

Chapter 4

OBSERVATIONS ON THE ANATOMY OF, AND DISPERSION OF CONTRAST
MEDIUM IN, THE DIGESTIVE TRACT OF MACROPODINES4.1 Introduction

Existing descriptions of the anatomy of the digestive tract of the macropodines have centred on the topographical features of the stomach, and on the histology of the stomach wall (see Section 2.1). In two early comparative studies some minor variations in stomach structure were noted among three species, M. giganteus (eastern grey kangaroo), M. parryi (whiptail wallaby), and Petrogale penicillata (one of the rock wallaby species) by Owen (1868), and between M. giganteus and M. rufogriseus var. bennetti (Tasmanian red-necked or Bennett's wallaby) by MacKenzie (1918). Schäfer and Williams (1876) described and compared the different and relative distributions of the squamous and cardiac glandular epithelial cell lining of the forestomach of M. giganteus and Dorcopsis luctuosa (one of the New Guinea wallabies).

More recently, Moir, Somers and Waring (1956) and Brown (1964) examined stomachs from a wider range of species and concluded that the general gross structure of the stomach was similar, and therefore the general pattern of digestive physiology should also be similar, in all species of macropodines.

However, preliminary dissection of the digestive tracts from M. eugenii (tammar wallaby), T. thetis (red-necked pademelon) and M. giganteus in the initial stages of the present study revealed marked differences among the three species in both the structure and the dimensions of the stomach. A more comprehensive comparative investigation was subsequently conducted in order to define differences in digestive tract structure and dimensions, and to determine whether the differences in stomach structure influenced the pattern of flow of digesta observed radiologically.

The digestive tracts from specimens of M. robustus (eastern wallaroo), Me. rufa (red kangaroo), W. bicolor (swamp wallaby), M. rufogriseus, M. parma (parma wallaby), T. stigmatica (red-legged pademelon) and T. billarderi (red-bellied pademelon) were also examined, and radiological observations on the dispersion of contrast medium in the stomach were also undertaken with M. robustus and W. bicolor.

4.2 Materials and methods

4.2.1 Anatomy

Digestive tracts were obtained either from animals shot in the field, or from animals housed under laboratory conditions. The entire digestive tract, from the hiatus oesophageus to the rectum, was dissected free from the abdominal cavity and carefully removed to minimise distortion, and dissected free of mesenteric attachment. After photography and recording of the topographical features of the gut, the stomach was opened along the medial surface, dorsal to the cardia, and parallel to and immediately ventral to the right taenia. Contents were removed, the mucosal surface washed free of digesta particles with 0.9% NaCl, photographed, and examined for distribution of the mucosal epithelia and definition of the sulcus.

Photography was done either by the Central Photographic Laboratory of the University of New England, or with the use of a Cosina SLR camera using 35 mm ASA 64/19 DIN or ASA 100/21 DIN Kodak film. Stomach wall sample blocks for histological examination were fixed in 10% buffered formalin and further processed by the CSIRO Division of Animal Physiology, Sydney.

The digestive tracts from animals of the other species mentioned above were also examined for comparison as material became available.

4.2.2 Dimensions and capacities of the digestive tract

In conjunction with Experiment 6 (see Chapter 7), measurements were recorded of the digestive tracts from four adult animals of each of the three species M. eugenii, T. thetis and M. giganteus. The twelve animals had been fed chopped lucerne hay ad libitum for a minimum period of seven weeks. Food was replaced twice daily during the last seven days and at 6 h intervals during the three days prior to, and up to, the time of slaughter.

After each animal was sedated with ketamine hydrochloride and then killed with an overdose of pentobarbitone sodium (see Section 3.4.1), body weight was recorded, the abdominal cavity opened along the ventral surface, and the digestive tract carefully dissected free and removed. Length and weights (with and without digesta contents) of each defined region of the gut were recorded. Digesta from each region was subsampled for estimation of dry matter. Both the small and the large intestine were dissected free of mesenteric attachment, care was taken to avoid stretching of the intestine, and estimates of length were recorded before removing the digesta contents.

4.2.3 Radiology

The initial dispersion and subsequent distribution of barium sulphate suspension in the stomach, and movement to and in the large intestine, were recorded on single radiographic plates using a Stanford "Stabil-X-40" portable x-ray machine (Department of Physiology, University of New England), or observed and recorded on videotape with the use of a Phillips "Super Practix" 15 cm image intensifier (at the Department of Veterinary Surgery, University of Queensland).

The animals used for these observations, four M. eugenii (3-5 kg body weight), four T. thetis (3-6 kg) and three M. giganteus (12-15 kg), were mature animals and were

maintained in metabolism cages and fed chopped lucerne hay ad libitum. Single plate observations were also made on two M. robustus robustus and two W. bicolor.

Individual animals were sedated with ketamine hydrochloride (10 to 20 mg/kg body weight) injected intramuscularly. The contrast medium ("Tixobar", Astra Chemicals, Sydney, N.S.W.) was then introduced orally with a syringe, and the animal induced to swallow, or infused via an oesophageal tube. Radiographic observations were made during the infusion and at intervals up to eight hours, then at 24 h with the animal either conscious and placed in a bag, or under ketamine hydrochloride sedation.

Four further animals, two M. eugenii and two T. thetis, were surgically prepared with an infusion catheter opening into the gastric region of the stomach (see Section 3.4.2). Initial and subsequent dispersion of contrast medium injected slowly through the catheter into the caudal region of the stomach was monitored with single radiographic plates.

4.3 Results

4.3.1 Stomach anatomy

The macropodine stomach consists of two functionally distinct regions, the enlarged forestomach, where microbial fermentation of ingested food occurs, and the hindstomach which is the acid-secretory region.

The forestomach is regarded as consisting of two regions, the sacciform forestomach and the tubiform forestomach. The division between these two regions extends in a perpendicular plane (in situ) from a ventral fold, adjacent to the cardia, to the dorsal wall of the forestomach (Langer, Dellow and Hume, in press).

a) Topography of the stomach

Diagrams (Fig. 4.1.a) of the photographs (Fig. 4.1.b) of stomachs from adult specimens of M. eugenii (body weight, 3.8 kg), T. thetis (4.1 kg) and M. giganteus (38.0 kg) denote the three regions and the main topographic features. In Fig. 4.2.a, the stomach and intestine of M. giganteus are displayed; the mesenteric attachments between segments of the stomach have been left intact and the stomach is viewed from the ventral surface.

In all three species, the stomach is essentially a long, curved tubular structure of varying diameter. Along most of the length of the greater curvature of the tubiform forestomach, and of the sacciform forestomach to a lesser extent, the stomach wall is extensively folded, particularly in the zone where the diameter is greatest; that is, in the proximal limb of the tubiform forestomach. These folds, or haustrations, are maintained by three bands of longitudinal muscle, the taeniae. Two of these taeniae, one on the left and one on the right of the tubiform forestomach, extend on to the sacciform forestomach wall. A third, less distinct taenia on the greater curvature of the stomach, and under the line of attachment of the gastro-splenic omentum, terminates proximally at the sacciform-tubiform forestomach junction. Distally, the three taeniae become less prominent towards the hindstomach.

The haustrations associated with these taeniae form deep semilunar folds within the stomach lumen. These folds extend around the greater curvature and are perpendicular to the long axis of the stomach. The degree of haustration of the forestomach wall varies among species. There are no haustrations along the lesser curvature of the forestomach wall between the right and left taeniae, or on the hindstomach wall, although in T. thetis, some infolding of the lesser curvature wall of the tubiform forestomach is apparent (Fig. 4.1.b).

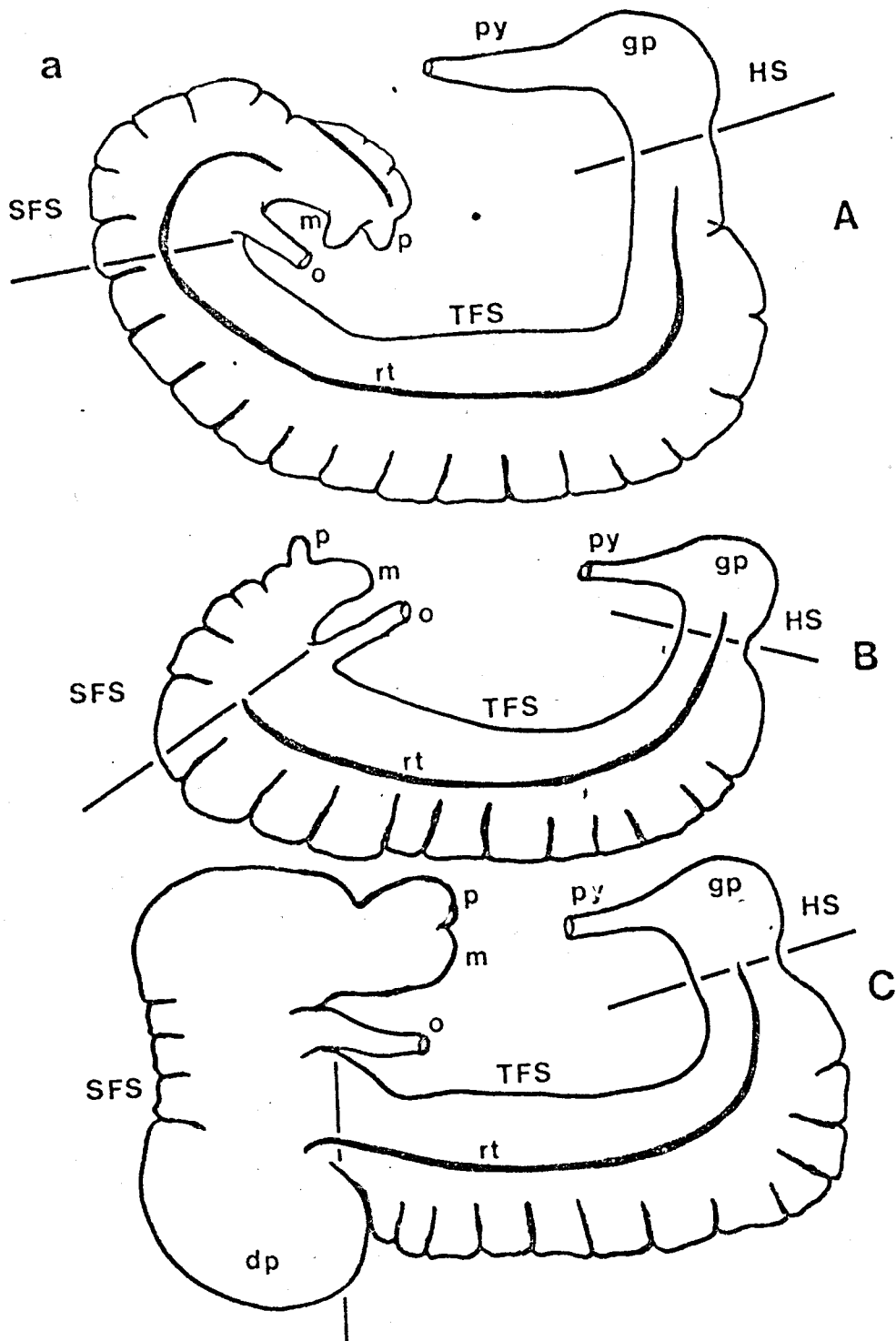


Fig.4.1. Diagrams (a) of the photographs (b) of the external features of the stomach of: A, *M. giganteus*; B, *M. eugenii*; C, *T. thetis*. Scales; in A and B the background squares are 10 cm X 10 cm, in C the scale is in cm. SFS = sacciform forestomach, TFS = tubiform forestomach, HS = hindstomach. dp = dorsal pouch (*T. thetis* only), gp = gastric pouch, m, p, = medial and parietal blind sacs, o = oesophagus, py = pylorus, rt = right taenia.



b

A



B



C

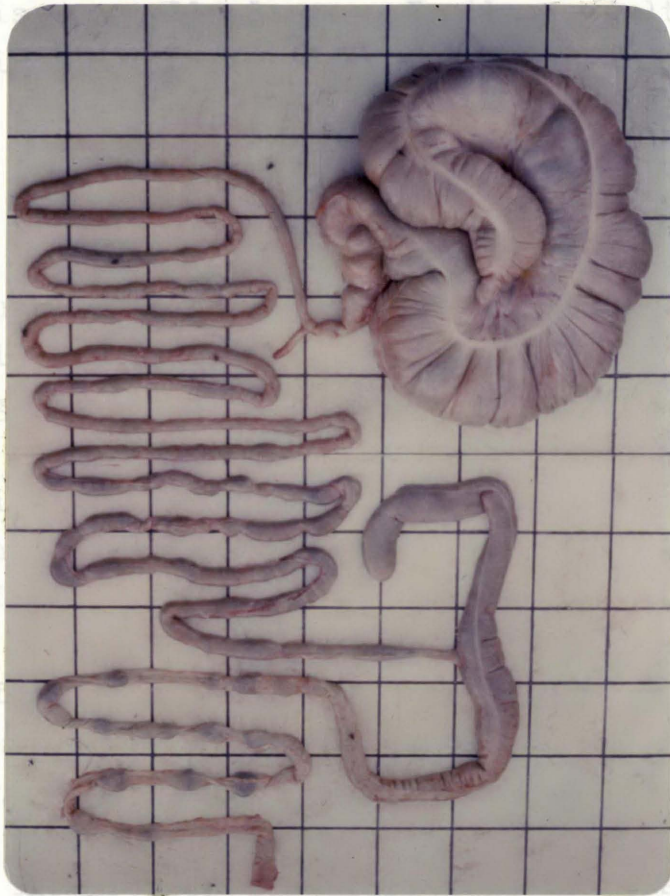


Fig. 4.2.a. Stomach and intestine of M. giganteus

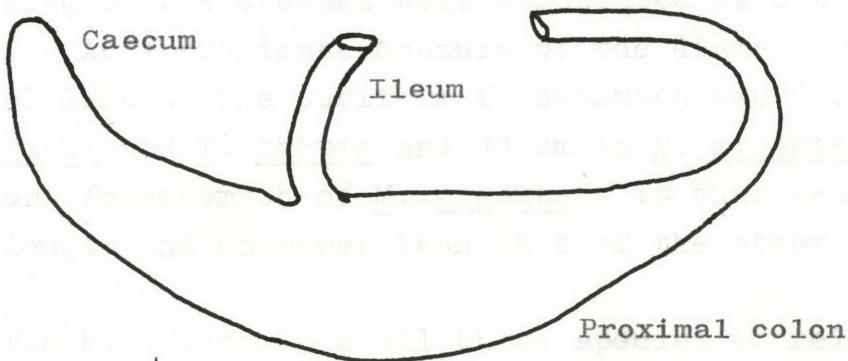


Fig. 4.2.b. Caecum-proximal colon of T. thetis

The abdominal segment of the oesophagus in the macropodines is unusually long. In these adult specimens (Fig. 4.1.b) it measured 5 cm in M. eugenii, 7 cm in T. thetis and 15 cm in M. giganteus, at the time of slaughter.

In these three species there are two diverticulae at the cranial end of the sacciform forestomach, the parietal and medial blind sacs. The size and shape of these blind sacs vary slightly among the three species.

The sacciform forestomach of T. thetis is relatively much larger than that of the other two species, and the upper region forms a large dorsal pouch.

The tubiform forestomach measures 15 cm from the cardia to the forestomach-hindstomach junction in the specimens of M. eugenii (Fig 41.b), 17 cm in T. thetis and 60 cm in M. giganteus.

The length of the greater curvature wall is considerably longer; from the tip of the forestomach to the forestomach-hindstomach junction it measured approximately 47 cm in M. eugenii, 48 cm in T. thetis and 170 cm in M. giganteus. This does not take into account the extensive transverse infolding of the stomach wall associated with the semilunar folds. An approximate measure of the diameter of the cranial limb of the tubiform forestomach was 5 cm in M. eugenii and T. thetis and 11 cm in M. giganteus. The tubiform forestomach of M. giganteus is thus relatively much longer and narrower than that of the other two species.

The hindstomach in all three species is relatively small. Approximately one third of the hindstomach is formed into a dorsal gastric pouch.

The stomach in situ lies on the ventral and lateral walls of the abdominal cavity, and is accommodated by extensive coiling as is evident in Fig. 4.2.a. The hindstomach lies dorsal to the caudal limb of the tubiform

forestomach in situ but in this picture it has been displaced to the left.

b) The mucosal surface of the stomach lumen

The mucosal surface of the macropodine forestomach is composed of squamous epithelium and cardiac glandular epithelium. Fundic and pyloric glandular epithelial cells are confined to the hindstomach. The histology of the cells lining the stomach of M. eugenii has been previously described in detail by Gemmell and Engelhardt (1977).

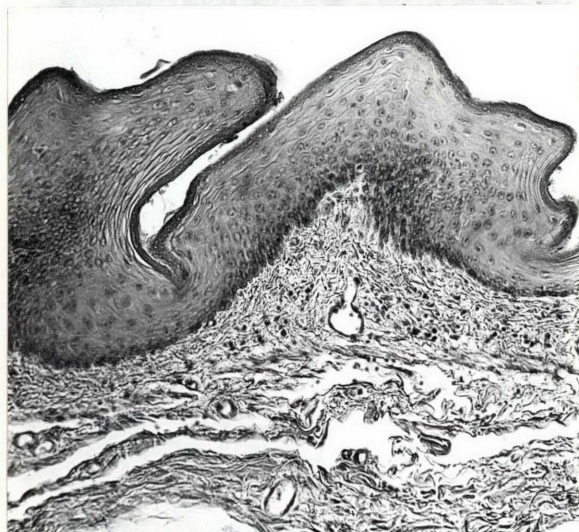
The structure of the squamous epithelium and of the cardiac epithelium found in the forestomach of T. thetis and M. giganteus is pictured in Fig. 4.3.a and Fig. 4.3.b, respectively.

Diagrams (Fig. 4.4.a) of the photographs (Fig. 4.4.b) of the mucosal surface of the stomachs of M. eugenii, T. thetis and M. giganteus illustrate the presence or absence of a gastric sulcus and the distribution of the four epithelial cell types.

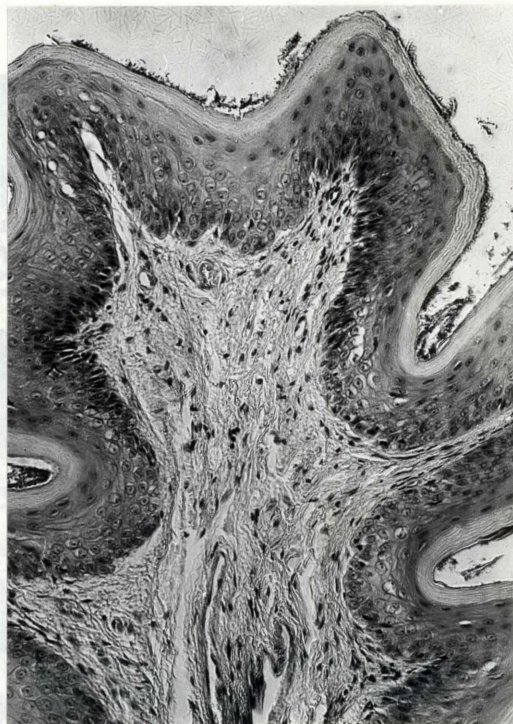
In M. eugenii the gastric sulcus is prominent and extends caudally from the cardia some two-thirds of the distance along the lesser curvature of the tubiform forestomach. The gastric sulcus is a wide, longitudinal groove bordered by a right and a left lip.

In the adult M. giganteus, the gastric sulcus is relatively much smaller (Fig. 4.4.b), and the associated lips are poorly defined. By contrast, the gastric sulcus of the milk-fed pouch young of this species is well developed (Fig. 4.5) and is a major feature of the undeveloped forestomach.

In T. thetis, the gastric sulcus is absent in both the adult (Fig. 4.4.b) and the pouch young (Langer, Dellow and Hume, in press).



A (x 100)



B (x 200)

Fig. 4.3.a. Squamous epithelium from the sacciform forestomach of: A, T. thetis; B, M. giganteus (H & E stain). Note cornification of the epithelia, this was not evident in tissue from M. eugenii. The epithelium is often folded, as above, and there is interdigititation with the lamina propria. Papillation within the sacciform forestomach is rare. Samples were obtained from adult animals shot in the field.



A (x 200)



B (x 200)

Fig. 4.3.b. Cardiac glandular mucosa from the ~~the~~ tubiform forestomach of: A, T. thetis; B, M. giganteus (H & E stain). The typical tubular glands were evident in all three species. This mucosa is generally much thicker than squamous epithelium; estimates of mean minimal thickness and relative distributions of stomach epithelia are detailed by Langer, Dellow and Hume, in press). Samples were obtained from adult animals shot in the field.

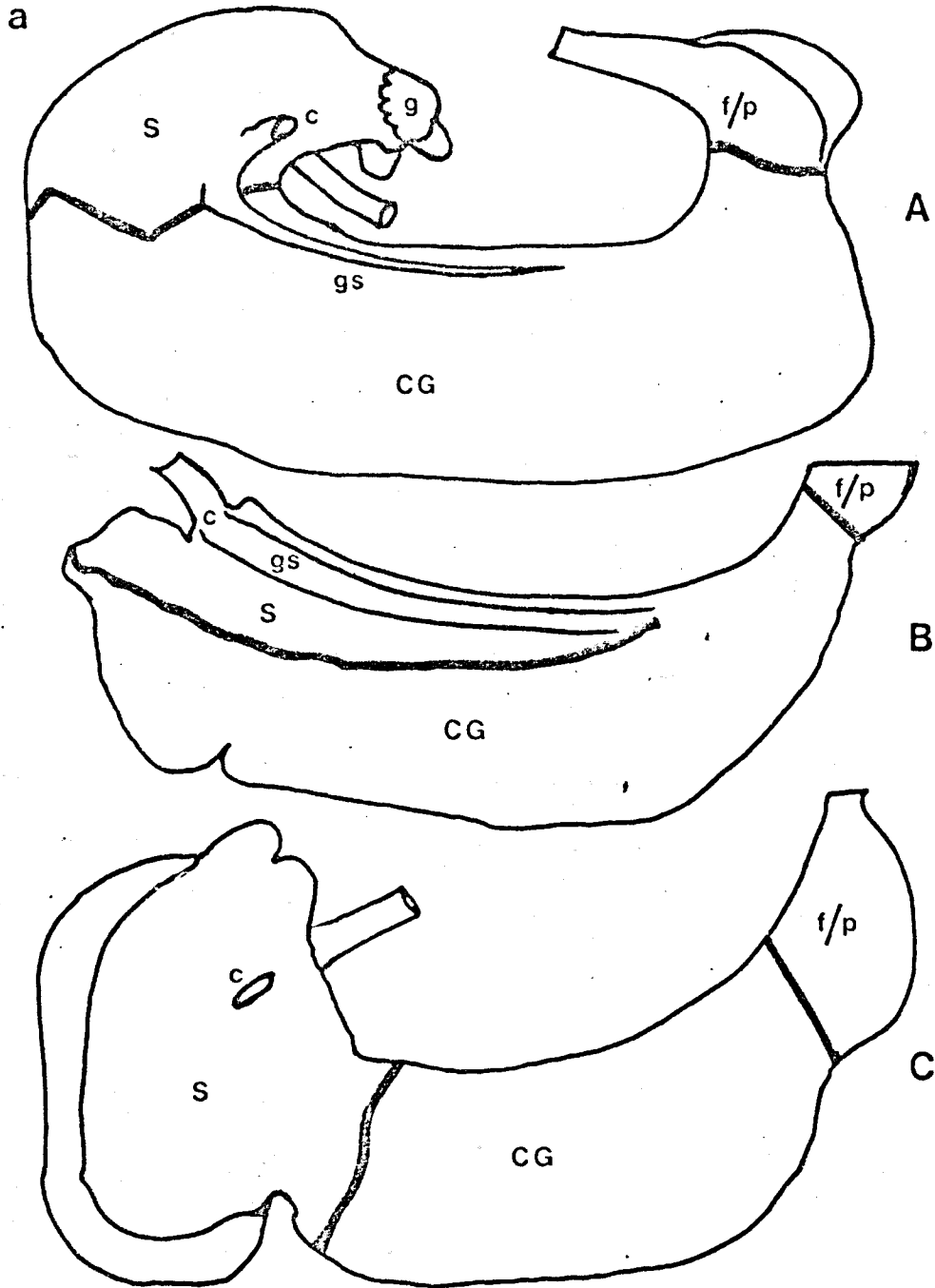


Fig. 4.4. Diagrams (a) of the photographs (b) of the mucosal surface of the stomach of: A, *M. giganteus*; B, *M. eugenii*; C, *T. thetis*. Scale; the background squares are 10 cm X 10 cm.

Zones of epithelia; S = squamous epithelium, CG = cardiac glandular epithelium, f/p = peptic and pyloric epithelia, g = glandular epithelium (*M. giganteus* only). c = cardia, gs = gastric sulcus.



b

A



B



C