ABSTRACT
The present investigation was planned to study the stomach of two species of bats, frugivorous bat (Rousettus aegyptiacus) and insectivorous bat (Taphozous nudiventris). Histologically, the stomach wall of both species exhibits four general regions, mucosa, submucosa, muscularis externa and serosa. The mucosa is thrown up into numerous villi-like folds (rugae) of various shapes and lengths and consists of gastric cells (surface and neck mucous cells, parietal and chief cells). The submucosa consists of connective tissue, blood and lymph vessels. The muscularis externa consists of outer thin longitudinal and inner thick circular muscle layers. The cytological observations confirmed the histological results. There are some differences between the four gastric cell types of the two species of bats are demonstrated. Additionally, by using Masson's trichrome and azan stains, the collagenous fibres are more numerous, dense and compact in tunica submucosa of T. nudiventris while the fibres are thin and irregular in R. aegyptiacus. In the histochemical study, the distribution of polysaccharides is demonstrated by PAS technique. The mucous cells of surface epithelium seem to secrete high mucin in both R. aegyptiacus and T. nudiventris. The gastric gland, mucous neck cells, and muscularis mucosa of R. aegyptiacus display moderate distribution of polysaccharides less than in T. nudiventris. The gastric cells of R. aegyptiacus have dense content of protein as shown by using BPB dye while muscularis externa and muscularis mucosa mucosa are demonstrated with moderate protein contents. In contrary, the gastric cells of T. nudiventris have moderate content of proteins while muscularis externa and muscularis mucosa mucosa have high proteins. Acid & alkaline phosphatases (AcP & AlP) activity is detected by azo dye precipitation (Gomori method). The gastric cells of mucosa of R. aegyptiacus have strong AcP activity and is more pronounced in muscularis, submucosa and muscularis of the stomach of T. nudiventris. The AIP activity is concentrated in the mucous cells of surface epithelium and isthmus region in both species of bats. The gastric cells of base and neck regions as well as muscularis and submucosa of stomach have no AIP activity in both species.

Key words: Bats, Stomach, Histology, Cytology, Histochemistry, Enzymes.
glands are present in clusters at the gastrointestinal junction in the duodenum. Agrawal and Gupta (1983) found that the stomach of Cynopterus sphinx (Frugivorous bat) is extremely large in size with large fundic cecum, long cardiac vestibule and long tubular terminus. The longitudinal muscles form a thin, almost uniform, sheet while the circular muscles are variable in depth. The gastroesophageal sphincter is absent. The pyloric sphincter is symmetrical with a long narrow pyloric valve. The rugae run longitudinally with a zigzag orientation in the fundic cecum, but is transversely oriented at its lesser curvature; short and discontinuously irregular on the lesser curvature; continuous longitudinal and parallel at the greater curvature. The parietal cells are numerous and concentrated in the middle zone of the fundic glands. Pyloric glands are extensively developed. The cardiac and pyloric glands resemble Brunner’s glands. Transitional glands occupy a small area. Brunner’s glands are not present at the gastro-duodenal junction.

The fundic mucosa in Trachops cirrhosus, Chiroderma trinitatum and C. villosum (Suborder, Microchiroptera) is studied comparatively by using transmission electron microscopy (Stucholme et al., 1986). Trachops is an animalivorous species that mainly feeds on Neotropical frogs, whereas both species of Chiroderma are frugivorous. In Trachops, the pepsin-producing chief cells are restricted to the basal portion of the gastric gland and produce an electron-dense product. In Chiroderma, the chief cells occupy up to 75% of the gland and produce a pale product. In Trachops, the parietal cells are less abundant and less active than in Chiroderma but mucous neck cells are far more abundant. The gastric pits are shallow in Chiroderma, whereas in Trachops it has deep gastric pits. The mucous secretary granules in the surface mucous cells in Chiroderma differ ultrastructurally from those in Trachops. Overall, the ultrastructure of gastric mucosa in Trachops resembles that found in Pyllostomus (animalivorous/ omnivorous) and Pteronotus (insectivorous), whereas these features in Chiroderma resemble those of Artibeus (frugivorous). The general histology of the stomach of Chiroderma is similar to that of a megachiropteran, Eidolon helvum, suggesting that histological convergence has occurred in the evolution of the stomach of microchiropteran and megachiropteran fruit bats.

The morphological and histological structures of the stomach are examined and compared in ten species of bats (Perrin and Hughes, 1992), eight microchiropteran and two megachiropteran species representing nine genera from five families. All stomachs are wholly glandular but differ in their gross morphology. The differences are observed between insectivorous, omnivorous and frugivorous species. Anatomical variations in the gastric mucosa between species are minor. The insectivorous bats exhibited little variation between species and possessed a simple tubular gastric stomach. The stomachs of the frugivorous species are more specialized with increased compartmentalization. Scanning electron microscopy revealed the presence of microvilli in stomachs of both insectivorous and frugivorous species.

Guico and Maala (1994) studied histology and histochemistry of the fundic gland regions of the insectivores Hipposideros diadema and frugivore Rousettus amplexicaudatus. Except for some minor differences, the fundic gland regions of the two bats are morphologically similar. Among the differences observed are the following: (a) collagenous fibres are more abundant in the tunica submucosa of H. diadema, (b) the tunica muscularis is more developed in H. diadema, (c) the glands in the fundic region of H. diadema are simple straight tubular while in R. amplexicaudatus, the glands are simple branched tubular, (d) the gastric glands in R. amplexicaudatus are clearly divided into the isthmus, neck and base, (e) the gastric pit openings are apparently wider and deeper in H. diadema, (f) the parietal cells are absent at the basal part of the gastric glands in R. amplexicaudatus. Mixed, acidic and neutral mucosubstances are observed in the fundic gland region of H. diadema and R. amplexicaudatus. Acidic mucosubstances are not demonstrated.

Suicmez and Ulus (2005) studied the anatomy, histology and ultra-structure of the digestive tract of Orthrias angarae using LM, SEM & TEM. They observed the J-shaped stomach had meshwork of folds in cardiac region and longitudinal folds in the fundic and pyloric regions. The stomach has thick muscle layer, numerous gastric glands in the submucosa of the cardiac stomach, but none were present in the pyloric region of the stomach. Carrason et al. (2006) displayed a large caecal type stomach in Dentex dentex (Pisces, Sparidae) by using LM & TEM.

Depending on diets, the two species of bats under the present investigation are classified as frugivorous and insectivorous. The present study throws the light on the histological, cytological and histochemical structures of the fundic region of stomach of both the frugivorous bat (Rousettus aegyptiacus) and the insectivorous bat (Taphozous nudiventris).

**MATERIAL AND METHODS**

Active adult male and female bats of the fruit bat, Rousettus aegyptiacus and insectivorous bat, Taphozous nudiventris were used in this study. Bats were obtained from their natural habitat in Abu-Rawash in late March. For histological and histochemical studies, the animals were sacrificed; the stomach was taken from each animal and was immediately fixed in 10% buffered formalin for 24 hr. The specimens were dehydrated in ascending grades of ethyl alcohol, cleared in xylene, embedded in paraffin wax and sectioned at 5-6µm thickness. The staining methods were done as following:

1. Harris Haematoxylin and Eosin stain according to Delafield (1984) for general histology.
2. Masson’s trichrome stain according to Masson (1929) to detect collagenous fibers.
3. Azan stain to demonstrate the collagenous fibres and mucous cells of the stomach (Humason, 1972).

http://www.egyptseb.org
4- Periodic acid Schiff’s technique (PAS) to demonstrate the polysaccharides (Hotchkiss, 1984).

5- Mercury-bromophenol blue (BPB) to illustrate the total protein contents (Mazia et al., 1953).

For enzymatic studies, specimens of stomach from each species were prepared to get cryostat frozen sections at 10µm thickness and processed to demonstrate the activities and localization of acid and alkaline phosphatases (Gomori, 1952).

For cytological studies, the stomach from the two species; *R. aegyptiacus* and *T. nudiventris* were dissected and cut into small pieces which were immediately fixed in a cold solution of 4F1G (40% formalin and 50% glutaraldehyde), buffered with sodium cacodylate at pH 7.2 for 24 hr and were then post-fixed in 1% osmium tetroxide for 2 hr at 4°C followed by dehydration in ascending grades of ethyl alcohol and embedded in Epon 812. Semi-thin sections of one micrometre thick were cut using ultramicrotome and stained with toluidine blue, then examined with the light microscope. After the proper areas were selected, ultra-thin sections (60-90 nm) were cut and mounted on copper grids. The sections were double stained with uranyl acetate and lead citrate (Reynolds, 1963), then examined on Jeo1 transmission electron microscope.

**RESULTS**

i- Histological observations

1- Haematoxylin & Eosin:—

a) *Rousettus aegyptiacus* (fruit bat):—

The stomach is considerably expanded portion of the alimentary tract that lies between the oesophagus and the small intestine. The stomach of *R. aegyptiacus* has an elongated shape and is located at the left side of the abdominal cavity. The low magnification figure illustrates a transverse section of the fundus of the stomach; the stomach wall exhibits four general regions that are characteristic of the entire digestive tract: the mucosa, submucosa, muscularis externa and serosa (Fig. 1).

The mucosa of stomach of *R. aegyptiacus* is thrown up into numerous villi-like folds (rugae) of various shapes and length with distinct neck at the base (Fig. 1).The tunica submucosa consists of collagen fibres, blood and lymph vessels. The blood vessels are abundant in areas where gastric folds are formed (Figs 1&2). The muscularis externa is composed of a thick inner circular and a thin outer longitudinal muscle layers. There is a connective tissue layer between the inner circular and outer longitudinal muscle layers. The serosa is composed of a single layer of squamous cells (Fig. 2).

![Fig. (1): Cross section of the stomach body of *R. aegyptiacus* showing well-developed folds (rugae) of gastric mucosa (A), submucosa (B) and muscularis externa (C). H&E, x 25](http://www.egyptseb.org)

![Fig. (2): High magnification of the previous section showing externa muscularis (C) which is composed of outer longitudinal muscle layer (L.M) and inner circular muscle layer (C.M). The submucosa (B) consists of connective tissue. A part of mucosa (A) is also shown. H&E, x 100](http://www.egyptseb.org)

![Fig. (3): High magnification of a part of well-developed fold of gastric mucosa of *R. aegyptiacus* showing three parts of tubular glands, isthmus (is), neck (ne) and base (ba) regions. The muscularis mucosa (mm) is also shown. H&E, x 100](http://www.egyptseb.org)
**Glands of the mucous membrane of the fundus:**

Each tubular gland consists of three segments, the deepest part is the base, the middle part is the neck and the upper part is the isthmus (Fig. 3). The isthmus is continuous with a pit, the isthmus contains two types of cells; the surface epithelial cells and the parietal cells. The surface epithelial cells are tall columnar with basal nuclei and clear cytoplasm (Fig. 5) with characteristic mucous droplets in their apical parts. The parietal cells are the largest ones in the gland; the majority of such cells are pyramidal and few cells are oval or spherical in shape. The cytoplasm is acidophilic and appears vacuolated, particularly around the nucleus (Figs 5&6).

In this species, the neck of the glands is occupied by a lot of parietal cells, but few numbers of mucous cells are also observed. The mucous neck cells are smaller than those in the surface mucous cells; their nuclei are basophilic and basally located (Figs 5&6). The base of the gland is made up mostly of zymogenic (chief) cells which are cuboidal or low columnar in shape. These cells have accumulations of basophilic materials in the cytoplasm near their bases. Some parietal cells are observed in the basal part of the gland (Figs 5&6).

**b) Taphozous nudiventris (insectivorous bat):**

The stomach of *T. nudiventris* is saccular with indistinct lesser and greater curvatures than that of *R. aegyptiacus*. It also consists of four regions; mucosa, submucosa, muscularis externa and serosa (Fig. 7). The mucosa is thrown up into longitudinal folds, simple or branched, called rugae. The gastric pit appears deeper and is wider than those in *R. aegyptiacus*. The lamina propria contains more collagenous fibres and also, extends between the bottoms of the pits. The muscularis mucosa is seen as thin slips of connective tissue between the glands (Figs 7&8).

The tunica submucosa consists of collagenous fibres, blood and lymph vessels. The collagenous fibres are dense, compact and more wavy than those in *R. aegyptiacus*. The muscular layer is more compact and composed of thick inner circular and thin outer longitudinal muscle layers. The connective tissue layer between the inner circular and outer longitudinal muscle layers is less distinct than in *R. aegyptiacus* (Fig. 8). The serosal layer is composed of a single layer of squamous cells.
As in *R. aegyptiacus*, the same three types of gastric cells are found in *T. nudiventris* but with some different mode in distribution. Also the isthmus, neck and base regions are not distinct opposite to that observed in *R. aegyptiacus*. The isthmus region contains surface epithelial cells that are tall columnar with basal nuclei (Fig. 10). The neck region contains mainly irregular mucous neck cells, that are compressed and distorted by adjacent cells. Few numbers of parietal cells are present (Fig. 10). The base region also contains enzyme producing cells (chief cells). These cells have large basal nuclei and contain eosinophilic refractile cytoplasmic granules (Fig. 10).

### 2- Masson's trichrome and azan stains:

Using either Masson's trichrome or azan stain demonstrates collagenous fibres in blue colour. In *R. aegyptiacus*, the collagenous fibres are seen as a blue irregular arrangement in tunica submucosa. The lamina propria and glandular cells appear with no fibres (Figs 11, 12, 15 & 16).

In tunica submucosa of *T. nudiventris*, the collagenous fibres are numerous, dense and compact. Little collagenous fibres are demonstrated.
clearly in lamina propria and in between the inner circular and outer longitudinal muscle layers. The surface of the epithelial cells is stained with intensity blue colour due to the presence of mucus secretion (Figs 13, 14, 17 & 18).

**Fig. (14):** High magnification of the previous section showing high compact dense collagenous fibres in submucosa and muscularis mucosa (arrows). Also, lamina propria appears with little fibres as thin films between the glandular cells (arrow-heads). The surface mucous cells are stained in moderate blue colour (double arrows).
Masson's trichrome, × 200

**Fig. (15):** Cross section of the body of stomach of *R. aegyptiacus* showing few collagenous fibres in submucosa and muscularis mucosa (arrows). Few collagenous fibres also appear in muscularis externa the and between the outer longitudinal and the inner circular muscle layers (arrow-heads). Azan, × 40

**Fig. (16):** High magnified sector of the previous section showing few collagenous fibres in muscularis externa, submucosa and muscularis mucosa (arrows). The lamina propria is also noticed with little collagenous fibres (arrow-heads). The surface mucous cells exhibit very weak stain (double arrows). Azan, × 100

**Fig. (17):** Cross section of body of stomach of *T. nudiventris* showing high compact, dense collagenous fibres in submucosa and tunica submucosa (arrows). Little collagenous fibres between outer longitudinal and the inner circular muscle layers are also noticed (arrow-head).
Azan, × 40

**Fig. (18):** High magnification of the previous section showing dense collagenous fibres in submucosa and tunica submucosa. Little collagenous fibres are seen between the outer longitudinal and the inner circular muscle layers (arrows). The surface mucous cells exhibit moderate stain reaction (double arrows). Azan, × 100

**ii- Cytological studies:**

As noted in the histological observations, the gastric cells are differentiated into surface mucous cells, mucous neck cells, parietal cells and chief cells in stomach sections of both bat species.

**Surface mucous cells:**

They are different in both species of bats. In *Rousettus aegyptiacus* (fruit bat), the surface epithelial cells are of two types, cells of type I are tall, columnar, and have dark cytoplasm and dark elongated nuclei. Cells of type II are shorter than type I, their cytoplasm and nuclei have light appearance. The nuclei are basally located. The two types have secretory granules accumulated at their apical parts just above the nuclei; such parts of the cells appeared devoid of other cellular organoids. Short microvilli are observed (Fig. 19).

In *Taphozous nudiventris* (insectivores bat), only one type of surface mucous cells with dark cytoplasm could be demonstrated. They are identified by superficial location, columnar shape and by their dense secretory granules. The luminal surface of these mucous cells shows short microvilli, while the lateral borders of the cells are often separated by intercellular gaps, which are traversed by cytoplasmic protrusions in the lateral walls. This gap disappears at
Fig. (19): An electron micrograph of the surface mucous cells of the gastric mucosa of *R. aegyptiacus* showing two types of cells. Type I is tall and columnar, has dark cytoplasm and many mucous granules (G) at the cell apex. A darkly-stained nucleus (N) is observed. Type II is shorter, has light cytoplasm and also contains mucous granules (G). Short microvilli are demonstrated (arrows). Lightly-stained nuclei (N) are also shown. 

The apical surface where the binding of adjacent cells is very tight. The nuclei are dark, located basically and irregular in shape (Fig. 24).

Fig. (20): An electron micrograph of a mucous neck cell of *R. aegyptiacus* showing its less regular shape, mucin granules (G), short microvilli (arrows) projecting into lumen (L) of the gland, and nucleus (N). × 7500

**Mucous neck cells:**

They are similar in both types of bats. They are less regular in shape because they are compressed and distorted by adjacent cells. They have basal irregular nuclei and small mucin vacuoles. Also, they have microvilli projecting into the lumina of the glands (Figs 20 & 25).

**Acid-producing (parietal) cells:**

They are similar in both *Rousettus aegyptiacus* and *Taphozous nudiventris*. They are very large pyramidal cells with pale eosinophilic cytoplasm. They have a vast luminal surface area as a result of deep microvillar-lined invaginations producing the so-called canaliculi. An extraordinary number of spherical or oval mitochondria with closely packed cristae are concentrated around the nucleus and others are distributed throughout the cytoplasm (Figs 21, 22, 25 & 26). The nucleus is centrally located, irregular in shape and has dark appearance.

Fig. (21): An electron micrograph of the base region of gastric gland of *R. aegyptiacus* showing the parietal cell (pc), two chief cells (cc) and nuclei (N). × 7500

Fig. (22): An electron micrograph of a parietal cell of *R. aegyptiacus* showing canaliculi (ca.) lined with microvilli (arrows), mitochondria (M) and nucleus (N). × 10000

Fig. (23): An electron micrograph of a chief cell of *R. aegyptiacus* showing secretory granules (G), rough endoplasmic reticulum (rER), mitochondria (M) and nucleus (N). ×10000
Histological, Cytological and Histochemical Studies

Enzyme-producing (chief) cells:

They are similar in both types of species. They are found at the base of the gastric glands and their fine structure is similar to other zymogenic cells. They contain many large grey-stained spherical granules which contain pepsinogen and are responsible for the eosinophilic granular appearance of these cells in H&E stained sections. They have an extensively developed rough endoplasmic reticulum, few spherical or elongated mitochondria with obvious cristae and basal nuclei with prominent nucleoli (Figs 21, 23 & 27).

iii- Histochemical observations:

1- Polysaccharides:

In *R. aegyptiacus*, the mucous cells lining the surface epithelium and gastric pits are very strongly stained with periodic acid Schiff's technique (PAS) that indicates the presence of high content of polysaccharides. The mucous neck cells, the gastric gland cells of neck and base regions and muscularis mucosa are elucidated with moderate content of polysaccharides (Figs 28 & 29).
Fig. (29): High magnification of the previous section showing high concentration of mucus at the surface epithelial cells (arrows). The cells of base and neck regions exhibit a moderate content of polysaccharides. PAS, × 200

In *T. nudiventeris*, the mucous cells of surface epithelial cells and gastric pits are elucidated with more polysaccharides, thus seeming to secrete higher amount of polysaccharides than cells that are internally located as in *R. aegyptiacus*. The muscularis mucosa revealed moderate to high content of polysaccharides (Figs 30&31).

Fig. (30): Cross section of the stomach body of *T. nudiventeris* showing a weak to moderate content of polysaccharides in the gastric cells. The surface mucous cells exhibit dense polysaccharides (arrows). The muscularis externa, submucosa and muscularis mucosa exhibit moderate to strong content of polysaccharides. PAS, × 100

Fig. (31): High magnification of the previous section illustrating the surface mucous cells filled with mucus (arrows). Weak to moderate content of polysaccharides in the gastric cells is shown. PAS, × 200

In *R. aegyptiacus*, the glandular cells of gastric mucosa appear to have a high content of total proteins in their cytoplasm and nuclei by using bromophenol blue (BPB). The mucous cells lining the surface epithelium have a weak content of total proteins. The muscularis externa and muscularis mucosa are demonstrated with a moderate amount of protein contents (Figs 32&33).

Fig. (32): Cross section of the stomach body of *R. aegyptiacus* demonstrating a moderate content of protein contents in muscularis externa (arrow), submucosal (B) and muscularis mucosa (arrow). BPB, × 100

Fig. (33): High magnification of the previous section showing high content of total protein contents in the glandular cells of base (ba) and neck (ne) regions. The isthmus region (is) demonstrates low content of proteins on the surface mucous cells. BPB, × 200

In *T. nudiventeris*, the gastric gland cells have mild affinity to BPB and have moderate content of proteins. The mucous cells lining the surface epithelium are also demonstrated with high protein contents as that observed in the muscularis externa, muscularis mucosa and lamina propria (Figs 34&35).

3- Enzymes:

**Acid phosphatase activity (AcP)**

In *R. aegyptiacus*, the gastric mucosa shows moderate activity of AcP. The AcP activity appears as light red granules. The epithelial mucous cells, muscularis externa and muscularis mucosa show...
Fig. (34): Cross section of the stomach body of *T. nudiventris* showing high content of total protein contents in muscularis externa (C), submucosa (B) and muscularis mucosa (arrow). A moderate amount of total proteins is noticed in the gastric cells. BPB, × 100

Fig. (35): High magnification of the previous section showing moderate content of total proteins in gastric cells while the surface mucous cells and muscularis mucosa exhibit more content of protein contents (arrows). BPB, × 200

Fig. (36): Frozen cross section of the stomach body of *R. aegyptiacus* showing moderate activity of acid phosphatase in glandular cells as red granules precipitate (arrows). Gomori, × 100

Fig. (37): High magnified portion of the previous section showing moderate activity of acid phosphatase in the glandular cells (arrows). The surface mucous cells show weak activity of acid phosphatase (arrow-head). Gomori, × 200

weak AcP activity (Figs 36&37). In contrast, in *T. nudiventris*, the mucous glands appear with weak activity of acid phosphatase. The AcP activity is more pronounced in muscularis externa, submucosa and muscularis mucosa as red sharp granules (Figs 38&39).

Fig. (38): Frozen cross section of the stomach body of *T. nudiventris* showing weak to moderate red precipitate granules of acid phosphatase activity in muscularis mucosa and surface mucous cells (arrows). The glandular cells have negative reaction to the enzyme activity. Gomori, × 100

Fig. (39): High magnified portion of the stomach body of *T. nudiventris* showing strong activity of acid phosphatase in the muscularis externa, submucosa and muscular mucosa (arrows). The glandular cells have negative reaction to the enzyme activity. Gomori, × 200
Alkaline phosphatase activity (AIP)

In *R. aegyptiacus*, the AIP is concentrated in mucous cells at the surface epithelium as sharp discrete blue patches. The gastric glands of the base and neck regions display no activity of AIP as well as in muscularis externa and submucosa while in the isthmus, moderate to strong AIP activity is demonstrated (Figs 40&41). In *T. nudiventris*, the gastric glands, surface epithelial cells, muscularis externa and submucosa have no activity of AIP (Figs 42&43).

**DISCUSSION**

The stomach is a muscular expansion of the digestive tube where food is stored and mixed with hydrochloric acid, mucus, water and proteolytic enzyme to form chyme. Three regions of the stomach are recognized anatomically: the cardia, the fundus and body, and the pylorus. The fundus and body was the most extensive region in the stomach. The stomach wall exhibits four general regions; the mucosa, submucosa, muscularis externa and serosa (Eroschenko, 1996; Suicmez & Ulus, 2005; Carrason et al., 2006).

In the present study, the fundus and body regions of the stomach of fruit bat (*R. aegyptiacus*) and insectivorous bat (*T. nudiventris*) was described. Except for shape, the gross anatomy of the stomach of *R. aegyptiacus* did not differ significantly from that of *T. nudiventris*. The stomach of *R. aegyptiacus* is elongated with a large fundus while in *T. nudiventris*, it is saccular. The large fundus in *R. aegyptiacus* may correspond to the so-called ‘fundic cecum’ of the New World bats (Rouk and Glass, 1970). The stomach of New World bats is C-shaped and similar to that of human. The same result is confirmed by Madkour (1975), Guico and Maala (1994), and Suicmez and Ulus (2005).
The histological structure of sections of the stomach in the present work designates that it consists of four layers: mucosa, submucosa, muscularis and serosa. One important histological observation is the presence of various shapes, branches and sizes of mucosal folds (rugae) in the stomach of *T. nudiventris* while in *R. aegyptiacus*, the mucosal folds are taller and less branched. The villi-like folds of various shapes and length are found in insectivorous bat *Hipposideros diadema*; they increase the surface absorptive area of the stomach (Guico and Maala, 1994).

The tunica submucosa contains numerous blood vessels of varying shapes and sizes in the studied two species of bats studied in as well as in other species of mammals. Guico and Maala (1994) found numerous blood vessels in the region of mucosal folds. They stated that the submucosal blood vessels are important for the absorption of the final product of digestion.

Due to the nature of diet, the externa and mucosa muscularis of *T. nudiventris* (insectivorous bat) are thicker and more compact than in the *R. aegyptiacus* (fruit bat). Insectivorous bats are voracious feeders and feed on beetles, termites, mosquitoes and cockroaches (Kok, 1996; Stuart et al., 2003), thus, a thicker tunica mucosa is needed for physical digestion. Suicmez and Ulus (2005) demonstrated that the stomach of *Orthrias angorae* is thick due to the thick muscle layer. Since *R. aegyptiacus* subsists on fruit juices and pulp (Makanya et al., 2001), a thick tunica mucosa is not so important.

The serosa layer is composed of a single layer of squamous cells in *R. aegyptiacus* and *T. nudiventris* in the present study as well as that reported in albino mice (Ramadan et al., 1992; Ghallab, 2004).

Light and electron microscope studies in the present work revealed that the gastric glands of fundus of *R. aegyptiacus* are divided into three distinct regions; from proximal to distal, these are the base, neck and isthmus. These regions are similar to those mentioned by DiFiore (1989). However, these three regions of the gastric glands are not distinct in *T. nudiventris*. These results agree with Guico and Maala (1994) who reported that the three divisions of mucosal gastric glands are not distinguished in the insectivoros bat *H. diadema*. There were numerous gastric glands in the submucosa layer of the cardiac stomach, but none were present in these pyloric region of the stomach of *Orthrias angorae* (Suicmez and Ulus, 2005).

The gastric glands of the fundic region of *R. aegyptiacus* and *T. nudiventris* in the present work are composed of four main secretory cell types: mucous (surface and neck mucous cells), parietal and chief (zymogenic) cells. The fine structure of the various cell types in the present study of the two types of bat species is fundamentally similar to that of the corresponding cell types of other mammals, but the relative cell numbers and distribution are somewhat different.

The surface epithelium of the stomach of *R. aegyptiacus* and *T. nudiventris* in the present study are lined with mucous columnar cells. The surface mucous cells of both two bat species have tall columnar appearance with secretory granules at the apex of the cells. These cells are of two types-I and II-depending on dark and light appearance of cytoplasm. The neck mucous cells of the two bat species have the same ultrastructure. They are less regular in shape as they are compressed by other cells. The surface and neck mucous cells have a secretory system which elaborates the copious mucous needed to protect the gastric mucosa from both physical and chemical injuries (Geibel and Wagner, 2006). Stucholme et al. (1986) stated that the mucous secretory granules in the surface mucous cells in Chiroderma (frugivorous species) differ ultrastructurally from those in Trachops (animalivorous species). In the present study, many short microvilli were found on the apical mucous cells in *R. aegyptiacus* and *T. nudiventris*. Apical microvilli are features of the epithelial cells from all regions of the gastro-intestinal tract in many species including juvenile and adult sole (MacDonald, 1987) and the black mollie, *Poecilia sphenops* (Caceci and Hrubec, 1990). Thomas and Ronald (1981) reported that the mortality rate of the surface epithelial cells is high and these cells are replaced by mitotic divisions of less differentiated cells situated in the deeper parts of the foveolae and upper regions of the gastric glands.

In the present work, the parietal cells of *R. aegyptiacus* were abundant and were found mostly in the middle zone of the gastric glands. Similar observations were reported by Guico and Maala (1994) in the insectivore *H. diadema*. However, in *T. nudiventris* the present study showed that some parietal cells were found in the isthmus and even in the basal part of the gland. This agrees with Stucholme et al. (1986), who reported that the parietal cells are less abundant and less active in Trachops than in Chiroderma. They also suggested that the distribution and numbers of parietal cells may remain static in the gastric mucosa of the insectivores.

No ultrastructure differences were observed in the parietal (acid-producing) cells of both *R. aegyptiacus* and *T. nudiventris*. They are large pyramidal cells, characterized by the presence of branching canaliculi which extend into them from their apex and by which they deliver their secretions into the lumen of the gastric glands. Also, they have mitochondria with well-developed cristae, a feature associated with high rates of metabolic oxidation (Ito and Winchester, 1963). The same ultrastructure of the parietal cell was found in mice (Ramadan, 2001). The parietal cells have abundant carbonic anhydrase, which is thought to play a vital role in generating H+ ions for the production of hydrochloric acid (Ham, 1974). Guvton (1986) reported that the parietal cells are important for secretion of the intrinsic factor which is a glycoprotein essential for the absorption of vitamin...
B12. According to Padynula (1977), the volume of tubulo-vesicle-system which is found only in parietal cells is inversely related to the volume of the intracellular canaliculi, which are maximally developed when much hydrochloric acids is produced.

In the present work, the chief (zymogenic) cells are more numerous in *R. aegyptiacus* than in *T. nudiventris*. They are present at the basal part of the gastric glands and have the same ultrastructure appearance. They are characterized by the abundance of cisternal and vesicular forms of rough endoplasmic reticulum and large zymogen granules. These results are similar to those obtained by Stuholme et al. (1986) and Ramadan (2001). The main function of peptic cells is to secrete pepsinogen. Pepsinogen is an inactive proenzyme or zymogen that is converted to the active protease pepsin when exposed to the acidic environment of the stomach lumen. The acidic fluid combines with enzymes that are secreted from neighbouring chief cells and passes out of the gland up through mucous jell layer covering the surface of the stomach producing a fluid entragastric pH of less than four. Also, chief cells secrete lipase that has only weak lipolytic activity (Geibel and Wagner, 2006).

The present work showed that by using Masson's trichrome and azan stains, the collagenous fibres in the tunica submucosa were more abundant in *T. nudiventris*, while they were less irregularly arranged in *R. aegyptiacus*. Similar distribution of collagenous fibres that provide tensile strength to the stomach wall especially during distension was demonstrated in insectivore *Hipposideros diadema* and the frugivore *Rousettus amplexicaudatus* bats (Guico and Maala, 1994). The surface epithelial cells and gastric pits in *T. nudiventris* are more active than in *R. aegyptiacus*. This suggests the presence of abundant mucous substances in the epithelial surface of *T. nudiventris*. Since the diet of *T. nudiventris* consists of chitinous parts of insects, the gastric mucosa should be adequately protected by secretions from surface mucous cells. These mucous substances also protect the mucosa from the acidic secretion of the parietal cells (Guico and Maala, 1994; Carrasson et al., 2006).

By using PAS technique, the present study showed high distribution of polysaccharides in mucous secreting cells of the surface epithelium of the stomach of *R. aegyptiacus* and *T. nudiventris*. A moderate amount of polysaccharides was noticed in the gastric glands of the two species of bats. This agrees with Zaher et al. (1995) who reported that presence of a large amount of PAS positive materials in the cells of gastric mucosal epithelium represents a common histochemical feature for the gastric mucosa of the insectivore *Chamaeleon vulgaris* and *C. basiliscus*. Similar results were demonstrated histochemically in the stomach epithelium of *Dentex dentex* (Carrasson et al., 2006). Ramadan (1995) illustrated the presence of general carbohydrate materials in mice gastric mucosa, being quite distinct in the surface mucous cells particularly in their apical portions.

By using BPB, the present work revealed high protein contents in glandular cells of gastric mucosa of stomach of *R. aegyptiacus* while in *T. nudiventris*, the gastric cells were shown to have moderate amount of protein contents. Similar results were described by Ramadan (1995) who reported that the protein contents in mice gastric mucosal cells were presented as granular particles scattered in the cytoplasm of the parietal cells and chief cells.

In the present investigation, moderate activity of acid phosphatase (AcP) was detected by using azo dye precipitation in the gastric glands of stomach of *R. aegyptiacus*, while the epithelial mucous cells and muscularis have weak AcP activity. In *T. nudiventris*, the mucous glands showed weak reaction for AcP activity. On the other hand, the muscularis and submucosa were found to have strong AcP activity. The pronounced high activity of AcP, which is a lysosomal enzyme, in the gut may be related to the active process of secretion occurring in the epithelial lining cells, and they could possibly be involved in the supply of energy for digestive process (Taib and Jarrar, 1983). Moreover, AcP could be involved in the process of intracellular digestion and in the degradation of ingested nucleoproteins by converting nucleic acids into nucleosides and phosphate (Mohallal and Rahmy, 1992). Also, AcP enzyme may play a role in the process of heterophagy that occurs in the cells against the foreign substances (Zaher et al., 1995).

Alkaline phosphatase activity (AIP) in the present work is strongly detected in surface epithelial cells and isthmus in *R. aegyptiacus* while the muscularis and submucosa were found to have no activity. In *T. nudiventris* the gastric cells, muscularis and submucosa were found to have no activity of AIP. The AIP is correlated with permeability processes of the cells and the absorption of fats (Zaher et al., 1995). Varying levels of activity of the digestive enzymes in insectivorous bats in all organs of the digestive tract have been observed by Zhukova-Natalya (2001). The author believes that the enzymatic activity may be bound not only to the composition of diets, but also to ecological characteristics of the species (foraging, regularity and intensity of feeding affect the dynamics and quantity of the food to be digested).

Thus, it may be presently concluded that the differences between the two species of bats in the histological and cytological structures of stomach wall, and the differences in the histochemical results of polysaccharides, proteins and activity of AcP & AIP may be related to the nature of diet, i.e. fruit feeding *R. aegyptiacus* and insect feeding *T. nudiventris*. 

http://www.egyptseb.org
دراسات هستولوجية وسينولوجيّة ومستوكيوماتيكيّة على معدة نعّان من الح复查كن وهمًا

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والدُجَّل في حُماية الح复查كن الطبيِّة لمعدة نعّان من
الح复查كن، والجثث الإلكترونية النادِية حيث نُشِرَ نتائج
على الح复查كن الطبيِّة السُّلْطِية والخلايا الطارية
والخلايا السُلْطِية والخلايا الطارية.

وثبَ أن الخلايا الطارية بشكل تأثیر يُشغِّل ناتج
السُلْطِية، وتتمثل في خلايا ديناميكية تلignantها
بتحديد تغذية النفايات، وتحمَّل النفايات، وتحمل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايات، وتحمَّل النفايا...