmission in sympathetic ganglia by reducing evoked release ACh	superior cervical ganglion	rabbit	183
* increases release excitatory transmitters	nerve terminals	lobster	298
* decreases affinity ACh to nicotine receptors	sympathetic ganglia	bullfrog	14
* induces long term metabolic changes in nerve terminals	nerve terminals	lobster	298
* alters metabolism catecholamines	review		see 747
* inhibition AChE	striatum	rat	570

Secretion and Absorption

EFFECT	SEGMENT	SPECIES	REFERENCES
* inhibition gastric secretion	stomach	rat dog	see 576 see 515; see 576
* stimulation secretion (directly or via mucosal sensory neurons or intramural nervous reflex(es) in which VIP may be involved)	small intestine	cat	see 310; 561
* increases net water and electrolyte secretion	intestine	rat rabbit dog	see 264; see 525; see 576 see 515; see 525; see 576 525; see 525
stimulates ileal secretion; depresses midjejunal absorption H_2O and electrolytes	small intestine	rabbit	177; see 264
decreases net Na^+ and Cl^- absorption	colon	rat	see 137; see 576
stimulates Cl^- secretion	ileum	rabbit	see 137
* stimulates mucus production	intestine	rat	see 576
* high doses 5-HT cause:			
gastric acid secretion	stomach	# species	see 743; see 747
inhibition pentagastrin-induced acid secretion	stomach	rat	see 299; see 576; 664
inhibition histamine-induced acid secretion	stomach	dog	see 576
basal gastric juice volume acid and pepsin output	stomach	rat	see 747
basal and induced gastric acid secretion	stomach	dog	see 747
mucus production; secretion and pepsin output	stomach	dog man	576; see 576 see 747

biphasic effect on pepsin secretion	stomach	guinea-pig	see 747
* involved in diarrhoea induced by cholera toxin	small intestine	rat; cat	562; see 576
* mediator in diarrhoea in amoebiasis	intestine		see 576
* water resorption	gut	# species	see 630
* in carcinoid syndrome (5-HT changes intestinal water and electrolyte transport).	small intestine	rabbit man	see 176; 177 see 134; see 137
* stimulates secretion from salivary glands	salivary glands	# species	see 747
* stimulates exocrine pancreatic secretion	pancreas	dog and other species	see 515
* inhibition bile flow	gall bladder	# species	see 515

Blood Flow

EFFECT	SEGMENT	SPECIES	REFERENCES
* constriction gastric and colonic vein and artery (arteries less sensitive)	stomach and colon	dog; man	309; see 529
* contraction saphenous vein	saphenous vein	dog	378
* vasoconstriction	intestine	# species	see 529; see 576; see 630
* reduces mucosal blood flow	gut	# species	see 747
* involved in vasomotor component of dumping syndrome	small intestine	dog	179; see 747
(cfr. basic defect in dumping is abnormality in distribution; binding and release of 5-HT)			
* vasodilation due to: - central neural reflex - stimulation beta-adrenoreceptors - inhibition transmitter release from adrenergic nerve endings - activation NANC nerves - direct action on vascular smooth muscle - attenuation smooth muscle responsiveness to adrenergic innervation			see 529
* vasodilation	intestine	cat other species	see 525; see 576 see 299; see 529
* increases capillary permeability		cat	see 576

MISCELLANEOUS

EFFECT	SEGMENT	SPECIES	REFERENCES
* decreases protein synthesis	intestine	rat	494
* modulates uptake; storage or release gastrointestinal polypeptide hormones	review		313; see 515; see 747
* proliferation of the gastrointestinal epithelium	review		see 310; 313
* 5-HT transmitter in some autonomic nerves of the gut.	review		see 104; 247
* vagotomy and pyloroplasty decreased 5-HT levels	upper intestine	rat	see 299
* 5-HT favours development gastric ulcers		rat	209
* 5-HT acts at receptors on enterocytes or on neurons innervating these cells			see 137
* intraluminally evoked effects of 5-HT abolished by: - removal of the mucosa - topical application anesthetics and tetrodotoxin			see 310

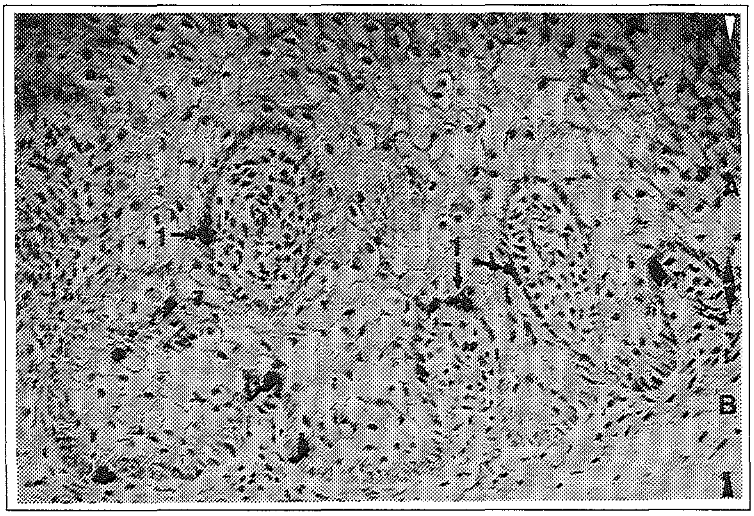


Photo 68. Reticulum.
5-HT, paraffin section (5 µm), foetus 37 cm.
Magn.422 x (interference contrast)

A. Tunica Mucosa
B. Tunica Submucosa

1. 5-HT-IR epithelial cells in the stratum germinativum of the primordia of the reticular folds

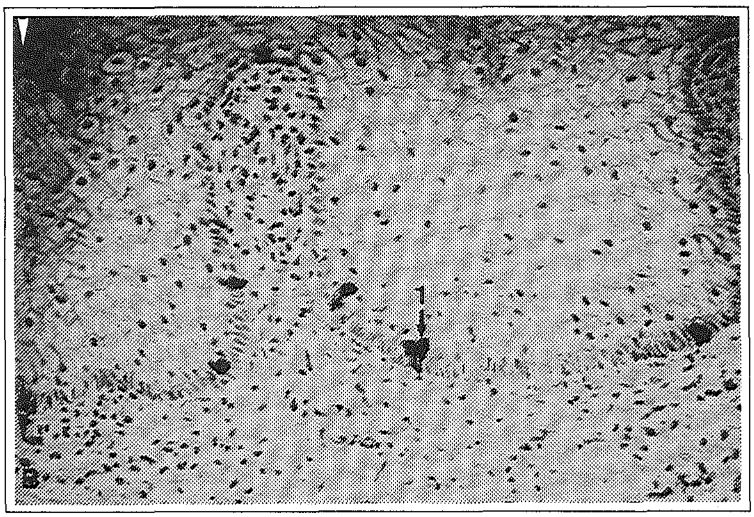


Photo 69. Ruminal Dorsal Sac.
5-HT, paraffin section (5 µm), foetus 37 cm.
Magn.422 x (interference contrast)

A. Tunica Mucosa
B. Tunica Submucosa

1. 5-HT-IR epithelial cells in the stratum germinativum of the primordia of the ruminal

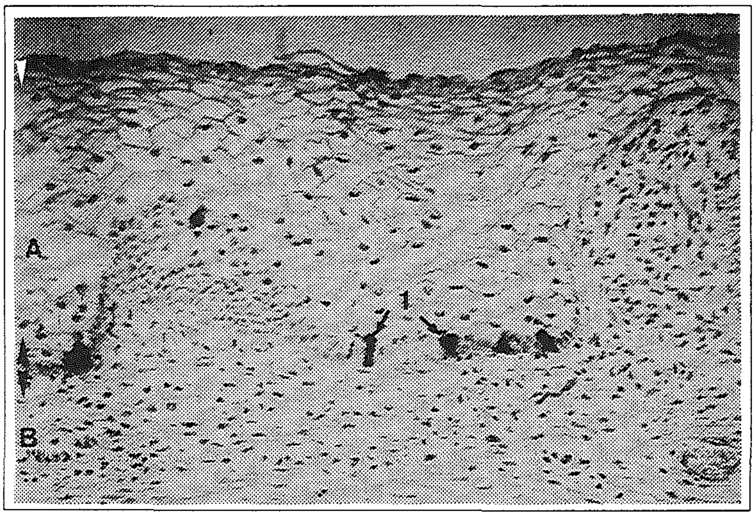


Photo 70. Ruminal Ventral Sac.

5-HT, paraffin section (5 μm), foetus 37 cm. Magn.422 x (interference contrast)

A. Tunica Mucosa
B. Tunica Submucosa

1. 5-HT-IR epithelial cells in the stratum germinativum

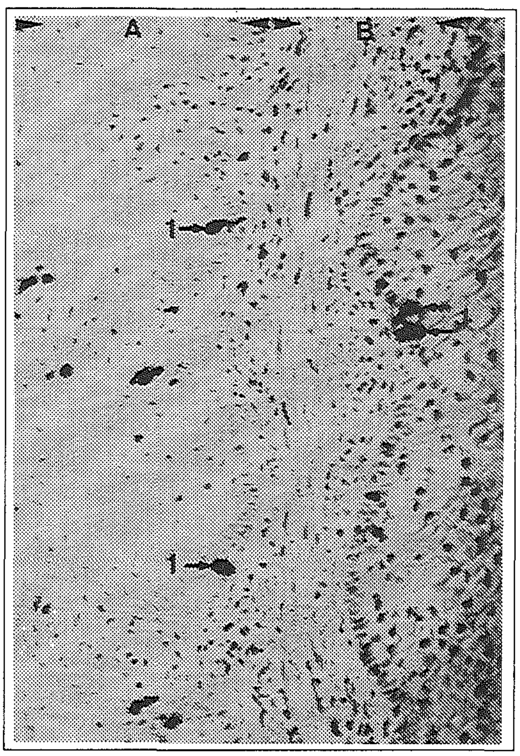


Photo 71. Omasum.

5-HT, paraffin section (5 μm), foetus 37 cm. Magn.422 x (interference contrast)

A. Tunica Mucosa
B. Tunica Submucosa

1. 5-HT-IR epithelial cells in the stratum germinativum of a primary omasal leaf

Photo 72. Abomasum.

5-HT, paraffin section (5 µm), counterstain 1% cresyl violet, foetus 37 cm. Magn.422 x

A. Tunica Mucosa
B. Tunica Submucosa

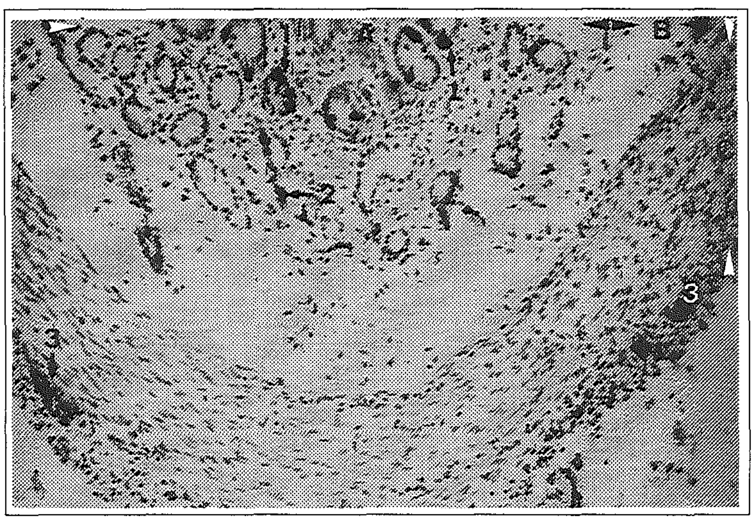
1. 5-HT-IR epithelial cells

Photo 73. Duodenum.

5-HT, paraffin section (5 µm), counterstain 1% cresyl violet, foetus 37 cm. Magn.262 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

1. 5-HT-IR epithelial cells in the crypts of Lieberkühn
2. 5-HT-IR epithelial cells at the onset of the Brunner glands
3. 5-HT-IR in Auerbach's plexus



Segment / Length	14	26	37
RET	+	+	+
RDS	+	+	+
RVS	+	+	?
OMA	?	+	+
ABO	+	+	+
AP	?	?	?
PYL	-	-	-

Lamina / Length	14			26			37		
	Duodenum	Jejunum	Ileum	Duodenum	Jejunum	Ileum	Duodenum	Jejunum	Ileum
Epithelium	+	+	+	+	+	+	+	+	+
Lam. Propria	-	-	-	-	-	-	-	-	-
Lam. M. Muc.	-	-	-	-	-	-	-	-	-
Submucosa	-	-	-	-	-	-	+	+	-
Circ. M. Layer	-	-	-	-	-	-	-	-	-
Auerbach	?	?	?	?	-	-	+	+	-
Long. M. Layer	-	-	-	-	-	-	-	-	-

Duodenum
Jejunum
Ileum

+ = 5-HT-IR
? = weak 5-HT-IR
- = no 5-HT-IR

Table 8. Distribution pattern of 5-HT-IR in the wall of the ruminant stomach and small intestine of the foetal sheep.

Segment	Adult	Foetus
RG	-	+
RET	-	+
RDS	-	+
RVS	-	+
OMA	-	+
ABO	+	+
AP	+	+
PYL	-	-

Table 9. Presence of 5-HT-IR epithelial cells in the wall of the ruminant stomach of the sheep.

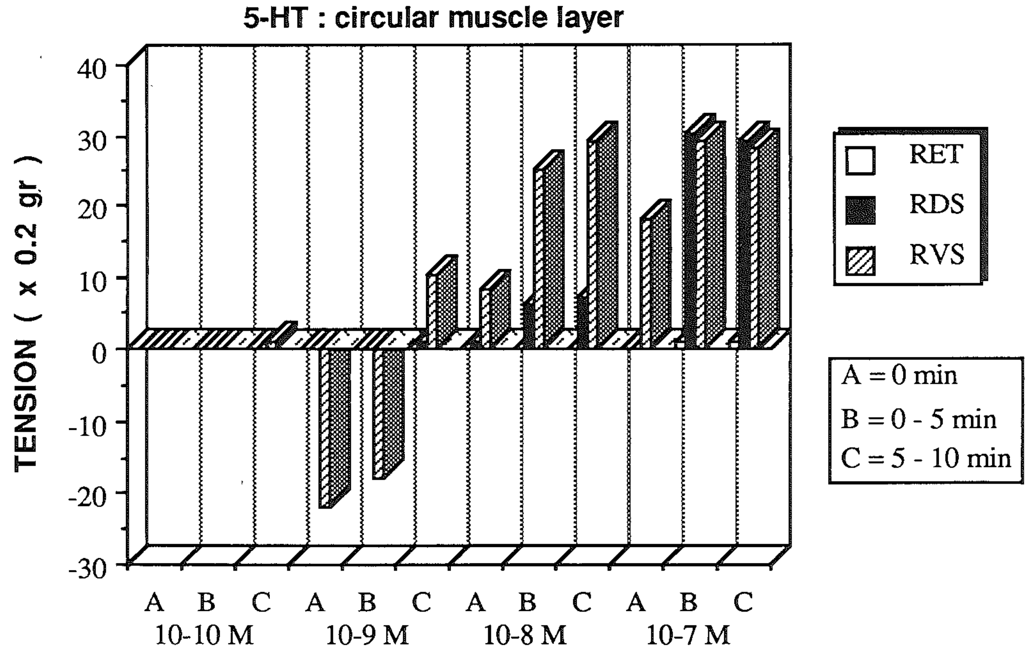


Fig. 29. Graphic representation of the in vitro effect of serotonin (5-HT) on the circular muscle layer of the RET; RDS and RVS.

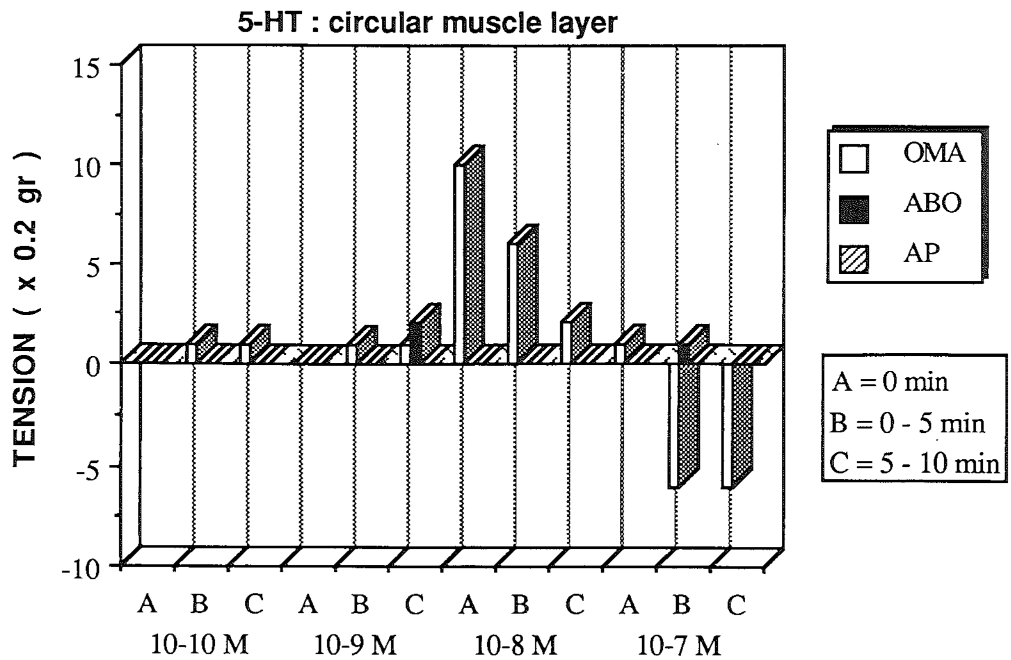


Fig. 30. Graphic representation of the in vitro effect of serotonin (5-HT) on the circular muscle layer of the OMA; ABO and AP.

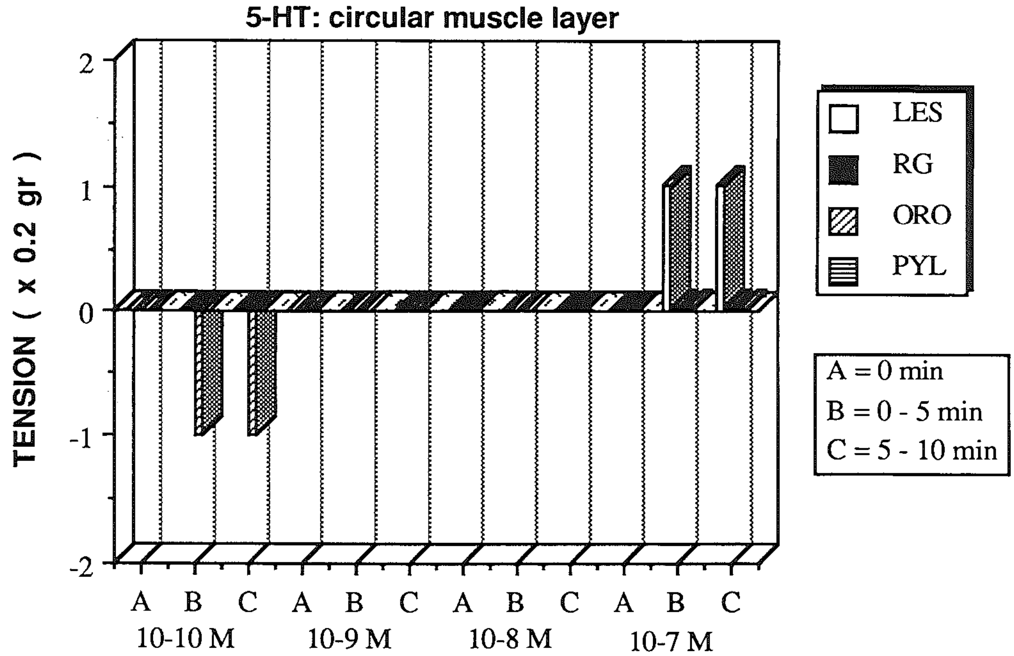


Fig. 31. Graphic representation of the in vitro effect of serotonin (5-HT) on the circular muscle layer of the sphincters: LES; RG; ORO and PYL.

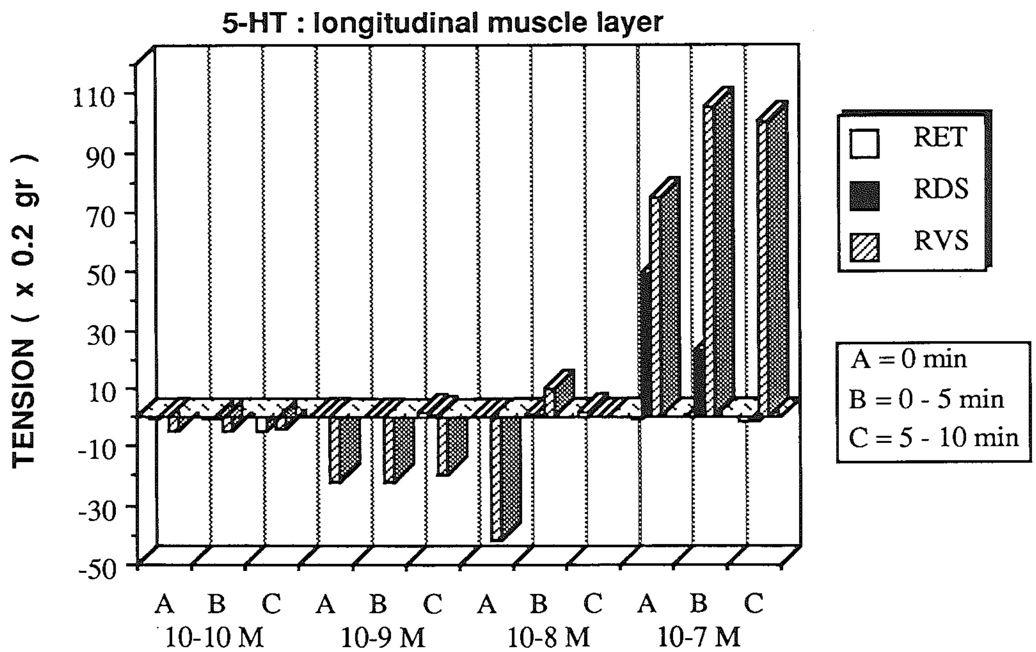


Fig. 32. Graphic representation of the in vitro effect of serotonin (5-HT) on the longitudinal muscle layer of the RET; RDS and RVS.

VASOACTIVE INTESTINAL POLYPEPTIDE (VIP)

PRESENCE of VIP in the gastrointestinal tract.

SEGMENT	LOCALIZATION	SPECIES	REFERENCES
* esophagus muscle layer	circular and longitudinal	rat; guinea pig; cat; pig; foetal pig; sheep; foetal sheep; man; human foetus; mammals	22; 198; 201; 203; 240; 324; 330; 406; see 605; 678; 755; 775; see 776
	neuronal structures myenteric plexus	foetal sheep	776
	VIP nerves destroyed in diabetes	rat	431
	VIP nerves absent in achalasia	man	see 5; see 660
	immunoreactive epithelial cells	cat; man (foetus)	351
* LES	circular muscle layer; plexus myentericus	rat; guinea-pig; cat; pig; man	see 5; 22; 67; 203; 240; see 325; 645; 755
* forestomach	muscle layer; myenteric plexus	sheep foetal sheep	332; 775 330; 776; see 776
* stomach	both muscle layers; both plexuses; lamina propria	leech; cods; chicken; mice; rat; guinea-pig cat; dog; sheep; man foetal sheep	22; see 118; 185; 203; 215; 240; 325; 332; 394; 405; 455; 458; 461; 518; 533; see 606; see 615; 678; see 680; see 683; 723; 775; see 810 331; see 373; see 659; 776
	VIP nerves increased in diabetes	rat	431
* pylorus	both muscle layers; plexus myentericus	cat; man sheep foetal sheep	185; 203; 240; see 325; 539 332; 775 330

* intestine (small and large)	both muscle layers; both plexuses; lamina propria	leech; mice; rat; guinea-pig; cat; dog; pig; sheep; foetal sheep; human foetus; man	see 20; 22; 42; 47; see 55; see 59; 71; 74; see 110; see 118; 138; 171; 185; 200; 203; 215; see 222; 240; see 246; 248; see 248; 325; 330; 332; 351; see 373; 374; see 374; 394; 405; 416; 417; 418; 421; 449; 458; 461; 463; 518; 533; see 542; see 567; see 583; 592; 605; see 606; 612; see 615; see 659; see 660; 677; see 677; 678; see 678; see 680; 681; see 681; see 723; 775; see 775; 776; see 776; see 794; see 810
	in neurons co-existence with NPY and PHI	man	70; see 660
	in small intestine VIP nerves and neurons increased in diabetes	rat	109; 431
	in large intestine VIP nerves absent in diabetes	rat	431
	VIP nerves lacking or much reduced in Hirschsprung's; Chagas' disease and colon cancer; Grass Sickness in horse	mice; rat; horse; man	see 373; 430; see 430; 431; see 431; see 606; see 615; 648; see 648; see 660; 804
	VIP nerves reduced in chronic constipation	man	434; see 606
	VIP nerves thickened; disorganized and extremely immunoreactive in Crohn's disease and ulcerative colitis	man	see 606; 615; see 615
	immunoreactive epithelial cells	quail; dog; pig; baboon	see 20; 619; see 775
* gallbladder	muscle layer and blood vessels	cat sheep	78; see 78; 726 775
* blood vessels	immunoreactive fibres in wall intramural blood vessels	rat; guinea-pig; cat; mammals	211; 269; see 269; 678; 723
* immunoreactive fibres in peripheral nerves (vagal and sciatic nerve)		man	489; see 660; 661
* glands	salivary glands	sheep	332; 775
	pancreas	sheep	332; 775
	in cholinergic neurons submandibular gland	cat	488; see 606
	sweat glands	cat	see 677

RELEASE VIP from intramural nervous elements

Stimulation

STIMULUS	SPECIES	REFERENCES
* food and pentagastrin in stomach	cat	757
* acidification of the duodenal content	mammals	172
* fat; bill; HCl and high concentration ethanol in duodenum	dog man	125; 267 see 215; see 222
* stimulation mechanoreceptors pharynx and esophagus leading to gastric receptive relaxation	cat mammals	see 246 198
* distention gastric fundus	dog	see 661
* mechanical stimulation intestinal mucosa	cat	see 661
* intestinal ischemia	mammals	see 495
* ATP IA to gut	cat	491
* acetylcholine IV	pig	see 110; see 495
* CCK		see 791
* cholinesterase inhibitors (neostigmine)	mammals	see 495; see 660
* atropine; serotonin; prostaglandins E_1 and D_2		see 660
* calcium IV	dog mammals	see 661 see 495
* electrical stimulation parasympathetic nerves (n. vagus; nn. pelvici)	guinea-pig cat pig mammals # species	198 78; 240 26; 203; 362; see 468 see 110; see 154; 172; 200; 204; 363; see 495; 554; see 723 see 605

* electrical stimulation non-adrenergic; non-cholinergic inhibitory fibres	cat	67
* electrical field stimulation gut	rabbit	see 661
* cholera toxin	cat	118; see 118; see 754
* E. coli endotoxin shock	pig	675

Inhibition

STIMULUS	SPECIES	REFERENCES
* electrical stimulation splanchnic nerves	pig	see 495
* tetrodotoxin	cat mammals	118 67; 754
* somatostatin	pig mammals	204 65; 198
* H_1 and H_2 receptor antagonists	guinea-pig	292
* atropine	rat guinea-pig dog	429 463 406
* nicotine antagonists	mammals	198; 203; 240
* opioids	rat	304

EFFECTS of VIP

Motility

EFFECT	SEGMENT	SPECIES	REFERENCES
* relaxation	esophagus	mammals	see 110; 198; 324
	LES	cat	67; 203; 240; see 495
		opossum	see 5; 203; 240; 405; see 495; see 678; see 694
		baboon	203; 240; 405; 694
		man	see 5; 203; 240; 405; 495
		mammals	172; 198; 325; see 660
* abolished the Sub. P induced increase in pressure	LES	pig	5
* relaxation (gastric receptive relaxation)	stomach and pylorus	rat	203; 240
		guinea-pig	203; 240; 306; 307; see 495
		cat	172; 185; 198; 203; 240; see 246; 324; 468; see 468; see 495; see 678
		dog	203; 240; 405
		pig	see 110; 203
		man	203; 240
		mammals	172; 198; 324; see 605; see 660
* relaxation muscularis mucosae	stomach and colon	dog	see 215
* dual effect on smooth muscles of the gut			
relaxation			
circular muscle layer (specially sphincters)	small and large intestine	rat	46; 320
		guinea-pig	240; 305; 306; 463
		other animals	20; see 59; see 79; see 110; see 223; 325; see 495; see 606; 616; see 678; 810
longitudinal muscle layer	colon	mouse	223; see 660
involved in the descending inhibitory component peristaltic reflex		guinea-pig	246; see 246; 248; see 248

involved in the dominant inhibitory tone in the circular muscle layer	colon	rat	see 791
contraction			
longitudinal muscle layer		mouse	223
		guinea-pig	62; see 223; see 810
		rabbit	240
		opossum	405
		dog	240
		man	76; 172
		mammals	172; 324; 325; 605; see 616; 723
* stimulates ACh release from myenteric neurons	small intestine	guinea-pig	571; see 794; see 808; 810
* VIP neurons inhibit phasic activity	colon	rat	304
* stimulates slow synaptic excitation in myenteric neurons	ileum	guinea-pig	see 567; 794
* relaxation gallbladder		cat	see 78; see 110; see 660
* relaxation arteries and veins	omentum	man	187

Secretion and Absorption

EFFECT	SEGMENT	SPECIES	REFERENCES
* inhibition acid and pepsin secretion	stomach	cod	364
		rat	see 495
		guinea-pig; dog	32; 33; see 215; 364; 405; 436; see 495; 496; see 660; see 678
* stimulation mucus and peptic secretion	stomach	guinea-pig	757
* stimulation secretion somatostatin	stomach	rat	658; 683
* stimulation intestinal secretion; inhibition absorption	small and large intestine	shark	769
		goldfish	42
		tilapia	493
		turkey	see 683
		rat	265; 405; 442; 645; see 678; see 683; 769
		guinea-pig	138; 265
		rabbit	113; 265; 405; 442; 449; 645; 702
		cat	293
		dog	47; 442; 445; 449; see 495
		man	see 215; 265; 405; 412; 440; 441; 442; 443; 444; 449; see 495
		mammals	see 59; 65; 74; see 79; see 110; 118; 172; 325; see 532; 605; see 605; 616; see 660; see 661; see 678; 723; 754
* involved in Verner-Morrison syndrome (VIP oma)	intestine	man	63; see 63; see 607; 657; see 660; see 678; 763; see 763; 765; see 765
* stimulation bicarbonate secretion from Brunner glands	duodenum	rat	222; 383; 429
* stimulation secretion pancreatic juice and bicarbonate	pancreas	birds; chicken; turkey	see 79; see 495; 533
		rat; guinea-pig	see 79; 203; 645; 803
		cat	see 79; 203; 413; see 495; 645
		dog	79; see 495
		pig	201; 203; 362; see 362; 363; see 495; 645; see 683
		man	see 495
		mammals	see 127; 172; 198; 200; 324; see 495; see 605; see 660; see 678; see 683

* stimulation fluid secretion	gallbladder	cat dog	78 79; see 79
* stimulation secretion insulin; somatostatin and bombesin		rat dog	683 381; 405
* stimulation secretion amylase; lipase; hydrolase and trypsin		rat; guinea-pig; dog;	see 127; 405
* reduces active intestinal Ca^{2+} transport directly		rat	641

Blood Flow

EFFECT	SPECIES	REFERENCES
* potent vasodilation (direct action on vascular smooth muscle)	# species	79; see 79; 118; 203; 269; see 269; 325; 360; 385; 480; see 578; 605; see 605; see 615; 616; 621; see 621; 661; see 678; 723
* involved in jejunal vascular response to fat (hyperemia)	dog	267

MISCELLANEOUS

* VIP coexists with AChE. in some sympathetic ganglion cells innervating sweat glands. VIP increases local blood flow; ACh influences sweat production.

	cat	see 386; see 677

* VIP present in primary sensory neurons.

		see 677

* VIP acts on the adenylate-cyclase system: Ca^{2+} mobilization and increase in c-AMP concentration followed by membrane phosphorylation

	shark	240
	mammals	118; see 123; 265; 269; 405; 548; 769; 803

in the intestine this effect is antagonized by angiotensin II and by noradrenaline

	rat	263

* VIP may be a regulator of the normal and tumoral development of the intestinal mucosa

	rat and man	123; 168; see 168

* VIP may regulate the differentiation and function of the enterocytes

	foetal rat	124

* VIP has a neurotrophic action on neuronal survival of cultured spinal cord neurons.

	mice	87

Layer	RG	RET	RDS	RVS	OMA	ABO	AP	PYL
Mucosa and submucosa	228	44	23	11	180	224	237	279
Muscularis	353	371	330	304	500	387	356	323

Table 10. Radioimmunological quantification of VIP (picogram/mg tissue) in the stripped layers of the ruminant stomach wall of the adult sheep (n=6).

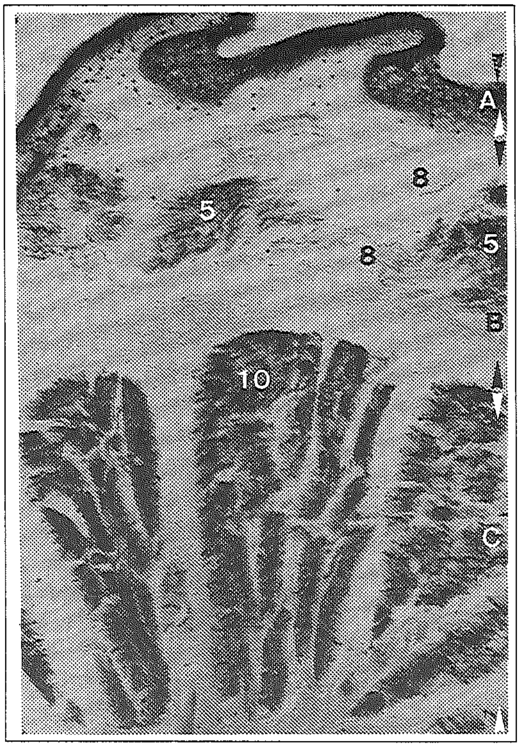


Photo 74. Reticular Groove.
VIP, cryostat section (50 µm), foetus 26 cm. Magn.296 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

5. Parts of the lamina muscularis mucosae innervated by several VIP-IR nerve fibres
8. Isolated VIP-IR nerve fibre
10. Intramuscular VIP-IR nervous network in the circular muscle layer

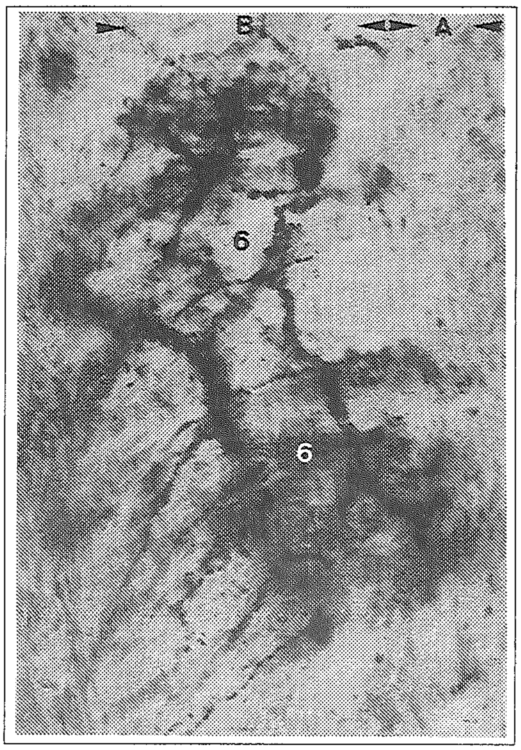


Photo 75. Reticular Groove.
VIP, cryostat section (50 µm), foetus 26 cm. Magn.1156 x

A. Tunica Mucosa
B. Tunica Submucosa

6. VIP-IR nervous network at the onset of a primary reticular fold

Photo 76. Reticular Groove.
VIP, cryostat section (50 μm), foetus 26 cm. Magn.555 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

10. Dense intramuscular VIP-IR nervous network in the circular muscle layer

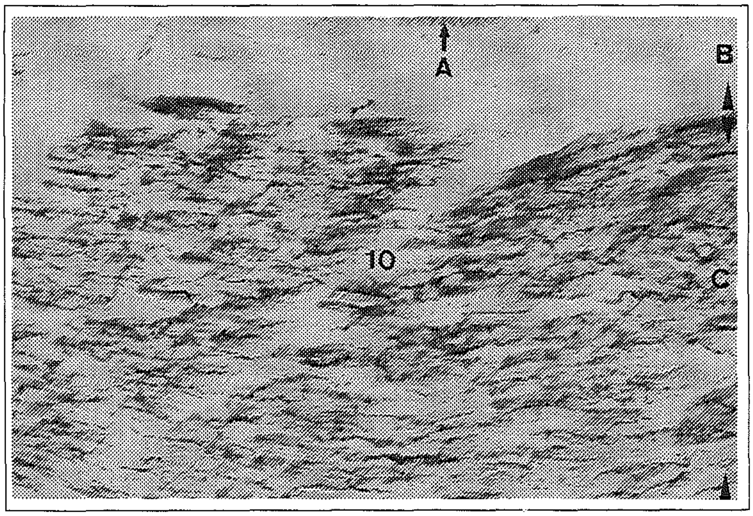
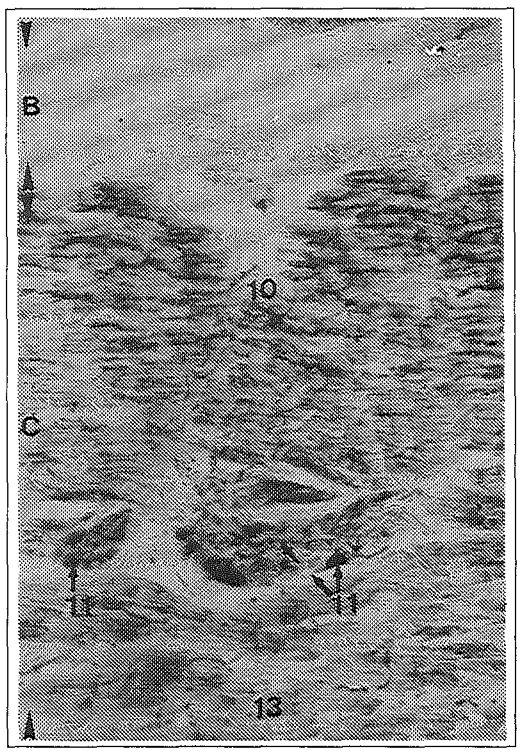


Photo 77. Reticular Groove.
VIP, cryostat section (50 μm), foetus 26 cm. Magn.555 x

B. Tunica Submucosa
C. Tunica Muscularis

10. Dense, intramuscular VIP-IR nervous network in the circular muscle layer
11. Plexus Auerbach: VIP-IR nerve fibres and VIP-IR perikarya (note their peripheral arrangement)
13. Intramuscular VIP-IR nervous network in the longitudinal muscle layer



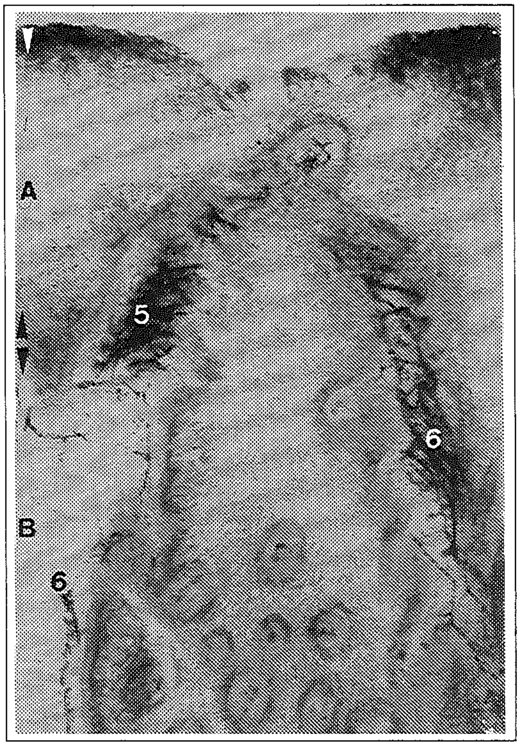


Photo 78. Reticulum.
VIP, cryostat section (50 µm), foetus 26 cm. Magn.296 x

A. Tunica Mucosa
B. Tunica Submucosa

5. Lamina muscularis mucosae innervated by VIP-IR nerve fibres
6. VIP-IR nervous network in a primary reticular fold

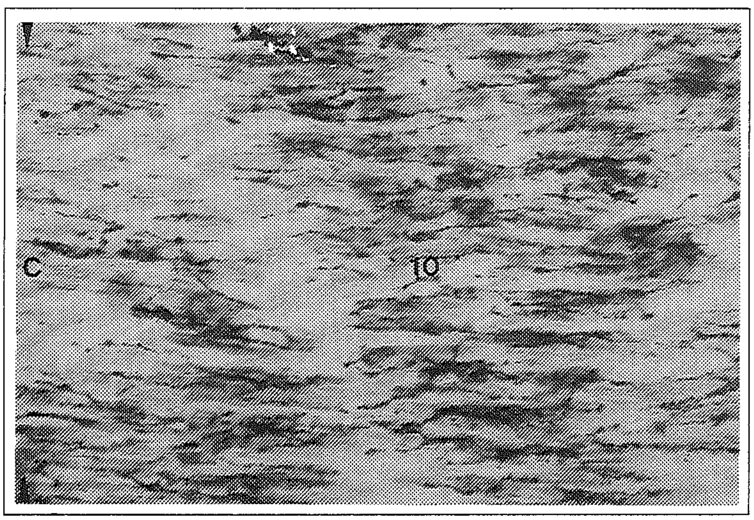


Photo 79. Reticulum.
VIP, cryostat section (50 µm), foetus 26 cm. Magn.60 x

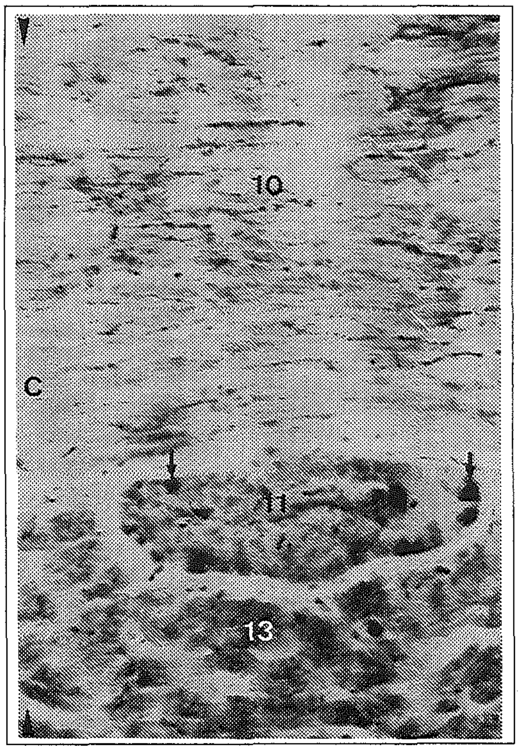
C. Tunica Muscularis

10. Dense, intramuscular VIP-IR nervous network in the circular muscle layer

Photo 80. Reticulum.
VIP, cryostat section (50 µm), foetus 26 cm. Magn.592 x

C. Tunica Muscularis

10. Dense, intramuscular VIP-IR nervous network in the circular muscle layer
11. Plexus Auerbach: VIP-IR nerve fibres and VIP-IR perikarya (note their peripheral arrangement)
13. Intramuscular VIP-IR nerve fibres in the longitudinal muscle layer



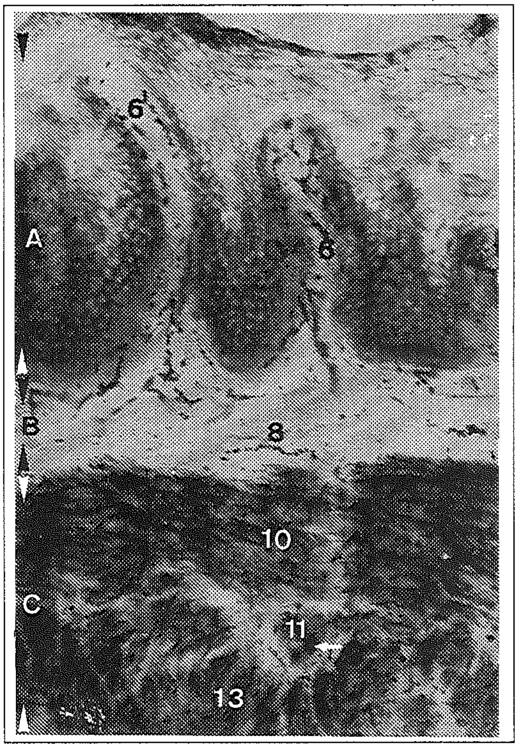


Photo 81. Ruminal Dorsal Sac.
VIP, cryostat section (50 µm), foetus 26 cm. Magn.373 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

6. VIP-IR nervous network in the primordium of the ruminal papillae
8. Isolated VIP-IR nerve fibre
10. Intramuscular VIP-IR nervous network in the circular muscle layer
11. Plexus Auerbach with VIP-IR perikarya
13. Intramuscular VIP-IR nervous network in the longitudinal muscle layer

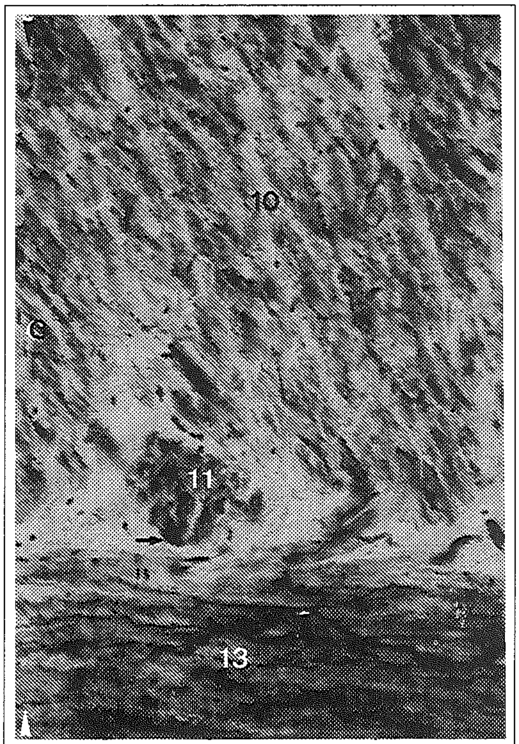


Photo 82. Ruminal Dorsal Sac.
VIP, cryostat section (50 µm), foetus 26 cm. Magn.583 x

C. Tunica Muscularis

10. Dense, intramuscular VIP-IR nervous network in the circular muscle layer
11. Plexus Auerbach with VIP-IR perikaryan
13. Intramuscular VIP-IR nervous network in the longitudinal muscle layer

Photo 83. Ruminal Ventral Sac.
VIP, cryostat section (50 μm), foetus 26 cm. Magn.373 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

6. VIP-IR nervous network in the primordia of the ruminal papillae
10. Intramuscular VIP-IR nervous network in the circular muscle layer
11. Plexus Auerbach with VIP-IR perikarya
13. Intramuscular VIP-IR nervous network in the longitudinal muscle layer

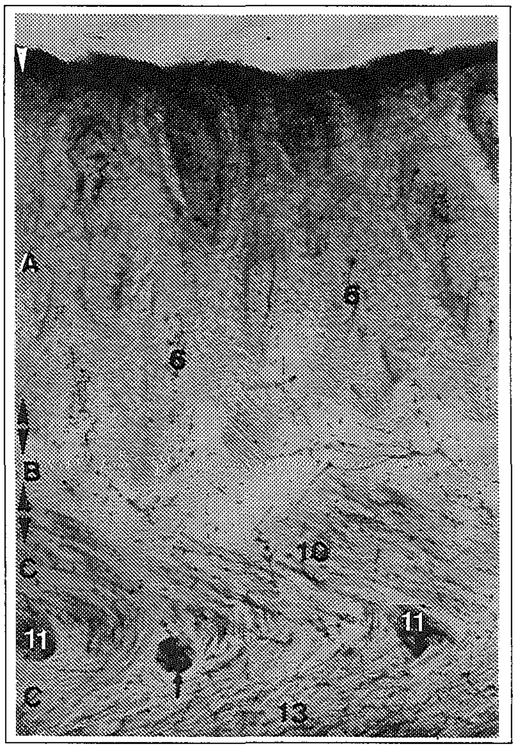
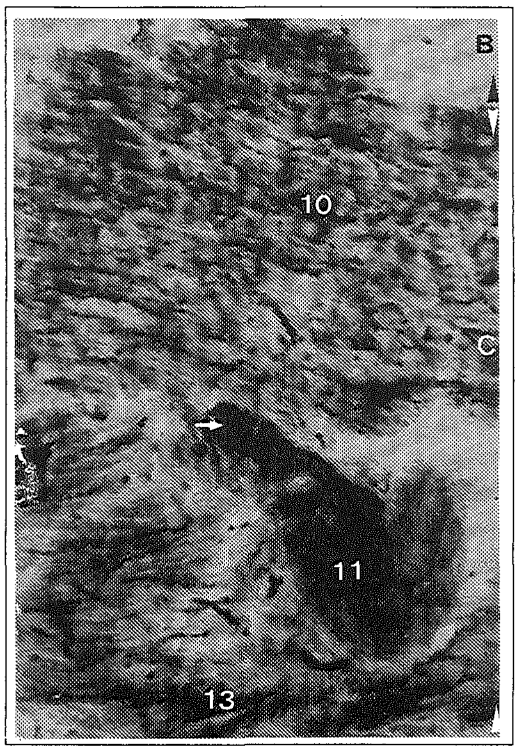


Photo 84. Ruminal Ventral Sac.
VIP, cryostat section (50 μm), foetus 26 cm. Magn.647,5 x

B. Tunica Submucosa
C. Tunica Muscularis

10. Intramuscular VIP-IR nervous network in the circular muscle layer
11. Plexus Auerbach: VIP-IR nerve fibres and VIP-IR perikarya
13. Intramuscular VIP-IR nervous network in the longitudinal muscle layer



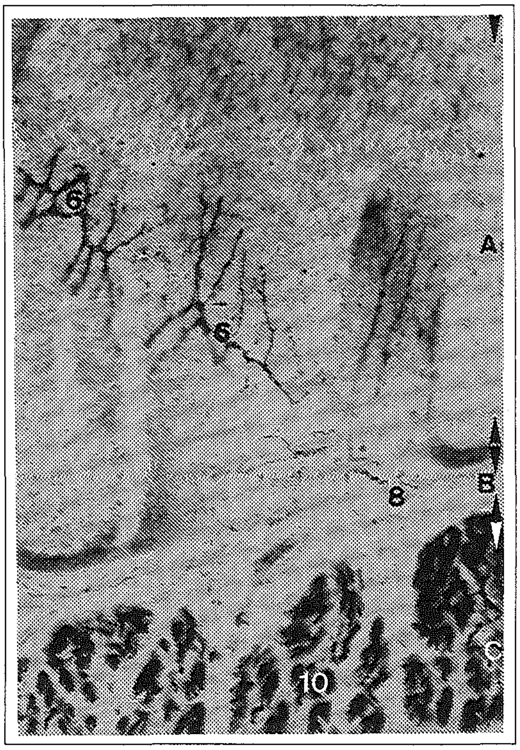


Photo 85. Ostium Reticulo-Omasicum.
VIP, cryostat section (50 μm), foetus 26 cm. Magn.373 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

6. VIP-IR nervous network in primary reticular fold
8. Isolated VIP-IR nerve bundle
10. Intramuscular VIP-IR nervous network in the circular muscle layer

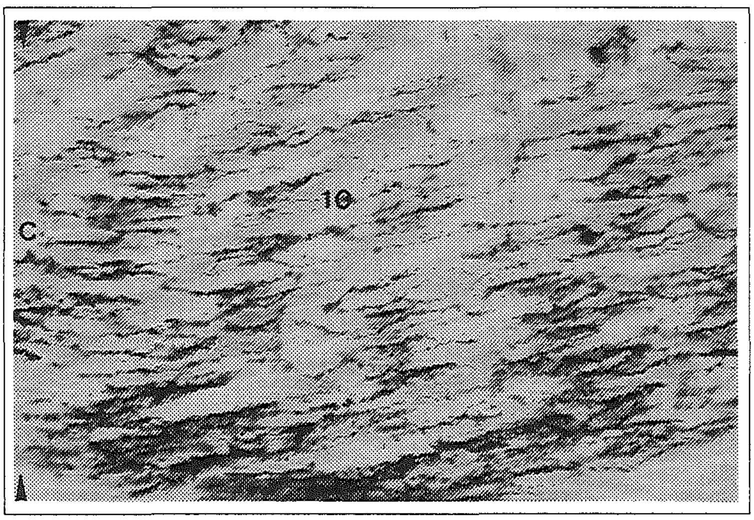


Photo 86. Ostium Reticulo-Omasicum.
VIP, cryostat section (50 μm), foetus 26 cm. Magn.592 x

C. Tunica Muscularis

10. Dense, intramuscular VIP-IR nervous network in the circular muscle layer

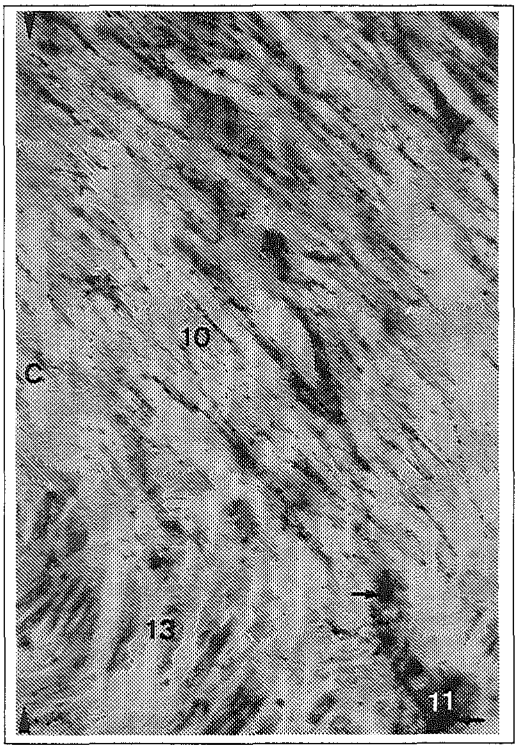


Photo 87. Ostium Reticulo-Omasicum.
VIP, cryostat section (50 µm), foetus 26 cm. Magn.592 x

C. Tunica Muscularis

10. Intramuscular VIP-IR nervous network in the circular muscle layer
11. Plexus Auerbach: VIP-IR nerve fibres and VIP-IR perikarya
13. Intramuscular VIP-IR nerve fibres in the longitudinal muscle layer

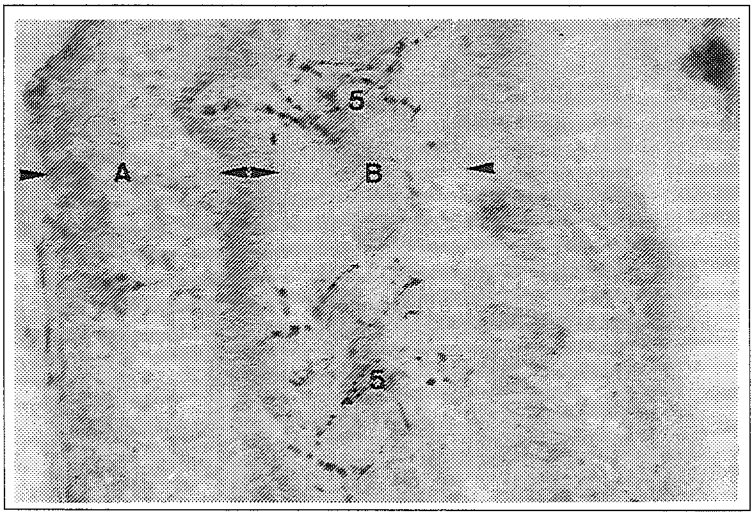


Photo 88. Omasum.
VIP, cryostat section (50 μm), foetus 26 cm. Magn.740 x

A. Tunica Mucosa
B. Tunica Submucosa

5. Primary omasal leaf: VIP-IR nerve fibres in the lamina muscularis mucosae and the protrusion of the circular muscle layer

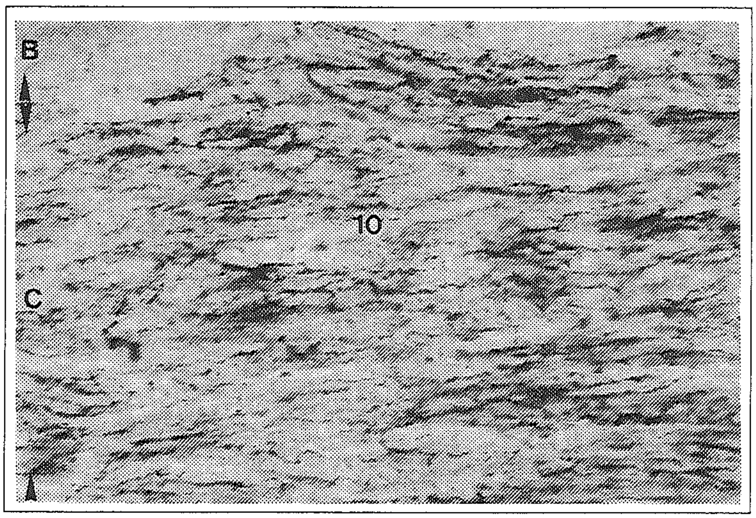


Photo 89. Omasum.
VIP, cryostat section (50 μm), foetus 26 cm. Magn.651 x

B. Tunica Submucosa
C. Tunica Muscularis

10. Intramuscular VIP-IR nervous network in the circular muscle layer

Photo 90. Abomasum.
VIP, cryostat section (50 μm), foetus 26 cm. Magn.533 x

A. Tunica Mucosa

2. Plexus mucosus: VIP-IR nerve fibres in the lamina propria
4. Plexus mucosus: periglandular plexus
5. Lamina muscularis mucosae innervated by several VIP-IR nerve fibres

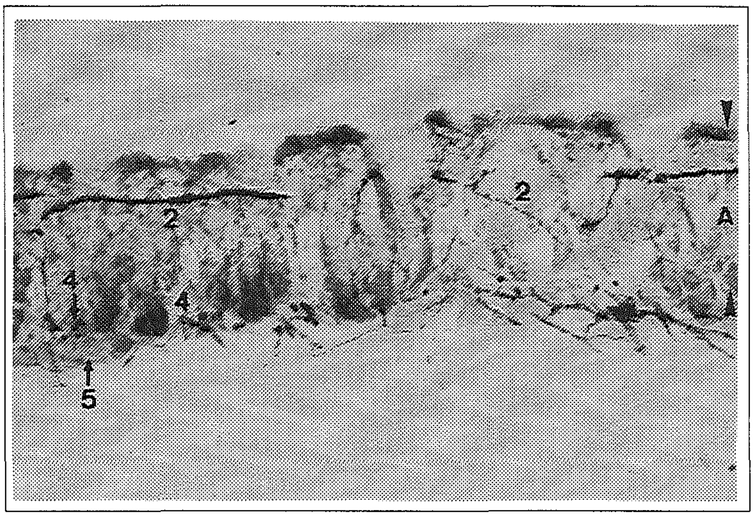
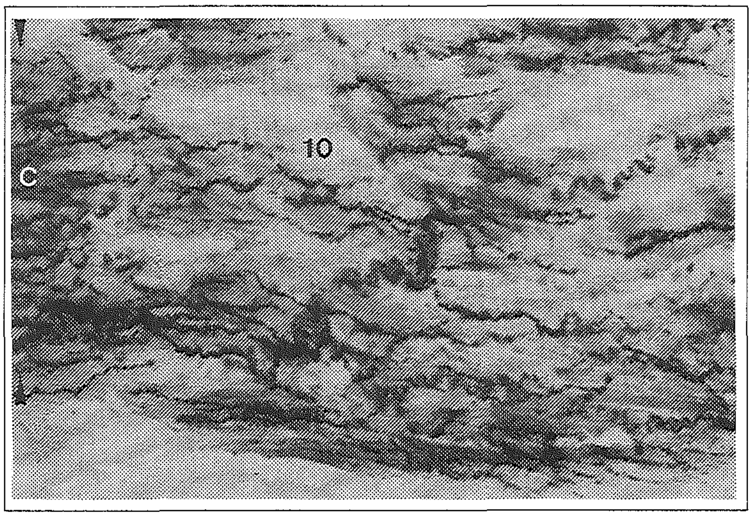


Photo 91. Abomasum.
VIP, cryostat section (50 μm), foetus 26 cm. Magn.832,5 x

C. Tunica Muscularis

10. Dense, intramuscular VIP-IR nervous network in the circular muscle layer



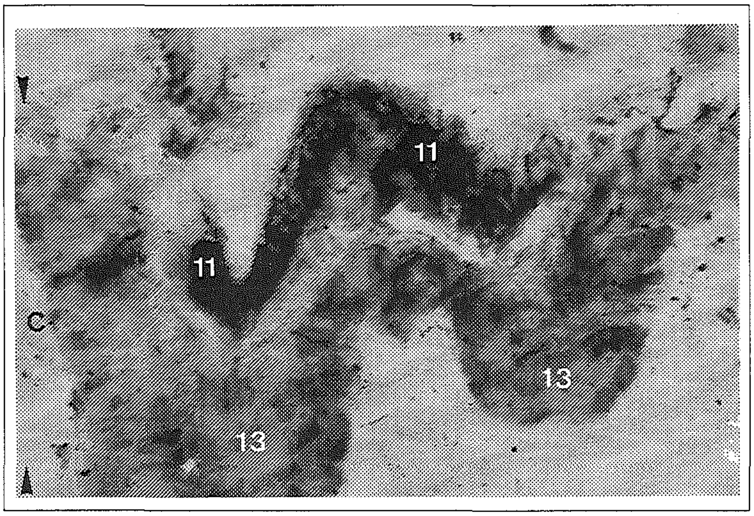


Photo 92. Abomasum.
VIP, cryostat section (50 µm), foetus 26 cm. Magn.740 x

C. Tunica Muscularis

11. Plexus Auerbach: VIP-IR nerve fibres and VIP-IR perikarya
13. Intramuscular VIP-IR nervous network in the longitudinal muscle layer

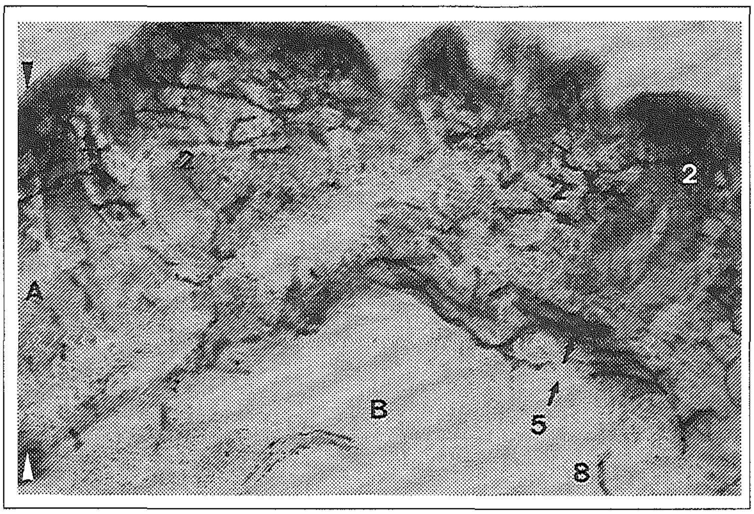


Photo 93. Antrum Pyloricum.
VIP, cryostat section (50 µm), foetus 26 cm. Magn.651 x

A. Tunica Mucosa
B. Tunica Submucosa

2. Plexus mucosus: VIP-IR nerve fibres the in lamina propria
5. Lamina muscularis mucosae innervated by several VIP-IR nerve fibres
8. Isolated VIP-IR nerve fibre

Photo 94. Antrum Pyloricum.
VIP, cryostat section (50 μm), foetus 26 cm.
Magn.355 x

A. Tunica Mucosa

2. Plexus mucosus: VIP-IR nerve fibres in the lamina propria
4. Plexus mucosus: periglandular VIP-IR nerve plexus

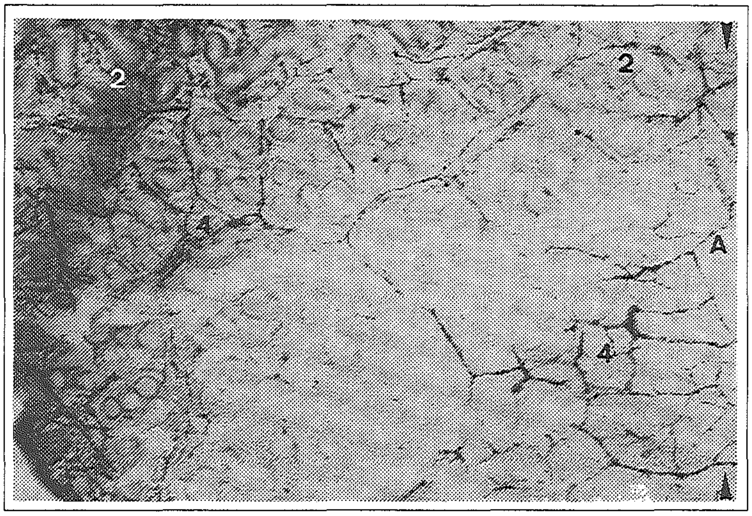
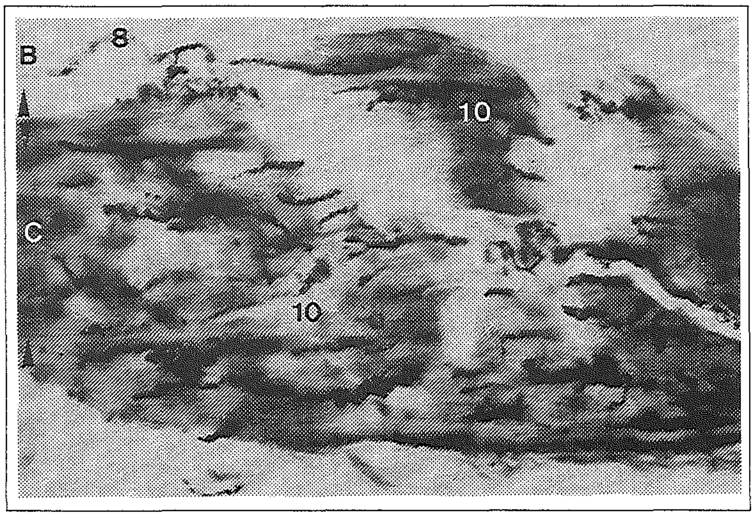


Photo 95. Antrum Pyloricum.
VIP, cryostat section (50 μm), foetus 26 cm.
Magn.740 x

B. Tunica Submucosa
C. Tunica Muscularis

8. Isolated VIP-IR nerve bundle
10. Dense, intramuscular VIP-IR nervous network in the circular muscle layer



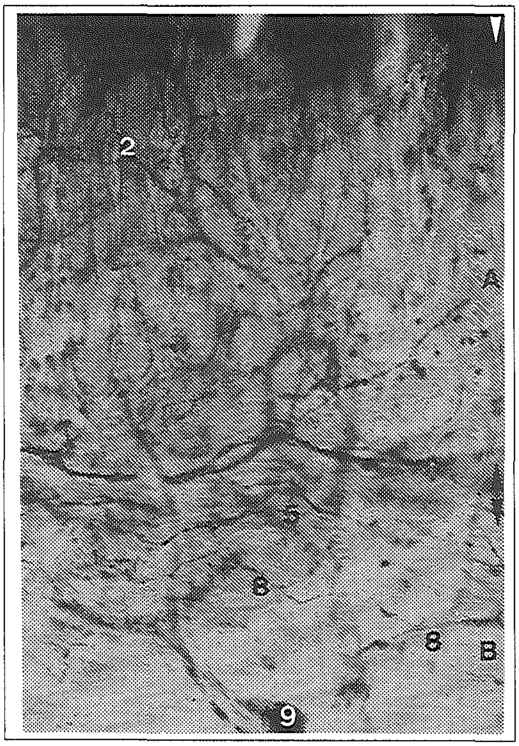


Photo 96. Pylorus.
VIP, cryostat section (50 μm), foetus 26 cm. Magn.601 x

A. Tunica Mucosa
B. Tunica Submucosa

2. Plexus mucosus: VIP-IR nerve fibres in the lamina propria
5. Lamina muscularis mucosae innervated by VIP-IR nerve fibres
8. Isolated VIP-IR nerve fibres
9. Plexus submucosus: ganglia showing VIP-IR

Paraffin sections

Adult sheep

Layer	RG	RET	RDS	RVS	OMA	ABO	AP	PYL
mucosa	+	+	-	-	+	++	++	++
submucosa	+	+	(+)	(+)	-	++	++	++
circular muscle layer	++(+)	++(+)	++(+)	++(+)	++(+)	++(+)	++(+)	+++(+)
Auerbach	+	+	+	+	+	+(+)	+	+
longitudinal muscle layer	+(+)	+(+)	+(+)	+(+)	+(+)	+(+)	+(+)	+(+)

Foetus

Layer	RG	RET	RDS	RVS	OMA	ABO	AP	PYL
mucosa								
submucosa								
circular muscle layer			no reaction in any segment					
Auerbach								
longitudinal muscle layer								

Table 11. Distribution pattern of the VIP-IR in the wall of the ruminant stomach of the sheep as seen in paraffin sections.

Cryostat sections

Adult sheep

Layer	RG	RET	RDS	RVS	OMA	ABO	AP	PYL
mucosa	+	+	-	-	+	++	++	++
submucosa	+	+	(+)	(+)	-	++	++	++
circular muscle layer	+++(+)	+++	+++	+++	+++	+++	+++	++++
Auerbach	+	+	+	+	+	+(+)	+	+
longitudinal muscle layer	++	++	++	++	++	++	++	++

Foetus

Layer	RG	RET	RDS	RVS	OMA	ABO	AP	PYL
mucosa	+	+	-	-	+	++	++	++
submucosa	++	++	++	++	+	++	++	++
circular muscle layer	+++	+++	+++	+++	+++	+++	+++	+++
Auerbach	++	++	+	++	+	++	++	++
longitudinal muscle layer	++	++(+)	++	++	++	++	++	++

Table 12. Distribution pattern of the VIP-IR in the wall of the ruminant stomach of the sheep as seen in cryostat sections.

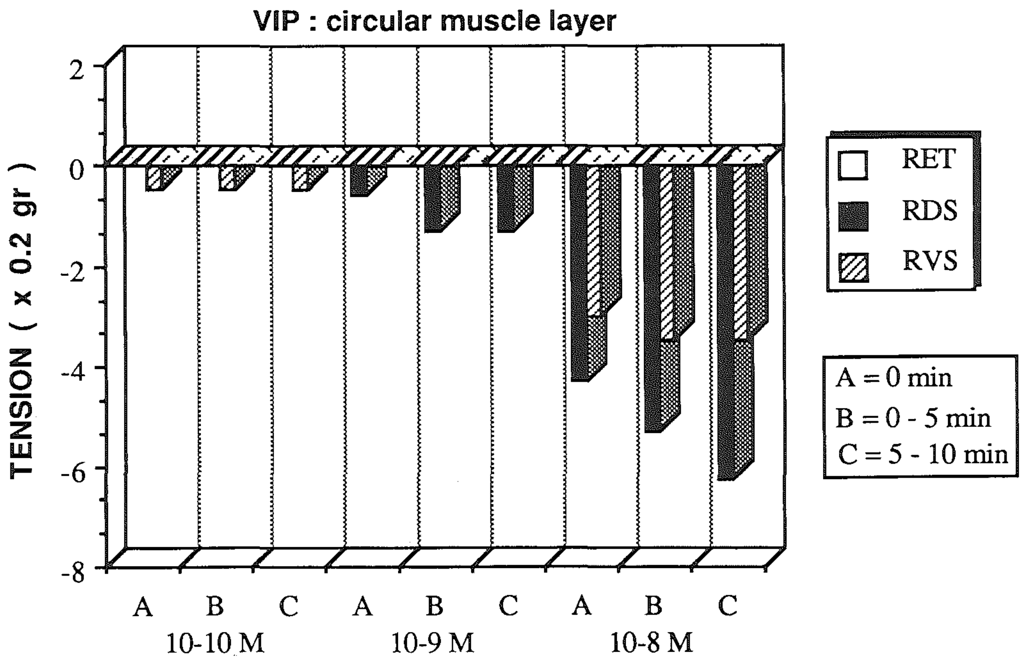


Fig. 33. Graphic representation of the in vitro effect of vasoactive intestinal polypeptide (VIP) on the circular muscle layer of the RET; RDS and RVS.

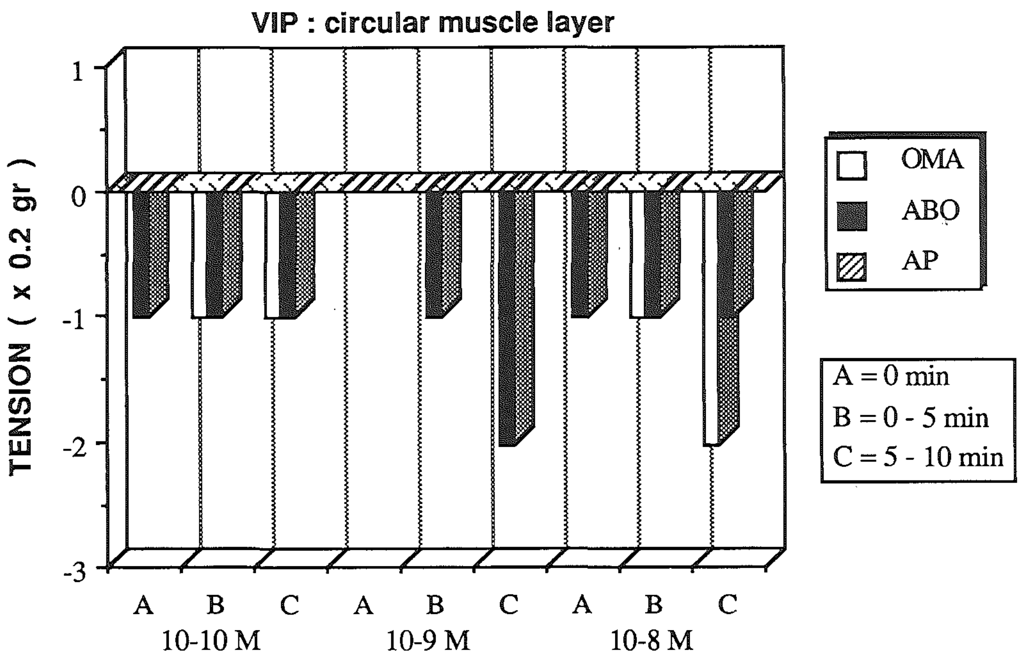


Fig. 34. Graphic representation of the in vitro effect of vasoactive intestinal polypeptide (VIP) on the circular muscle layer of the OMA; ABO and AP.

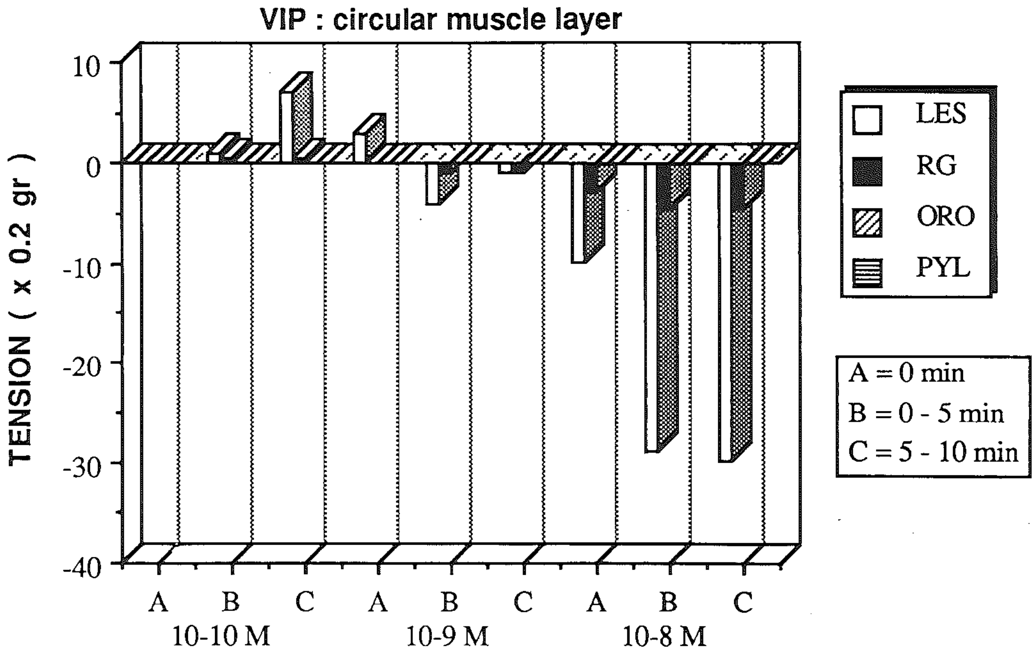


Fig. 35. Graphic representation of the in vitro effect of vasoactive intestinal polypeptide (VIP) on the circular muscle layer of the sphincters: LES; RG; ORO and PYL.

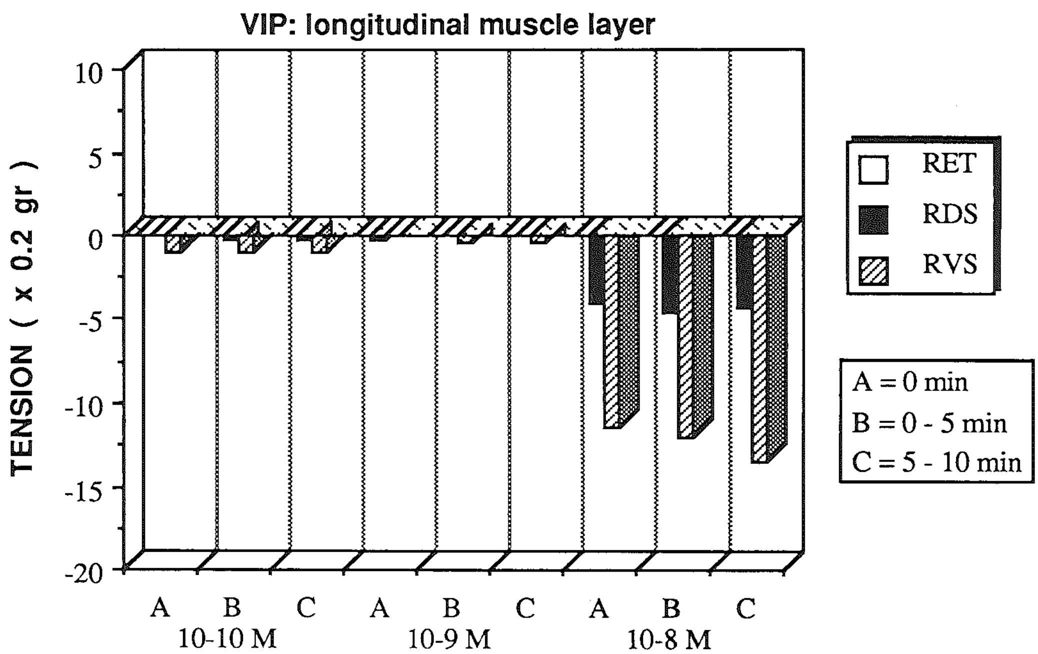


Fig. 36. Graphic representation of the in vitro effect of vasoactive intestinal polypeptide (VIP) on the longitudinal muscle layer of the RET; RDS and RVS.

SUBSTANCE P (Sub. P)

PRESENCE of Sub. P in the gastrointestinal tract

SEGMENT	LOCALIZATION	SPECIES	REFERENCES
* dental pulp; paradental tissue		cat	555
* tong	taste buds	rat	805; 806
* esophagus	muscle layer; myenteric plexus	foetal sheep	330
		# specimens including man	see 5
	longitudinal muscle and musicularis mucosae	opossum	see 152
	in cholinergic neurons musicularis mucosae	opossum	171
* forestomach	muscle layer; myenteric plexus	sheep	331; 775
		foetal sheep	330; 776
* stomach	mucosa	rat	335; see 371; 534
		dog	see 522
		foetal sheep	330; 776
		adult sheep	331; 775
		man	215; see 215
	nerve fibres in myenteric plexus throughout intestine	trout	see 361; see 819
		rat	690
		sheep	331; 775
	in nerve fibres both plexuses	leech	see 461
		cat	333
		foetal sheep	776
		sheep	331; 775; 776
		human foetus	414
* intestine (small and large)	both muscle layers; both plexuses; submucosa; epithelial endocrine cells	invertebrates	408; 461
		cod	392
		chicken	91; see 583; 727
		mouse	see 52; 560; 681; 727; see 775
		rat; guinea-pig	see 52; see 53; see 94; 109; 142; 162; see 162; 174; see 208; 294; see 368; 369; 409; 421; see 492; 500; 520; 543; see 583; 678; 690; 727; see 775
		rodents	see 52; see 583; 727
		cat	9; see 52; 171; 333; 468; 470; see 560; 727; see 775

	dog	see 52; 643; see 775
	pig	see 52
	foetal sheep	330; 776
	sheep	see 52; 331; 775
	bovine foetus	see 776
	cattle	432
	horse	75; 155
	man	see 52; 215; see 215; see 617
	human foetus	583
	mammals	2; see 52; see 55; 74; see 109; see 110; 139; see 142; see 152; see 173; see 246; see 295; see 301; see 325; see 327; see 333; see 368; see 369; see 373; see 408; see 432; see 515; see 519; see 522; see 525; see 526; see 543; see 567; 589; 605; 615; see 615; 617; see 659; see 678; see 680; see 681; see 690; see 723; 724; see 724; see 746; see 775; see 791; see 808; see 810; see 811
co-storage with 5-HT in enterochromaffin cells		see 52; 368; see 368; see 772
co-existence with 5-HT in gut neurons	guinea-pig	see 52; see 468; see 515
co-existence with ACh in myenteric plexus	guinea-pig	see 94; see 522
co-existence with ACh in submucous plexus small intestine	guinea-pig	see 52
co-storage with somatostatin in nerve fibres	mouse rat mammals	560 357 589
co-existence with calcitonin-gene-related peptide	guinea-pig	294
co-storage with neurokinin A in myenteric neurons	guinea-pig cattle	162; 163 see 52
co-existence with met-enkephalin in myenteric neurons	cat	see 52; 171
significant decrease in Hirschsprung's; Chagas' disease; pyloric stenosis; Grass Sickness in horse	horse; man	see 373; see 560; see 606; see 615; see 678; 733; see 733

* in midgut carcinoids		man	7; see 134; see 526; 646; see 699
* gallbladder	chromaffin cells	rabbit	see 746
	in neurons biliary tract	guinea-pig	see 746
		foetal sheep	330
		sheep	331; 775
* primary sensory neurons of visceral receptors		rat	680
		guinea-pig	88; 294; see 368; 680
		cat	680
* co-storage with calcitonin gene related peptide	capsaicin sensitive varicose axons to viscera	guinea-pig	294
* pancreas		sheep	331; 775
* salivary glands and pancreas		foetal sheep	330
* blood vessels	intestinal mucosa	mammals	605; 727
	intestinal wall	rat; guinea-pig; cat	see 52; 211; see 211; 678
	mesentery	rat	182; 224; 686; 690
		cattle	432
* vagal nerve		mammals	74; 88; 155; see 333; see 368
* splanchnic nerve		guinea-pig	519
		cat	see 333
* all prevertebral ganglia	immunoreactive fibres; no immunoreactive neurons	guinea-pig	333; see 333
* celiac superior mesenteric ganglion complex		guinea-pig	354; see 356; see 368
		cat	354; 356; see 368; 680
* intermesenteric nerves		guinea-pig	519
* inferior mesenteric ganglion	immunoreactive fibres around principal ganglion cells	rat	354; see 356; 680
		guinea-pig	519
* colonic; hypogastric nerves		guinea-pig	519
* lumbar paravertebral ganglia	immunoreactive fibres	guinea-pig	519

Note: Species differences

in large intestine (colon)

* plexus submucosus numerous; plexus myenteric small number of immunoreactive nerve cell bodies

		horse; man	74
opposite in		guinea-pig; cat	74

* even distribution of immunoreactive nerve fibres in both muscle layers

		cat; man	74

circular muscle layer highest density of immunoreactive nerve fibres

		dog; horse	74

* sparse immunoreactive nerve fibres in mucosa	cat	74
numerous immunoreactive nerve fibres in mucosa	dog; horse; man	74; 215

* high Sub. P levels			
	duodenum	dog	1
	jejunum	rabbit	1
low Sub. P levels			
	fundus	dog	1
	antrum	rabbit	1

RELEASE Sub. P

Stimulation

STIMULUS	SPECIES	REFERENCES
* acidification distal esophagus	cat	see 52; 634
* transmural electrical stimulation esophagus	opossum	see 52; 152
* acidification duodenum	rabbit	see 310
	cat	see 310; 634
* feeding	dog	see 52
* increase intraluminal pressure	guinea-pig	see 52; 173
* electrical stimulation stomach and intestine	guinea-pig	see 52; see 173; see 208
	dog	see 52
* rise in extracellular K^+	guinea-pig	see 52
* stimulation vagal nerve and splanchnic nerves	cat	see 52; 165; see 246; see 299; see 310; see 311; 468; 469; 470; see 525; 756
	other species	see 55; see 301; see 310
* peristalsis	rat; guinea-pig; cat	see 52; see 55; see 173; 468; see 468
* neurotoxins (capsaicin)	guinea-pig	173
* acetylcholine	guinea-pig	see 52; see 173; see 408
	cat	756
* acetylcholine and adrenaline I V	cat	see 52; 756
* antral perfusion with ACh	cat	see 52; 756
* cholecystokinin	guinea-pig	see 52; see 173
* serotonin	guinea-pig	791
* neurotensin	guinea-pig	see 52
* leukotriene D4	guinea-pig (ileum)	82
* opioid blockade (naloxone)	guinea-pig	see 52

Inhibition

STIMULUS	SPECIES	REFERENCES
* atropine	cat	9; 469; 470
* noradrenaline (pressure induced Sub. P release) via alpha-adrenoreceptors	guinea-pig	see 52; 173
* tetrodotoxin	guinea-pig cat	see 52; 173 634
* opioids (endogenous and exogenous)	guinea-pig	see 52; 53; 173; see 173; 296; see 296

EFFECTS Sub. P

Motility

EFFECT	SEGMENT	SPECIES	REFERENCES
* contraction muscularis mucosae (direct effect)	esophagus; stomach; colon	guinea-pig dog opossum	see 52; 409 see 215 see 52
* contraction	LES	rat; guinea-pig cat opossum pig	66 see 52; 634 see 5; see 52; see 368 see 5; 6
* contraction longitudinal smooth muscle	esophagus	opossum	see 52; 152
* contraction direct stimulation circular muscle indirect stimulation longitudinal muscle layer	stomach	trout rat; guinea-pig; cat; dog and other species	see 361 see 52; 165; 229; 342; see 368; see 371; 468; 522; see 522; 523; 524; 531; 556
indirect via cholinergic excitatory interneurons	stomach	rat cat	371 see 52; 468
indirect via activation 5-HT neurons	stomach	trout	819
contraction by inhibiting K^+ current	stomach	toad	see 567; 697
* inhibition isolated contractions	stomach	rat	771
* increases pressure in gastric wall	stomach	cat dog	46 see 522
* contraction	pylorus	cat dog	9; 470; see 522 531
* influences gastric emptying	stomach	rat	see 371

* contraction both muscle layers	small and large intestine	cod	392
		chicken	91
		rat	see 52; see 55; 365; see 492; 770
		guinea-pig	see 52; see 55; see 94; see 142; see 208; 235; 365; 370; 446; see 492; 536; 557; see 605; see 697; see 746; 777; 807
		rabbit	see 52; 365; see 746
		cat	see 52; 365
		dog	30; see 52; see 55; 376
		pig	see 52; 365
		horse	687
		mammals	see 52; see 55; see 66; 74; see 142; see 246; see 295; see 301; see 325; see 368; see 468; see 492; see 500; see 522; see 526; see 560; 605; see 678; see 697; see 811
direct effect (reduction K^+ conductance; influx Ca^{2+}; release Ca^{2+} from intracellular stores into cytosol)	intestine	rat	662
		guinea-pig	see 228; 326; see 326; 368; see 791; 807
		mammals	see 52; 53; see 53; 139; see 228; 325; 336; see 368; see 468; see 492; 605; 616; see 678; 723
indirect effect stimulation afferent nerves in peristaltic reflex arch	intestine	guinea-pig	336
		mammals	see 325
induction peristaltic reflex after intraluminal installation	intestine	guinea-pig	see 52
modulation cholinergic transmission in intramural neurons	intestine	mammals	74; see 171; 336; see 368; see 492; see 678; 723; 736; see 810
depolarizes myenteric neurons (inactivation resting K^+ conductance)	intestine	guinea-pig	see 52; see 139; see 142; see 171; 327; see 327; 368; see 368; 419; see 678; see 810
mimics the slow synaptic potentials in myenteric neurons	intestine	guinea-pig	see 52; 768; see 768; 794

stimulates ACh release from myenteric neurons	small intestine	guinea-pig	see 13; see 52; 228; see 228; see 468; see 522; 808; see 808; 810; see 810
		cat	468
		dog	228; see 228
		other species	see 791
lowers threshold pressure to evoke peristalsis	intestine	guinea-pig	see 52
modulates adrenergic transmission	intestine	mammals	74
induces 5-HT release from myenteric neurons	stomach	trout	see 52; 361
induces GABA release from myenteric neurons	intestine	guinea-pig	736
induces contraction circular muscle layer	ileum	guinea-pig	52
* contraction longitudinal muscle layer	intestine	chicken	91
		guinea-pig	60; 367
direct action		guinea-pig	see 52; 53; see 53; 235; 365; see 408; 536; 557; 622; 742; see 742; 807
		rabbit	see 52; 365
		cat	365
		dog	30; 376
indirect via ACh from myenteric plexus	intestine	rat	365
		guinea-pig	see 52; 208
		cat	365
		dog	31
		pig	365
* induces slow depolarization myenteric neurons	caecum	guinea-pig	see 195; 327; see 368
* augments excitability cultured myenteric neurons	caecum	guinea-pig	327
* transmitter role in excitatory NANC transmission	ileum	guinea-pig	520

* inhibition tonic and phasic activity	intestine	dog	228
* contraction muscularis mucosae (via bombesin)	intestine	dog	258
* sensory neurotrans-mitter involved in peristalsis	intestine	mammals	231; see 468
* modulator muscular tone	intestine	mammals	see 52; 605
* excitatory transmitter of interneurons with peripheral branches in tunica mucosa	intestine	guinea-pig other species	605 571
* induces antegrade peristaltic contractions of the Oddi sphincter	intestine	opossum	54
* contractions gall-bladder (direct action)	gallbladder	dog	746
* excitatory transmitter motorneurons		mammals	723

Secretion and Absorption

EFFECT	SEGMENT	SPECIES	REFERENCES
* inhibition secretion induced by pentagastrin	stomach	rat dog	301 27; 515; see 515
* stimulation secretion (mucosal electrogenic secretion of Cl^- and reduction absorption)	intestine	rat guinea-pig rabbit	see 13; see 215; 407; see 515; see 525 175 85; see 525
* increases Ca^{2+} entry in enterocytes	proximal jejunum	dog	525; see 525; 526; see 526
* stimulation K^+ secretion	jejunum	dog	526
* decreases glucose absorption	jejunum	rat	see 526

* multifactorial modulator gastrointestinal homeostasis	intestine	mammals including man	526
* suppresses release somatostatin	stomach	rat	see 526
* stimulation secretion (direct effect)	pancreas	dog mammals	see 301; 407; see 515 325; see 515; see 526; 723
* stimulation secretion	exocrine glands	mammals	84; see 84; see 325; see 526; see 723

Blood Flow

EFFECT	SEGMENT	SPECIES	REFERENCES
* vasodilation (splanchnic area; etc.)	blood vessels	dog horse mammals; including man	811 687 see 134; see 182; 187; see 187; see 215; 325; see 328; 365; see 519; see 560; see 678; 723; see 811
* increases local mucosal blood flow after endoluminal perfusion	jejunum	cat	311; see 311; see 525; see 526
* increases blood flow to muscularis	stomach and ileum	dog	see 526
* causes a dose dependent decrease in diastolic and systolic pressure		guinea-pig	328

MISCELLANEOUS

EFFECT	SEGMENT	SPECIES	REFERENCES
* functional role in some type of visceral sensory functions and in special types of reflex arches in primary sensory neurons	extramural ganglia	guinea-pig rat	356; see 371 435
* Sub. P levels elevated in peripheral circulation of some carcinoid patients			134; see 134
* induced accumulation of phosphadityl inositol in the longitudinal muscle	ileum	rat guinea-pig	777 see 52; 366; see 500
* facilitation neuro-muscular transmission		frog	771
* stimulates abdominal visceral sensory endings		cat	467
* trophic role: growth and differentiation neural and other tissues			see 477
* increases c-AMP and nerve fibre outgrowth	cultured dorsal root ganglia	chicken	see 477
* counteracts neurotoxic effect 6-hydroxy-dopamine	brain	rat	see 477
* stimulates DNA synthesis	cultured arterial smooth muscle cells skin fibroblasts	rat man	see 477 see 477

Layer	RG	RET	RDS	RVS	OMA	ABO	AP	PYL
Mucosa and submucosa	66	55	34	31	53	77	90	76
Muscularis	75	78	55	65	59	69	67	78

Table 13. Radioimmunological quantification of Sub. P (picogram/mg tissue) in the stripped layers of the ruminant stomach wall of the adult sheep (n=6).

Photo 97. Reticular Groove.
Sub. P, cryostat section (50 µm), foetus 26 cm. Magn.555 x

A. Tunica Mucosa
B. Tunica Submucosa
C. Tunica Muscularis

8. Isolated Sub. P-IR nerve fibres
10. Intramuscular Sub. P-IR nervous network in the circular muscle layer

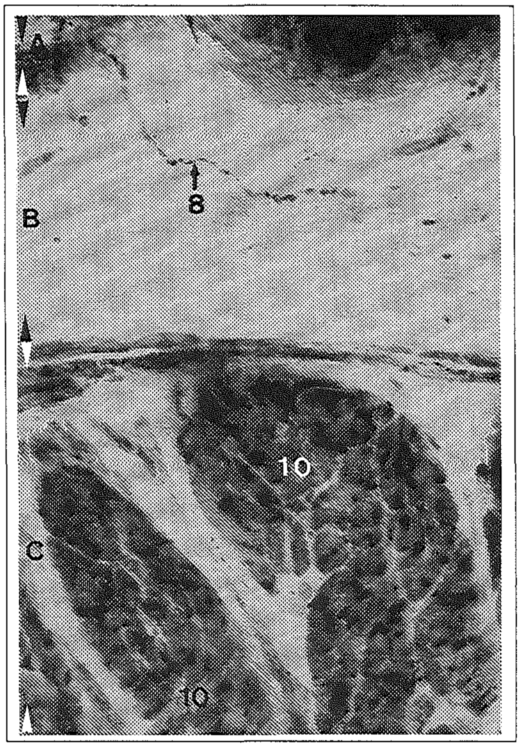
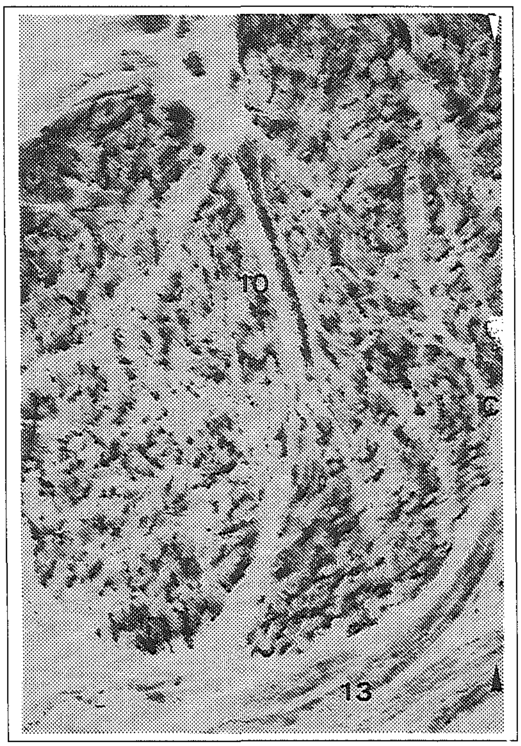


Photo 98. Reticular Groove.
Sub. P, cryostat section (50 µm), foetus 26 cm. Magn.373 x

C. Tunica Muscularis

10. Dense, intramuscular Sub. P-IR nervous network in the circular muscle layer at the level of the lip
13. Intramuscular Sub. P-IR nerve fibres in the longitudinal muscle layer



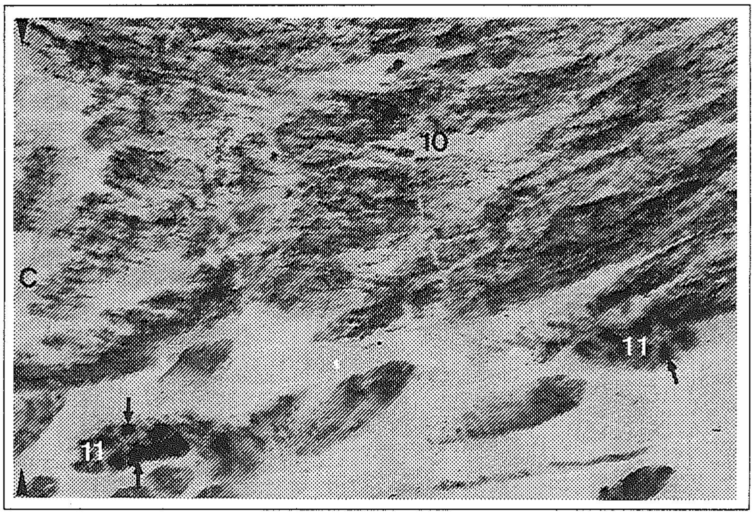


Photo 99. Reticular Groove.

Sub. P, cryostat section (50 µm), foetus 26 cm. Magn.414 x

C. Tunica Muscularis

10. Dense, intramuscular Sub. P-IR nervous network in the circular muscle layer
11. Plexus Auerbach with Sub. P-IR perikarya

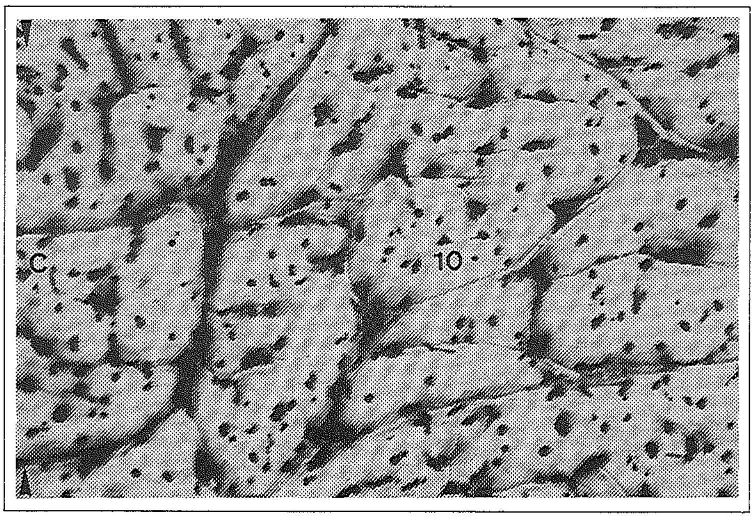


Photo 100. Reticular Groove.

Sub. P, cryostat section (50 µm), adult sheep. Magn.533 x

C. Tunica Muscularis

10. Dense, intramuscular Sub. P-IR nervous network in the circular muscle layer. Note the thicker Sub. P-IR nerve bundles between and the thinner Sub. P-IR nerve bundles within the smooth muscle bundles

Photo 101. Reticulum.

Sub. P, cryostat section (50 μm), adult sheep. Magn.474 x

C. Tunica Muscularis

10. Intramuscular Sub. P-IR nervous network in the circular muscle layer. Note the thicker Sub. P-IR nerve bundles between and the thinner Sub. P-IR nerve bundles within the smooth muscle bundles

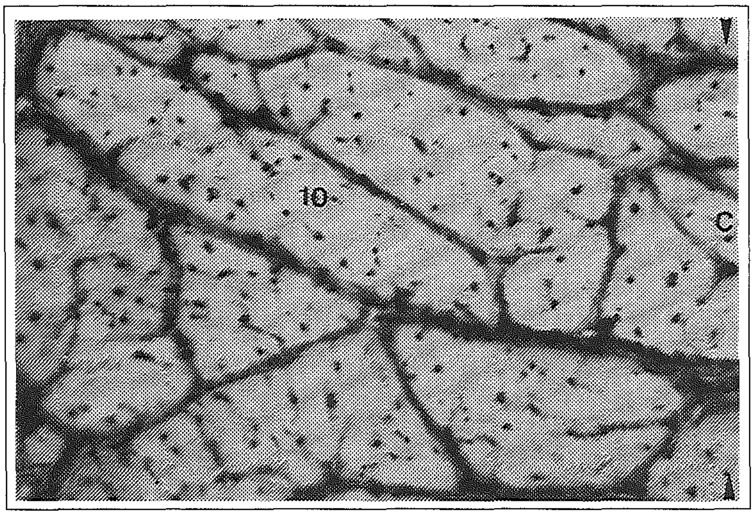


Photo 102. Reticulum.

Sub. P, cryostat section (50 μm), adult sheep. Magn.474 x

C. Tunica Muscularis

13. Intramuscular Sub. P-IR nervous network in the longitudinal muscle layer

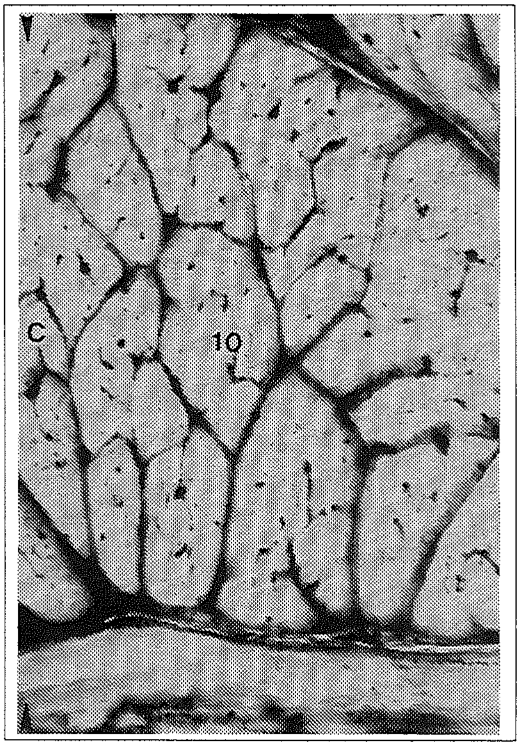


Photo 103. Ruminal Dorsal Sac.
Sub. P, cryostat section (50 µm), adult sheep. Magn.474 x

C. Tunica Muscularis

10. Intramuscular Sub. P-IR nervous network in the circular muscle layer. Note the thicker Sub. P-IR nerve bundles between and the thinner Sub. P-IR nerve bundles within the smooth muscle bundles

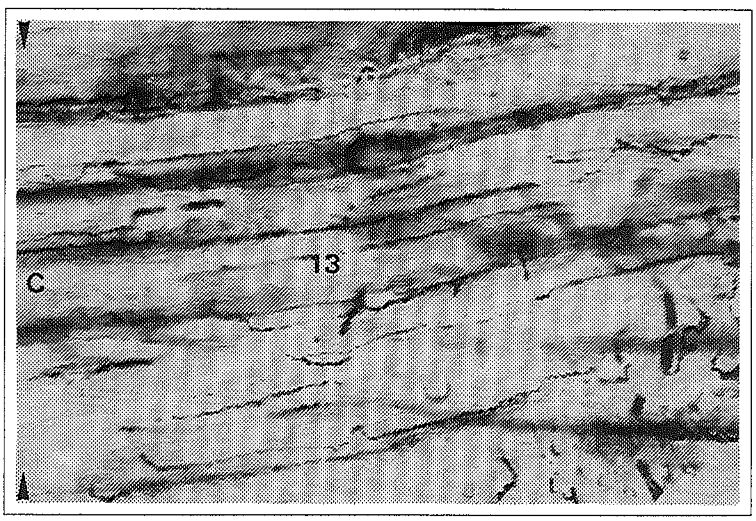


Photo 104. Ruminal Dorsal Sac.
Sub. P, cryostat section (50 µm), adult sheep. Magn.474 x

C. Tunica Muscularis

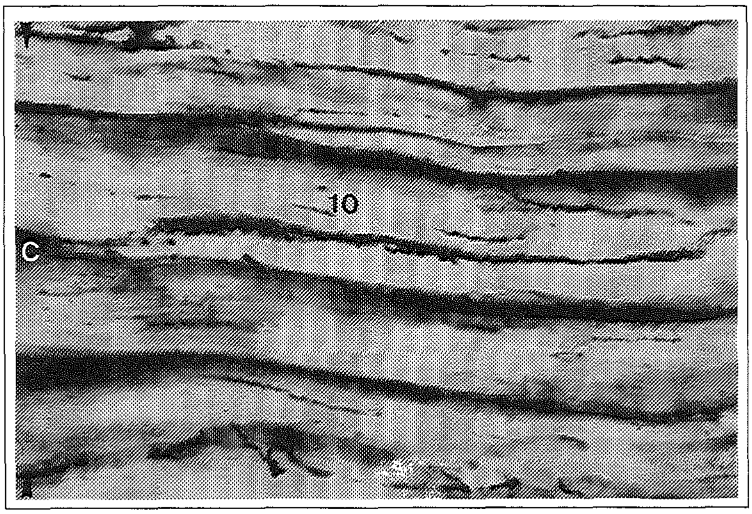
13. Intramuscular Sub. P-IR nervous network in the longitudinal muscle layer

Photo 105. Ruminal Ventral Sac.

Sub. P, cryostat section (50 µm), adult sheep.
Magn.503 x

C. Tunica Muscularis

10. Intramuscular Sub. P-IR nervous network in the circular muscle layer



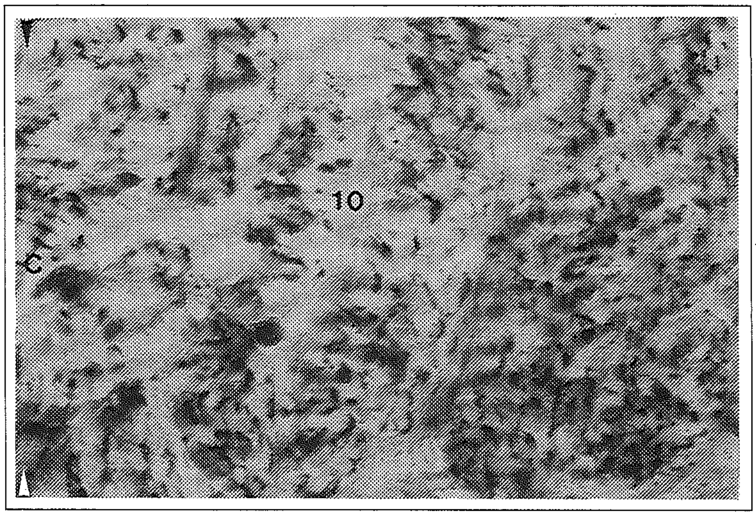


Photo 106. Ostium Reticulo-Omasicum.

Sub. P, cryostat section (50 μm), foetus 26 cm. Magn.503 x

C. Tunica Muscularis

10. Intramuscular Sub. P-IR nervous network in the circular muscle layer

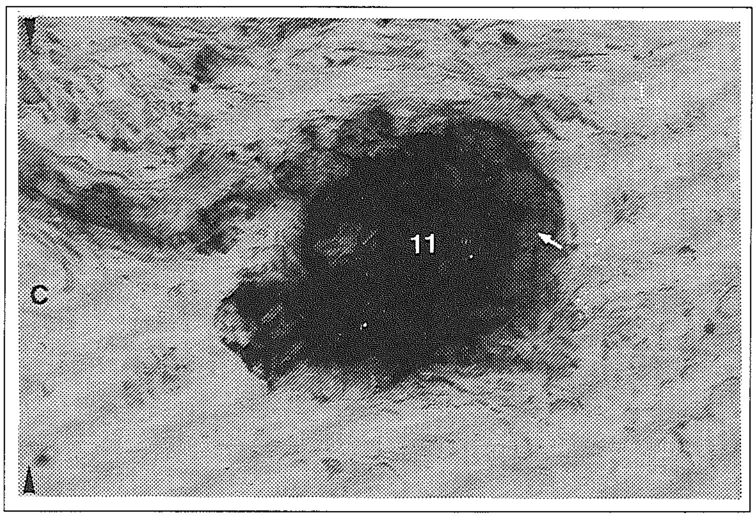


Photo 107. Ostium Reticulo-Omasicum.

Sub. P, cryostat section (50 μm), foetus 26 cm. Magn.1156 x

C. Tunica Muscularis

11. Plexus Auerbach: Sub. P-IR nerve fibres around non-immunoreactive perikarya

Photo 108. Abomasum.

Sub. P, cryostat section (50 µm), foetus 26 cm. Magn.592 x

C. Tunica Muscularis

10. Intramuscular Sub. P-IR nervous network in the circular muscle layer

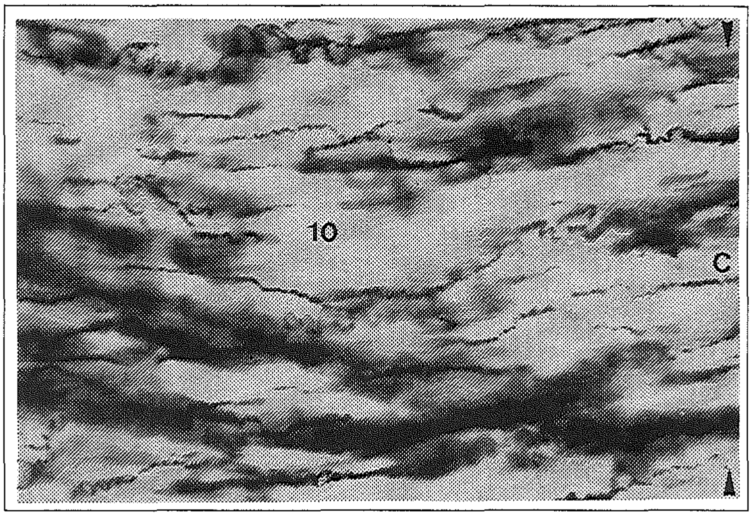
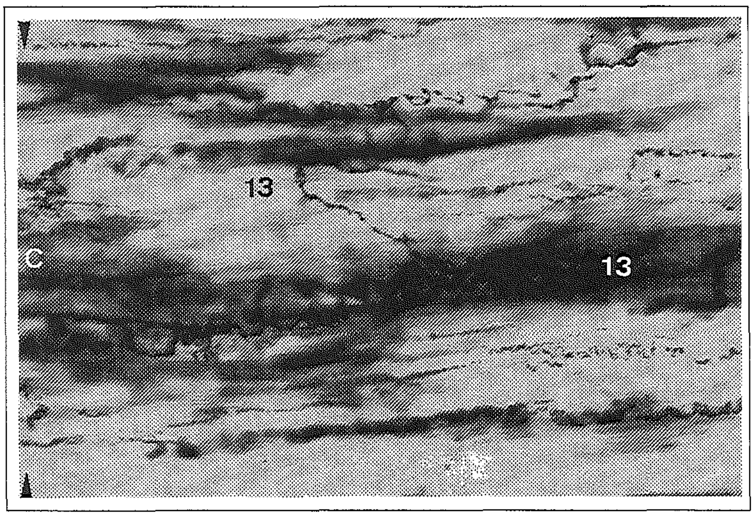


Photo 109. Abomasum.

Sub. P, cryostat section (50 µm), foetus 26 cm. Magn.651 x

C. Tunica Muscularis

13. Intramuscular Sub. P-IR nervous network in the longitudinal muscle layer



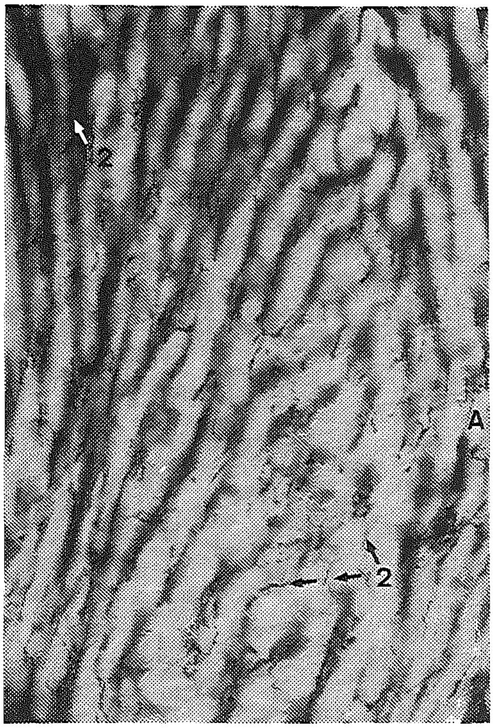


Photo 110. Pylorus.

Sub. P, cryostat section (50 µm), adult sheep. Magn.414 x

A. Tunica Mucosa

2. Plexus mucosus: Sub. P-IR nerve fibres in lamina propria

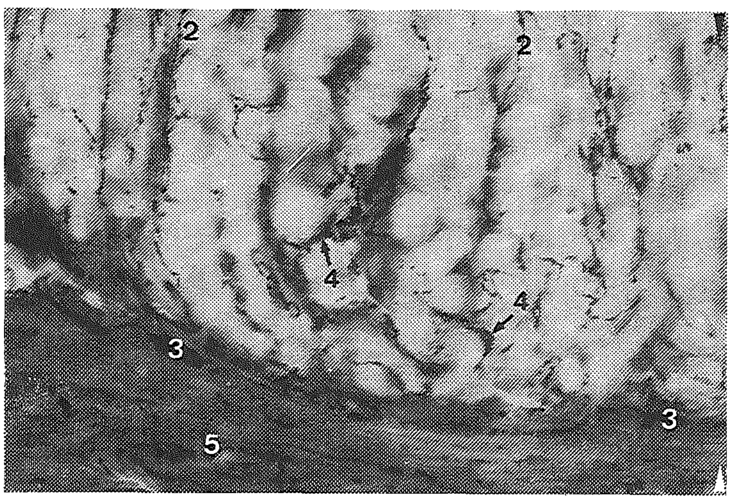


Photo 111. Pylorus.

Sub. P, cryostat section (50 µm), adult sheep. Magn.414 x

A. Tunica Mucosa

2. Plexus mucosus: Sub. P-IR nerve fibres in lamina propria
3. Plexus mucosus: ganglion, showing Sub. P-IR, between the basis of the glands and the lamina muscularis mucosae
4. Plexus mucosus: periglandular Sub. P-IR nerve plexus
5. Lamina muscularis mucosae innervated by several Sub. P-IR nerve fibres

Photo 112. Pylorus.

Sub. P, cryostat section (50 μm), adult sheep. Magn.414 x

C. Tunica Muscularis

10. Intramuscular Sub. P-IR nervous network in the circular muscle layer

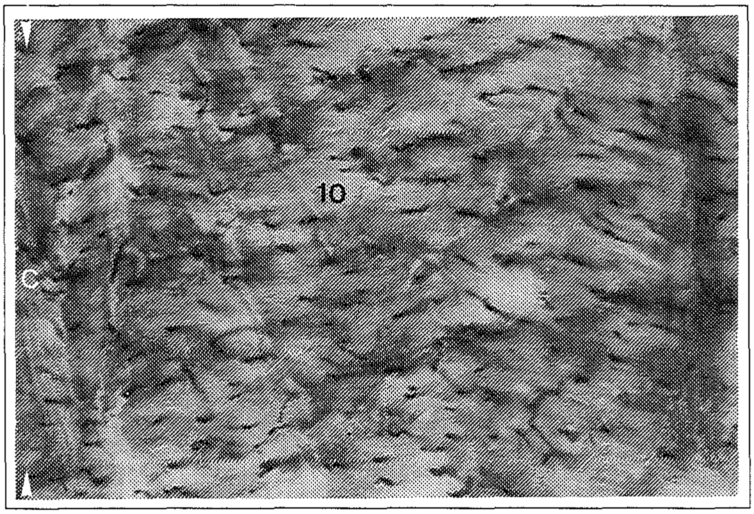


Photo 113. Pylorus.

Sub. P, cryostat section (50 μm), adult sheep. Magn.373 x

C. Tunica Muscularis

13. Intramuscular Sub. P-IR nervous network in the longitudinal muscle layer

Paraffin sections

Adult sheep								
Layer	RG	RET	RDS	RVS	OMA	ABO	AP	PYL
mucosa	+	+	-	-	+	+	+	+
submucosa	(+)	(+)	(+)	(+)	-	+	+	+
circular muscle layer	++	++	++	++	++	++	++	++
Auerbach	+	+	+	+	+	+(+)	+	+
longitudinal muscle layer	+	++	+	+	(+)	+	+	+
Foetus								
Layer	RG	RET	RDS	RVS	OMA	ABO	AP	PYL
mucosa								
submucosa								
circular muscle layer			no reaction in any of the segments					
Auerbach								
longitudinal muscle layer								

Table 14. Distribution pattern of the Sub. P-IR in the wall of the ruminant stomach of the sheep as seen in paraffin sections.

Cryostat sections

Adult sheep								
Layer	RG	RET	RDS	RVS	OMA	ABO	AP	PYL
mucosa	+	+	-	-	+	+	+	++
submucosa	+	(+)	-	+	-	+	+	++
circular muscle layer	++	++	++	++	++	++	++	+++
Auerbach	(+)	++	++	+	+	+	+	+
longitudinal muscle layer	+(+)	++	+(+)	+(+)	+	?	+(+)	+(+)
Foetus								
Layer	RG	RET	RDS	RVS	OMA	ABO	AP	PYL
mucosa	+	+	-	-	+	+	+	+
submucosa	+(+)	+(+)	+(+)	+(+)	(+)	+(+)	+	++
circular muscle layer	++	++	++	++	++	++	++	++
Auerbach	+	+	+	+	+	+	+	+
longitudinal muscle layer	+	++	+	+	+	+(+)	+	+(+)

Table 15. Distribution pattern of the Sub. P-IR in the wall of the ruminant stomach of the sheep as seen in cryostat sections.

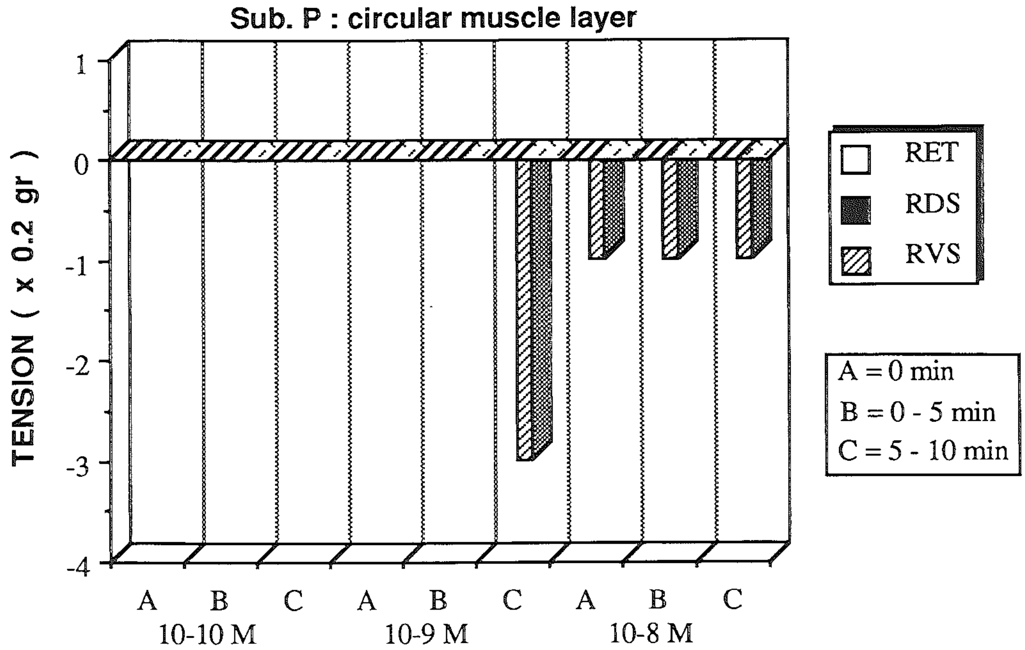


Fig. 37. Graphic representation of the in vitro effect of substance P (Sub. P) on the circular muscle layer of the RET; RDS and RVS.

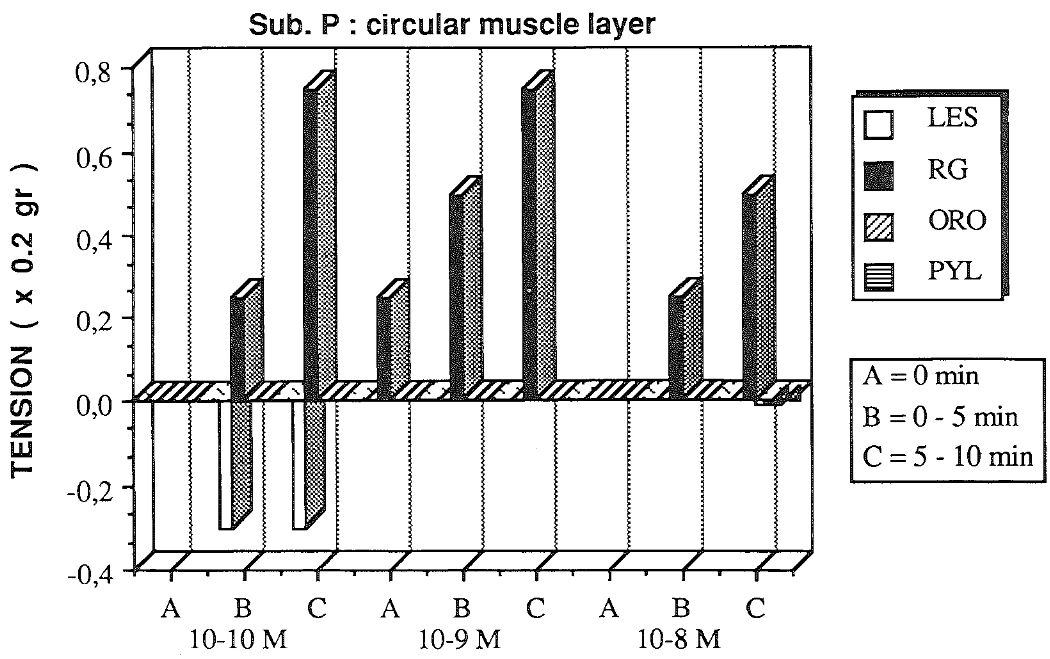


Fig. 38. Graphic representation of the in vitro effect of substance P (Sub. P) on the circular muscle layer of the sphincters: LES; RG; ORO and PYL.

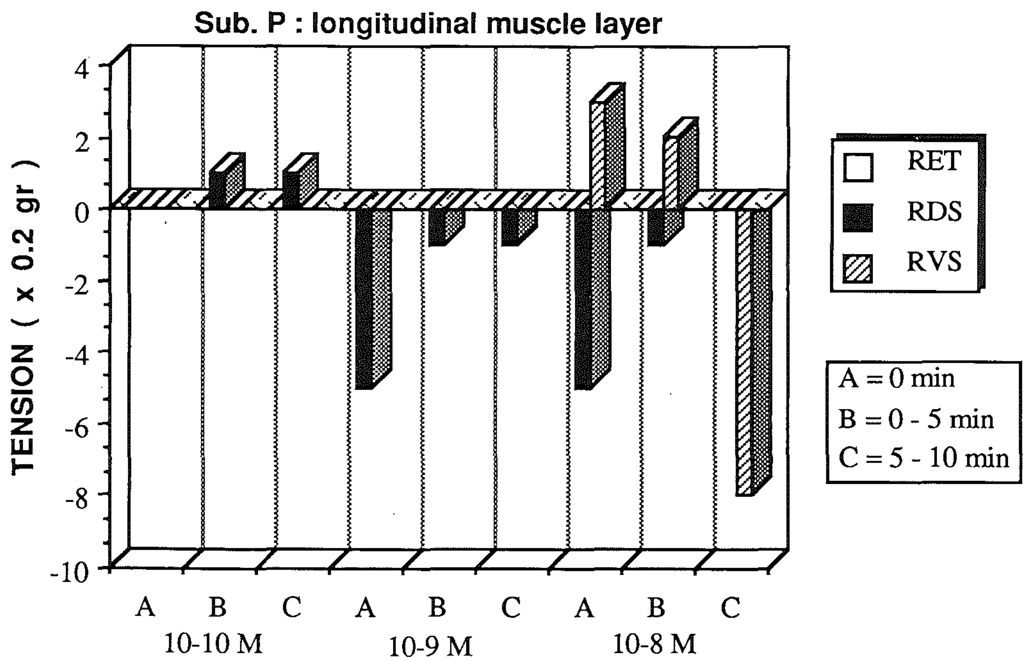
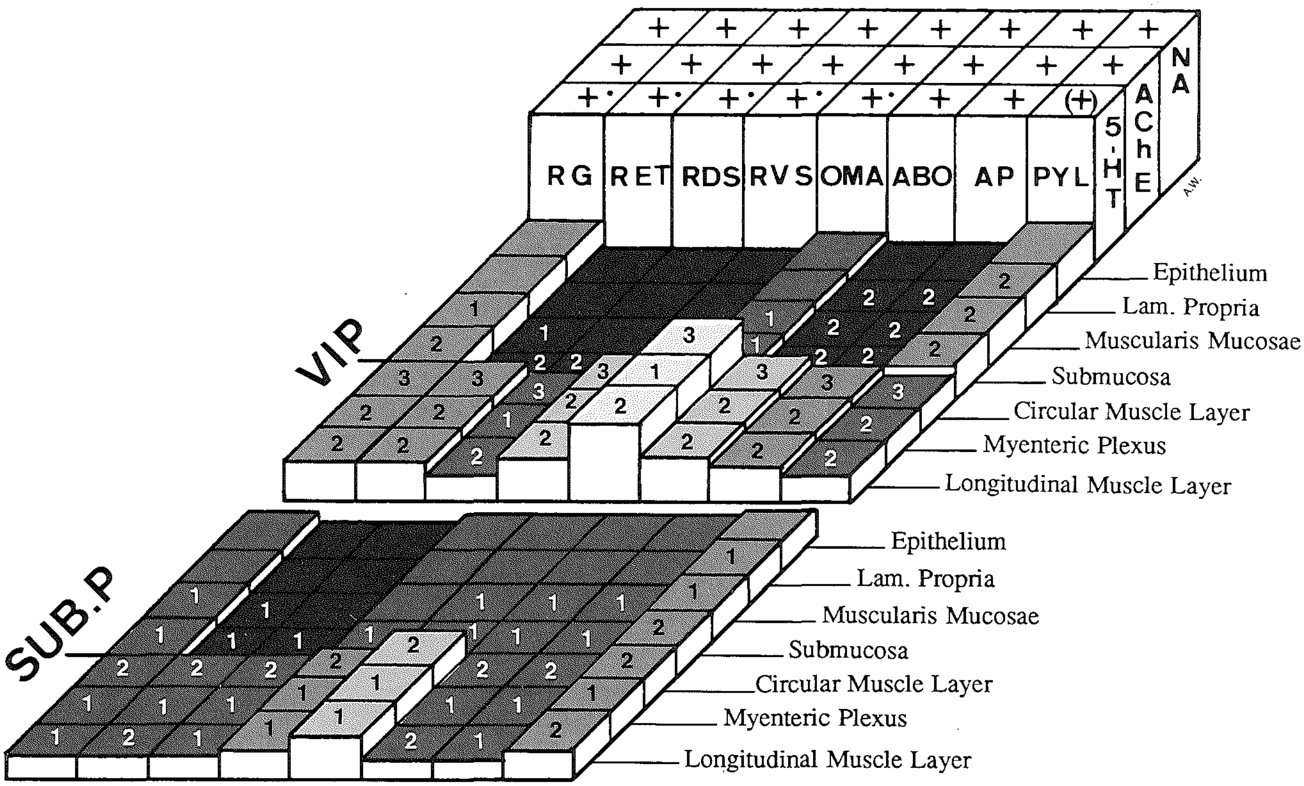


Fig. 39. Graphic representation of the in vitro effect of substance P (Sub. P) on the longitudinal muscle layer of the RET; RDS and RVS.



+ = positive reaction; + * = positive reaction in foetuses only; 1= few, 2= several and 3= numerous immunoreactive structures.
ABO: abomasum; AChE: acetylcholinesterase; AP: antrum pyloricum; NA: noradrenaline; OMA: omasum; PYL: pylorus; RDS: ruminal dorsal sac; RET: reticulum; RG: reticular groove; RVS: ruminal ventral sac; SUB. P: substance P; VIP: vasoactive intestinal polypeptide; 5-HT: serotonin.
The height of the blocks is directly related to the quantitative results of the radioimmunological study; the density of the lattice is inversely related to these results. The results of the immunohistochemical study are represented by the numbers 1 to 3.

Fig. 40. Diagram summerizing the results of the histochemical, radioimmunological and immunohistochemical approach used in the study concerning the neurotransmitters/modulators involved in the motor and secretory functions of the ruminant stomach of the sheep.

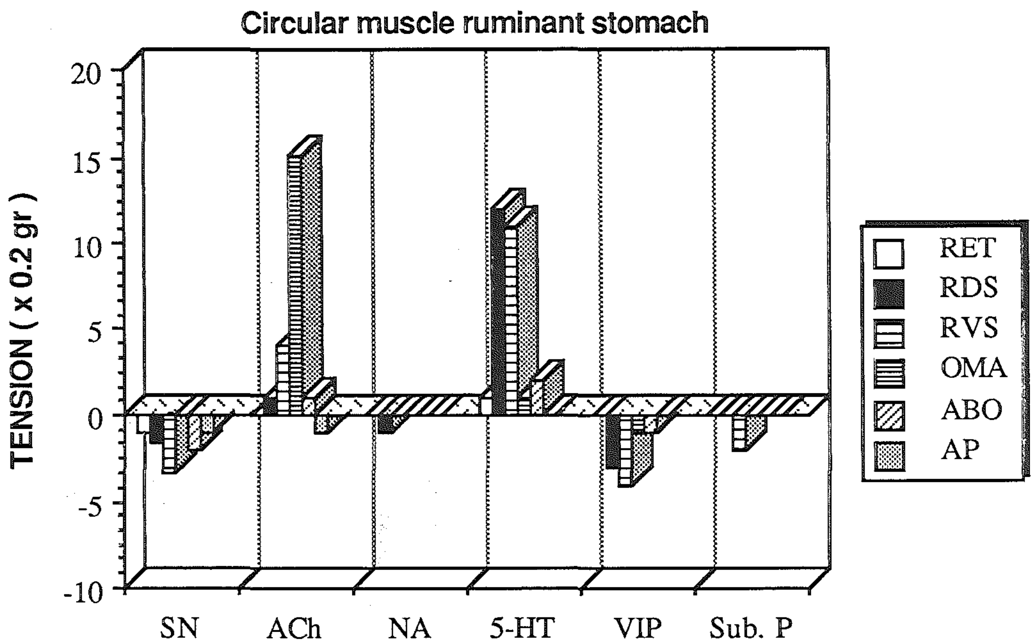


Fig. 41. Graphic representation of the mean in vitro effect of SN and different neurotransmittres on the tone of the circular muscle layer of the RET; RDS; RVS; OMA; ABO and AP.

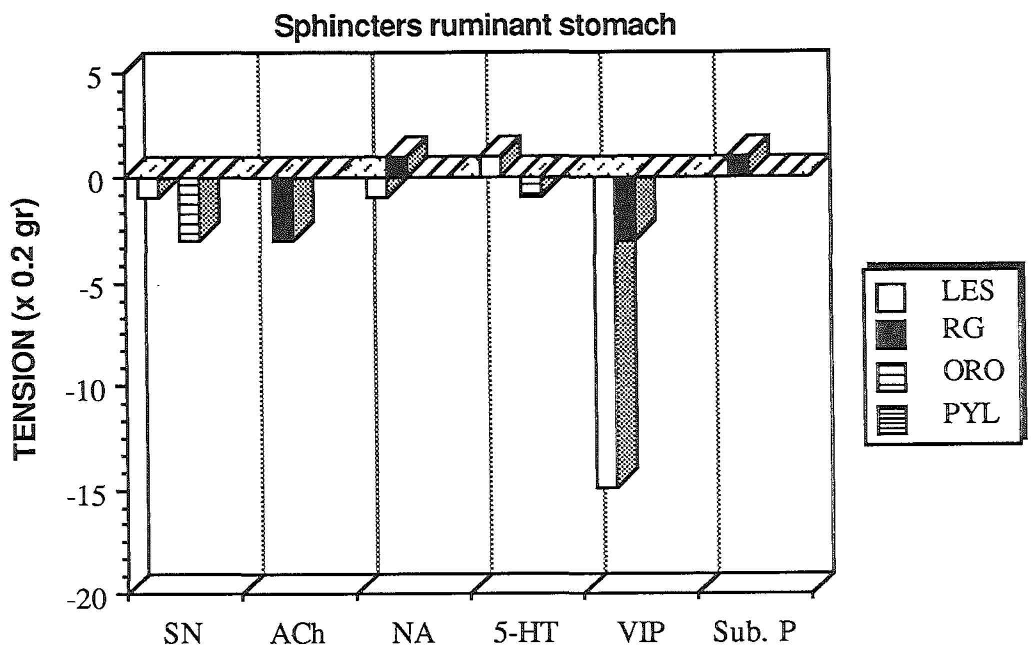


Fig. 42. Graphic representation of the mean in vitro effect of SN and different neurotransmittres on the tone of the circular muscle layer of the sphincters: LES; RG; ORO and PYL.

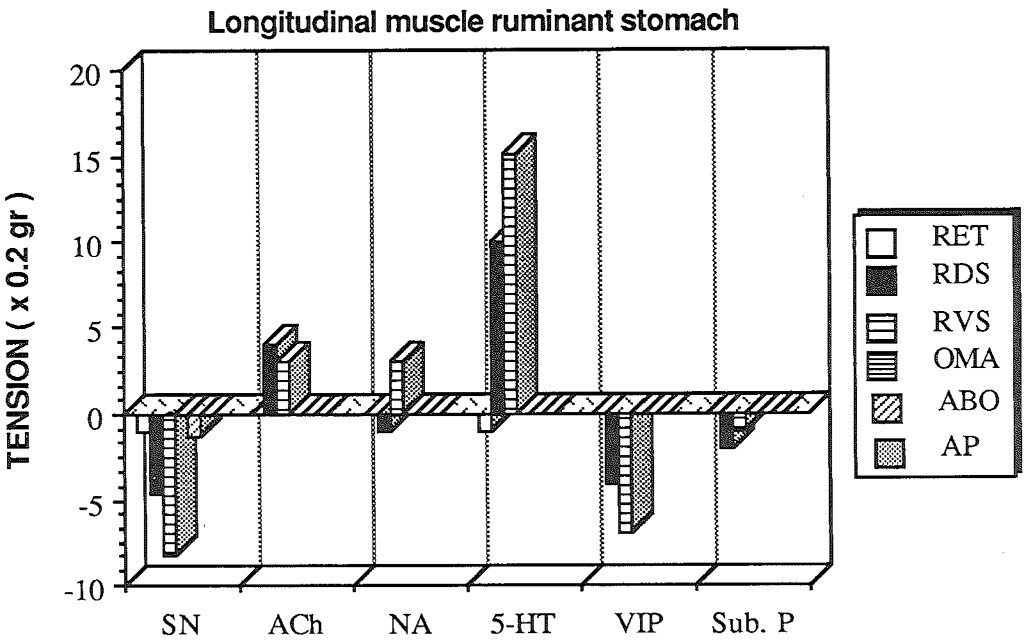


Fig. 43. Graphic representation of the mean in vitro effect of SN and different neurotransmittres on the tone of the longitudinal muscle layer of the RET; RDS; RVS; OMA; ABO and AP.

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