GASTRIC MORPHOLOGY IN SELECTED MORMOOPID AND GLOSSOPHAGINE BATS AS RELATED TO SYSTEMATIC PROBLEMS

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ABSTRACT.—Stomachs of selected species of two groups of North American bats [Mormoopidae and Glossophaginae (Phyllostomatidae)] were studied grossly, histologically, and histochemically. The stomachs of two mormoopids, *Pteronotus parnellii* and *Mormoops megalophylla* are most similar in gross and histological features to those of fish-eating bats of the family Noctilionidae. Species of the predominantly nectar-feeding Glossophaginae have stomachs of two basic morphological forms, which are considered to probably reflect early divergence in food habits. Additionally, studies of the histochemistry of gastrointestinal mucins suggest a similar dichotomy in glossophagines. The above results are reviewed in light of several recent studies of the systematics of the Mormoopidae and Glossophaginae. It is concluded that a comprehensive study of the food habits of glossophagines should be undertaken to test some proposed relationships between gastric morphology and feeding characteristics in these bats.

Recent investigations of certain genera and subfamilies of the North American leaf-nosed bats, family Phyllostomatidae, have proposed noteworthy changes in the traditional systematic arrangements, and explanations of phylogeny of these groups. Insect-feeding bats of the subfamily Chilonycterinae have been reviewed critically by Smith (1971) who regards them as distinctive enough to be relegated to a separate family, Mormoopidae. Vaughn and Bateman (1970) support this proposal with evidence from studies of the functional morphology of flight. Phillips (1971) examined the deciduous and adult dentitions of selected nectar-feeding species of the subfamily Glossophaginae. He concluded that this group is either diphylletic in origin and not a natural assemblage, or that the subfamily contains a dichotomy of types that is the product of an early evolutionary divergence. Based on karyotypic evidence, Baker (1967) previously had reported a dichotomy in the glossophagines, but the two species groups devised by him do not correspond precisely with those of Phillips.

In an effort to further examine these three systematic proposals, bats of species representing the groups were selected and their stomachs were examined morphologically and compared with those of closely related taxa. The relationship between the Mormoopidae and the fish-eating bats of the family Noctilionidae also was studied and the results are discussed herein. The systematic value of such studies of gastrointestinal morpholopy has been discussed previously by Forman (1971) and Schultz (1970).

MATERIALS AND METHODS

Preserved stomachs of one species of mormoopid and four species of glossophagines were examined grossly, histologically, and histochemically. The kinds and numbers examined were as follows: Mormoopidae; *Mormoops megalophylla* (2), Glossophaginae; *Glossophaga commissarisi* (2), *Anoura geoffroy* (1), *Choeroniscus godmani* (1) and *Lichonycteris obscura* (2). Previous accounts of gastric morphology and histochemistry in the mormoopid *Pteronotus parnellii* (Forman, 1971), and the glossophagines *Glossophaga soricina* (Forman, *op. cit.*) and *Leptonycteris sanborni* (Rouk and Glass, 1970) are employed in discussions to follow.

All specimens from which stomachs were removed are stored in the Museum of Natural History, The University of Kansas.

Standard histological and histochemical procedures employing Harris' haematoxylin and eosin, and periodic acid Schiff-Alcian blue for gastric mucus were used (see Forman, 1971). Hale's colloidal iron reaction was used in addition to Alcian blue as a test for acid mucopolysaccharides (procedure after Lillie, 1965). All stomachs were sectioned at five to seven microns. Drawings of stomachs were produced by projecting midlongitudinal sections onto paper, by means of a photographic enlarger.

Results

Gastric Morphology in the Mormoopidae. The stomach of *Mormoops* (Fig. 1) is simple in overall configuration, and is nearly identical in topography to that of *Pteronotus parnellii* (Forman, 1971). The stomach is symmetrical (gastroesophageal junction midway along lesser curvature) with a short, pointed fundic caecum, and an equally short and unusually broad pyloric endpiece. The cardiac vestibule is minute, as it is in nearly all other insectivorous bats examined thus far (see Forman, 1971).

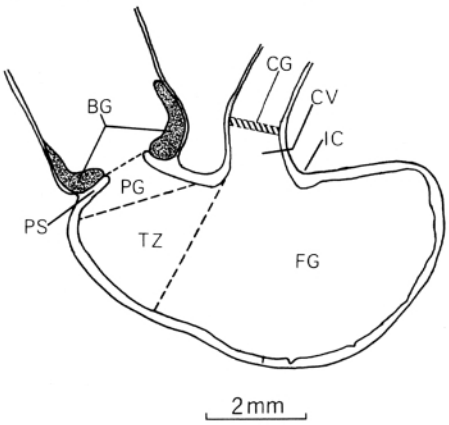

FIGURE 1. Mid-longitudinal representation of the stomach of *Mormoops megalophylla*. Explanation of symbols: CG, cardiac glands; BG, Brunner's glands; PG, pyloric glands; TZ, transitional zone; FG, fundic glands; IC, incisura cardiaca; CV, cardiac vestibule; PS, pyloric sphincter.

The pyloric sphincter is asymmetrical, as in *Pteronotus*, the valve on the greater curvature being longer and narrower than that of the lesser curvature. However, the marked reduction in mass of the lesser valve seen in *Pteronotus* is lacking in *Mormoops*. The circular muscle layer of the stomach wall is extremely thick, as in *Pteronotus*.

The glands of Brunner at the gastroesophageal junction of *Mormoops* are indistinguishable in cellular morphology from those of *Pteronotus parnellii*, as well as *Noctilio leporinus* and *N. Labialis* (Noctilionidae). The tubules are narrow and the cells are small with extremely small, flattened nuclei not juxtaposed to the basement membrane. This condition is in contrast to the broader tubules with larger, circular juxtaposed nuclei usually found in Brunner's glands in bats of the families Vespertilionidae, Phyllostomatidae, Emballonuridae and Molossidae. Brunner's glands are unusually abundant in *Mormoops* (Fig. 1) and *Pteronotus*, a condition shared with *Noctilio*. The extreme breadth of the duodenum at the gastroesophageal junction of *Mormoops*, *Pteronotus*, and *Noctilio* is, in part, due to the unusually large complement of Brunner's glands in these genera.

The distribution of gastric mucosa in *Mormoops* closely resembles that of *Pteronotus*, and thus is distinctive among bats studied to date (except for *Noctilio*) by virtue of having an extremely narrow zone of mucus-producing pyloric glands (Fig. 1). The proportion of gastric mucosa that may be considered

transitional (between fundic and pyloric glands) is extremely high in mormoopids, although a similar condition is found to occur in some phyllostomatids and in *Noctilio*. The relative frequency of mucosal folds is low in *Mormoops* and *Pteronotus*, considerably lower than in any other kinds thus far examined.

The fundic mucosa of *Mormoops*, which produces hydrochloric acid and pepsin, has a number of features found to occur additionally only in *Pteronotus* and in the *Noctilionidae*. The fundic tubules are long, highly convoluted, and extremely narrow (Fig. 2) in contrast to the broader, often shorter glands in members of other families of North American bats (Fig. 3). All cellular elements of the fundic glands (parietal, mucous neck, chief, and argentaffin cells) are extremely small in comparison to other bats, and correspondingly are relatively abundant. In comparison with other species, nuclei of these cells are of moderate size, suggesting a decrease in cytoplasmic mass. Zymogenic (chief) cells are abundant within the bases of fundic glands only in the cardiac vestibule and lesser curvature of *Mormoops* and *Pteronotus*.

Gastric Morphology in the Glossophaginae. Careful examination of

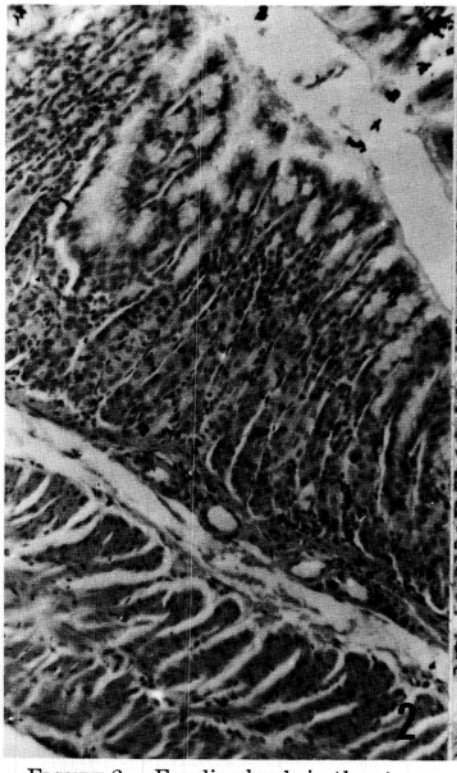

FIGURE 2. Fundic glands in the stomach of *Mormoops megalophylla*. Note the great length and narrowness of these glands (X200).

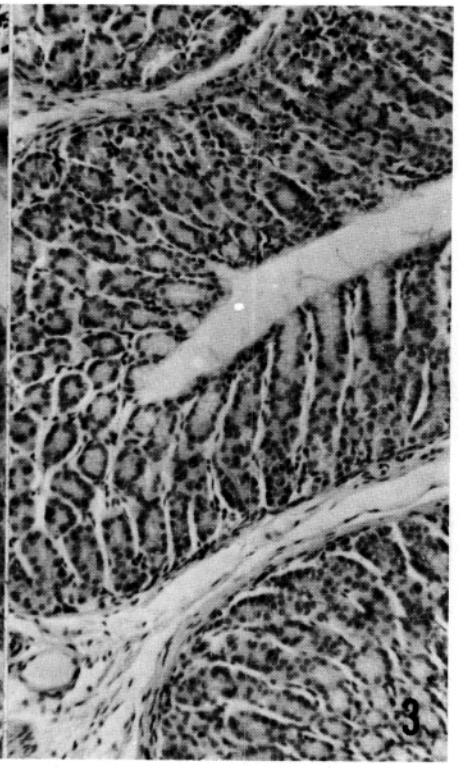

FIGURE 3. Fundic glands in the stomach of *Glossophaga soricina* (family Phyllostomatidae). Note the greater breadth of these glands as compared to those in Fig. 2 (X200).

Figures 4 to 7 reveals the extensive variation in gross morphology of stomachs within the nectar-feeding Glossophaginae. Stomachs of glossophagines thus far examined can

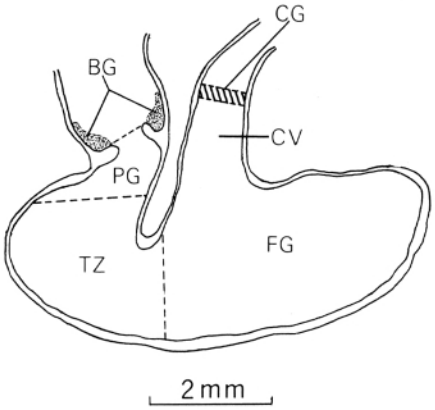

FIGURE 4. Mid-longitudinal representation of the stomach of *Glossophaga commissarisi*. For explanation of symbols, see Fig. 1.

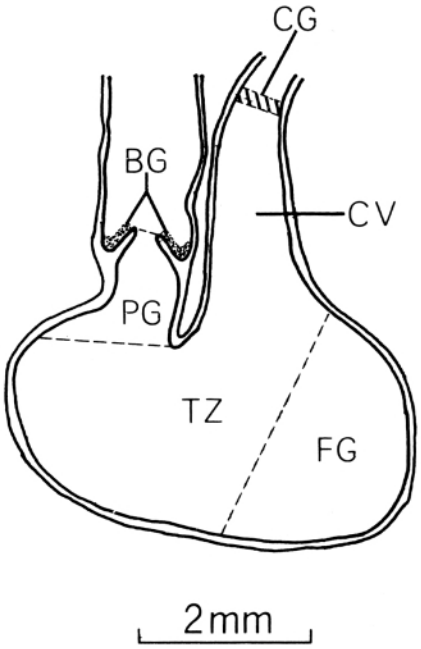

FIGURE 6. Mid-longitudinal representation of the stomach of *Choeroniscus godmani*. For explanation of symbols, see Fig. 1.

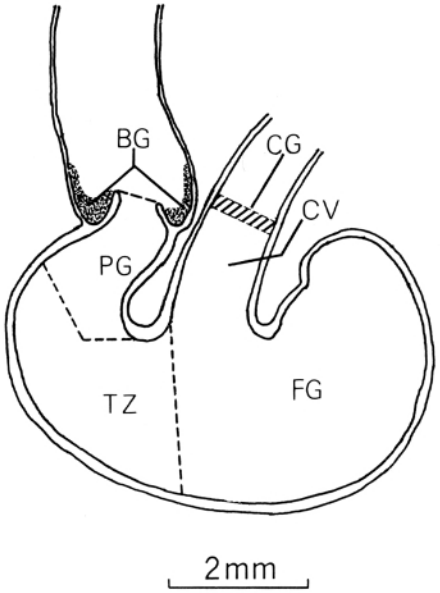

FIGURE 5. Mid-longitudinal representation of the stomach of *Anoura geoffroy*. For explanation of symbols, see Fig. 1.

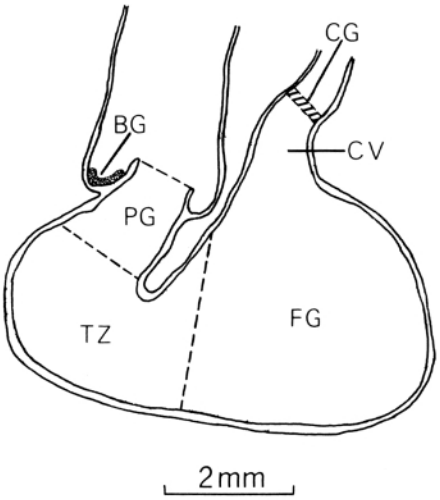

FIGURE 7. Mid-longitudinal representation of the stomach of *Lichonycteris obscura*. For explanation of symbols, see Fig. 1.

be divided into two groups on the basis of topographic features and various features of the gastric mucosa. Group A includes *Glossophaga soricina* (examined by Forman, 1971), *G. commissarisi* (Fig. 4), *Leptonycteris sanborni* (examined by Rouk and Glass, 1970), and *Anoura geoffroy* (Fig. 5). Group B includes *Choeroniscus godmani* (Fig. 6) and *Lichonycteris obscura* (Fig. 7).

The stomachs of Group A are characterized by a relatively long, narrow fundic caecum, and a comparatively small or no cardiac vestibule (tubular portion of stomach between gastroesophageal junction and lesser curvature). The incisura cardiaca (fold in the stomach wall at the junction of the cardiac vestibule and fundic caecum) is moderately to extensively developed. The terminal portion of the stomach (tubular segment between the gastroesophageal junction and pyloric sphincter) is always moderately well developed. The pyloric sphincter possesses comparatively short valves, with well developed musculature, and is always assymmetrical, with the valve of the greater curvature being the most massive.

In regard to gross morphology of the stomach, *Glossophaga soricina* is most deviant from the general plan within Group A. A cardiac vestibule is completely lacking in this species, and the apparent relationship between this condition and insect-feeding in this bat previously has been discussed (Forman, 1971).

The stomachs of Group B are distinguished from those of Group A on the basis of morphology of the fundic caecum and pyloric sphincter. The fundic caeca of *Choeroniscus* and *Lichonycteris* are short, rounded, and slightly dilated on the dorsal or "back" surface. An incisura cardiaca is completely lacking. The cardiac vestibule is generally better developed than those of Group A, and more closely approximates the type found to occur in fruit-eating leaf-nosed bats. The terminal portion of the stomach is relatively elongate as in Group A, however, the pyloric sphincter differs by having narrower valves of greater length. This latter condition more closely resembles the pattern found in frugivorous phyllostomatids, than that of Group A.

The mucus-producing glands of Brunner reveal distributional and structural differences between the two groups. These submucosal glands within the duodenal wall at the pyloric sphincter are relatively more abundant in both species of *Glossophaga* and in *Anoura* than in *Choeroniscus* and *Lichonycteris*. They are limited to a narrow band on only the lateral one-half of the pyloric sphincter in *Lichonycteris* (Fig. 7). The tubules of Brunner's glands are more highly coiled and considerably broader in Group A than in the second group, suggesting greater production of mucus from Brunner's glands in *Glossophaga* and *Anoura*. Of the three species examined in Group A, *Anoura* has Brunner's glands which most closely approach those of Group B in morphology of the tubules.

The entire inner lining of the stomach of all glossphagines is occupied by typical tubular gastric glands. Differences in the distribution of various portions of the gastric mucosa within the Glossophaginae are not striking, except for the extremely limited distribution of true fundic glands in *Choeroniscus godmani* (Fig. 6). The zone of transitional mucosa between fundic and pyloric glands is characteristically broad in glossophagines, being maximal in *Choeroniscus* with the absence of zymogenic cells

throughout the cardiac vestibule (Fig. 6).

Although distinctive differences in distributions of glandular types are not apparent among the glossophagines, two conditions of the frequency of zymogenic cells are found to occur within the fundic glands. Fundic glands of *Glossophaga* and *Anoura* contain relatively large numbers of zymogenic cells within the basal one-fourth to one-third of each tubule. These cells are abundant throughout that portion of the stomach in which they occur, being most abundant within the fundic caecum (*Anoura*) and lesser curvature (*Glossophaga*). In contrast, chief cells are considerably less frequent in both *Lichonycteris* and *Choeroniscus*, being least abundant in the latter, and are generally restricted to the lower one-seventh to one-tenth of each tubule in both. Parietal cells, which occupy only the midregion of fundic tubules in *Glossophaga* and *Anoura*, are usually found among chief cells in *Lichonycteris*, and are always together with these cells in *Choeroniscus*. The most abundant concentration of chief cells in both species of Group B is within the extreme apex of the fundic caecum.

Histochemistry of the Gastric Mucosa. Staining of stomachs with Alcian blue, Hale's collidal iron stain, and the periodic acid Schiff reaction (paS) revealed few differences in the quality of gastric mucus among mormoopid or glossophagine bats. Alcian blue and Hale's iron, both of which are considered to color acid mucopolysaccharides, stained mucus only of the cardiac glands in *Mormoops* and *Pteronotus*. Mucus of the surface epithelium of these genera stained strongly with paS (for neutral mucins), as did cells of the gastric pits within the cardiac and pyloric glands. Mucous neck cells interspersed among parietal cells in the fundic and transitional glands stained moderately strong with paS, as did cells within the basalmost one-fifth of the pyloric glands. Brunner's glands gave a strong reaction to paS in both species of mormoopids. With the exception of somewhat less reactivity in the mucous neck cells of *Mormoops*, there was little difference between mormoopids in staining with paS.

The surface epithelium of all glossophagine stomachs gave a strong reaction to paS, but none with Alcian blue or Hale's colloidal iron. Results also were consistent for the cardiac glands, with the upper three-fourths of each tubule staining strongly with paS and not at all with either acid mucopolysaccharide technique. The basal one-fourth of the cardiac gland tubules stained only moderately with paS, and moderate to heavily with both Alcian blue and Hale's colloidal iron.

The pyloric glands and mucous neck cells of glossophagines did not stain with Hale's iron, but revealed interspecific variation in staining with Alcian blue. Mucous neck cells within the lower portions of the fundic glands stained strongly in *Glossophaga*, moderately in *Anoura*, and not at all in *Choeroniscus* and *Lichonycteris*.

The pyloric glands stained in a similar fashion. Those of *Glossophaga* (both species examined) colored intensely throughout the length of the tubule, whereas, those of *Anoura* stained with equal intensity, but only within the basal arc of each tubule. The pyloric glands of *Choeroniscus* and *Lichonycteris* did not stain with Alcian blue.

Discussion

Review of Food Habits. The food of mormoopid bats is fairly well established in the literature as consisting mostly of flying insects. In

contrast, however, the food habits of many glossophagine species, which previously were assumed to be obligate nectar feeders, are inadequately or inaccurately documented. *Glossophaga soricina* now may be considered an omnivore (see Goodwin and Greenhall, 1961; Arata *et al.*, 1967), that consumes insects as well as nectar. The food of *Anoura geoffroy* is said by Goodwin and Greenhall (*op cit.*) to consist of nectar and soft fruit pulp. There is little evidence, as yet, that this bat takes insects. *Choeroniscus godmani* is assumed to be an obligate nectar feeder, but it is of interest to note that *C. intermedius* on Trinidad has been reported to include numerous insects in its diet (based on a single specimen examined by Goodwin and Greenhall, *op cit.*). The teeth of *Choeroniscus* are greatly reduced in breadth and height in comparison to most other glossophagines. Thorough masceration of insect material, which is characteristic of insect-feeding bats, seems unlikely in *Choeroniscus*, and thus insect feeding by this bat is probably rare. Stomach contents of *Leptonycteris sanborni*, as examined by Hoffmeister and Goodpaster (1954), consisted of 92 per cent pollen and eight per cent insect remains. Although Barbour and Davis (1969) reported that this species will eat a variety of fruits in captivity, insects possibly are not uncommon in the diet of this species. *Leptonycteris nivalis* is not formally known to take insects, however, it seems likely that general accounts of *Leptonycteris sanborni* apply to this species. Little is known, directly, of the food habits of *Choeronycteris mexicana*. Indirect evidence (heads and faces of specimens covered with pollen, as reported by Barbour and Davis, *op cit.*) would suggest that this bat probably is an obligate nectivore. Little information is available concerning the food habits of *Lichonycteris obscura*, but it is assumed that this species feeds on pollen and nectar.

Gastric Morphology in Relation to Feeding. Numerous morphological features of the stomachs of *Pteronotus* and *Mormoops* (simple overall configuration, thick and assymmetrical pyloric sphincter, small fundic caecum, and an extensive complement of zymogenic cells) are strikingly similar to conditions found in insect-feeding bats of the large North American family Vespertilionidae. Elongation of the terminal portion of the stomach, found to occur in North American insectivorous bats of the families Molossidae, Natalidae, and Emballonuridae, as well as in frugivorous and nectivorous phyllostomatids, is lacking in mormoopids. Mormoopids thus appear to parallel only vespertilionids in maintenance of a generalized gastric form. The glands of Brunner at the gastroesophageal junction are extremely abundant in both *Pteronotus* and *Mormoops*, resembling the condition found in other insectivorous, as well as fish-eating kinds. Non-carnivorous bats generally possess relatively fewer and less well developed Brunner's glands than carnivorous kinds.

Upon a review of the morphological features of stomachs of the glossophagines examined, it can be seen that there are two general structural forms. Of genera examined, *Glossophaga* and *Anoura* have stomachs of one form; *Choeroniscus* and *Lichonycteris*, the other. The somewhat more saccular stomach with expanded cardiac vestibule found in *Choeroniscus* and *Lichonycteris* more closely approximates the form found in frugivorous phyllostomatids, than does the form found in the other group of glossophagines. The stomachs of *Glossophaga* and *Anoura* are more tubular, with

less well developed cardiac ampullae, more closely resembling gastric configurations of insectivorous or carnivorous species. In the absence of adequate studies of food habits of most glossophagine genera, it would be premature to make an unqualified statement about gastric morphology as it relates to feeding in the Glossophaginae. However, there is sufficient evidence to suggest that there are two morphological forms of stomachs, and that an increase in stomach complexity is probably related to a decrease in insect- or flesh-eating. The descriptive account of gastric morphology, as well as an included diagram, of the stomach of *Leptonycteris sanborni* by Rouk and Glass (1970) closely parallels that of *Glossophaga soricina* (Forman, 1971), *G. Commissarisi*, and *Anoura geoffroy*. For this reason, the stomach of *Leptonycteris sanborni* here is considered to be most like those of Group A.

Several microanatomical features, which are found in two conditions or states in glossophagines, apparently are related to food habits, and reflect trends found to occur in other groups of bats. For example, there are two patterns of distribution of the glands of Brunner in the Glossophaginae that tend to parallel the two conditions observed in frugivorous and insectivorous or carnivorous species. Infrequent Brunner's glands, as found in *Choeroniscus* and *Lichonycteris*, is common, although not universal among frugivores. On the other hand, relatively abundant glands (*Glossophaga* and *Anoura*) is a characteristic of carnivorous bats. Additionally, zymogen or "chief" cells (those cells that presumably secrete proteolytic enzymes) are abundant in the fundic mucosa only in *Glossophaga* and *Anoura*. This probably is a further indication of the carnivorous habits of these bats.

Studies of gastrointestinal histochemistry revealed no striking differences between insect- and nectar-feeding bats. The significance of acid mucopolysaccharide in the fundic and pyloric glands of *Glossophaga* and *Anoura*, and the apparent absence of this material, except for universal staining in the cardiac glands, in either of the other two glossophagines or in the insect-feeding mormoopids remains unexplained.

Systematic Relationships as Revealed by Gastric Morphology. Systematic relationships among various closely related families of North American bats (Phyllostomatidae, Mormoopidae, Noctilionidae and Emballonuridae) recently have been reviewed by Smith (1971). He stated, on the basis of several features of external and internal morphology, that the Mormoopidae, Noctilionidae and Phyllostomatidae resemble one another more than they resemble any other New World group. He further suggested, on the basis of morphology of the male phallus and position of wing attachment, that mormoopids and noctilionids may be more closely related than previously thought. An examination of gastric structure in these two groups provides support for Smith's proposal.

Forman (1971) studied gastric morphology in the insect-feeding *Noctilio labialis*, and reported the presence of several features, which are noted here as being found together also only in *Mormoops* and *Pteronotus*. A large complement of Brunner's glands occurs at the gastroesophageal junction of *N. labialis*. These glands are indistinguishable in cellular morphology from those of the mormoopids examined, and differ from most other bats in possessing small cells with extremely small nuclei. Stomachs of *Noctilio* and the Mormoopidae

also resemble one another in having extremely limited distributions of pyloric glands, extremely long, narrow, and slightly coiled, gastric glands, short and pointed fundic caeca, and a relatively short terminal portion (that portion between the gastroesophageal junction and pyloric sphincter). None of the afore-mentioned features has yet been found in species of the Phyllostomatidae. A suggestion that similarity in gastric morphology is entirely attributable to consumption of similar foods by noctilionids and mormoopids, and therefore of little or no taxonomic value, would not be in order. Most of the morphological features discussed above have not been found to occur in other families of bats that characteristically consume insects or flesh (*e.g.* Natalidae, Vespertilionidae and Molossidae).

Baker (1967) studied several species of Glossophagines and found three species-groups based on chromosome number and morphology. One group included *Choeronycteris mexicana* and *Choeroniscus godmani*. The second group was composed of *Leptonycteris sanborni* and three species of *Glossophaga* (plus three genera of phyllostomatids not assigned to the subfamily Glossophaginae). The third group included only *Anoura geoffroyi*. Baker suggested that *Leptonycteris* and the species of *Glossophaga* form a natural assemblage because their karyotypes are quite different from those of other phyllostomatids in that karyotypic grouping. Differences between the first and second groups included differences in both fundamental number and morphology of individual chromosomes. Additional support for the distinctiveness of karyotypic groups in the Glossophaginae is provided in the observation by Baker that similarities between karyotypes of *Phyllostomus* (Phyllostomatinae) and *Leptonycteris* are greater than those between the *Choeroniscus* group and *Leptonycteris*. The karyotype of *Anoura* was said to be somewhat intermediate in having a fundamental number and X and Y elements resembling those of the *Glossophaga* group, but yet showed similarities with the *Choeroniscus* group in morphology of some autosomes.

Similar results are found in the studies of Phillips (1971) on dentitions (adult and deciduous) in glossophagines. He recognized 1) a *Glossophaga* group of 10 genera, within which were included *Glossophaga, Leptonycteris* and *Anoura*, and 2) the *Choeronycteris* group including *Choeroniscis*.

The results of studies of gastric morphology and histochemistry presented here indicate that there are two groups of glossophagines. The features of gastric morphology used as criteria for determining composition of the two groups appears elsewhere in this discussion. The groups recognized are 1) *Glossophaga, Anoura,* and *Leptonycteris* and 2) *Choeroniscus* and *Lichonycteris*.

Although the groups presented here do not correspond precisely with those of Baker or Phillips, they most closely approximate those of the former author. Baker indicated that *Anoura* possessed chromosomes with features of the other two groups of glossophagines. The stomach of *Anoura* tends, in several respects, to be intermediate between those of the other two groups recognized here. Examples of distinguishing features include a larger and more elongate cardiac vestibule than in either *Glossophaga* or *Leptonycteris*, and a tendency toward intermediate staining of acid mucopolysaccharide within the fundic and pyloric glands. As do Baker and Phillips, I consider the sub-

family Glossophaginae to be composed of at least two groups of species that probably represent an unnatural assemblage. Differences in gastric morphology are tentatively considered to be the result of early divergence in feeding habits. Stomachs of the *Glossophaga* group more closely resemble those of obligate insect feeders than those of the *Choeroniscus* group. Stomachs of the latter assemblage possess many features found to occur otherwise only in fruit-eating species. This divergence probably involves unknown differences in quality or quantity of food ingested, or a combination of these factors. Thorough examination of feeding ecology and ethology should be undertaken to test this proposal.

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Literature Cited

Arata, A. A., J. B. Vaughn, and M. E. Thomas. 1967. Food Habits of Certain Colombian Bats. J. Mamm., 48(4):653-655.

Baker, R. J. 1967. Karyotypes of Bats of the Family Phyllostomidae and Their Taxonomic Implications. Southwestern Naturalist., 12(4):407-428.

Barbour, R. W., and W. H. Davis. 1969. Bats of America. Univ. Kentucky Press. 286 pp.

Forman, G. L. 1971. Comparative Histological and Histochemical Studies of Stomachs of Selected American Bats. Kansas Univ. Sci. Bull., in press.

Goodwin, G. G., and A. M. Greenhall. 1961. A Review of the Bats of Trinidad and Tobago. Bull. Amer. Mus. Nat. Hist., 122 (Art.3):191-301.

Hoffmeister, D. F., and W. W. Goodpaster. 1954. The Mammals of the Huachuca Mountains, Southeastern Arizona. Illinois Biol. Monogr., 24:1-52.

Lillie, R. D. 1965. Histopathological Technic and Practical Histochemistry. McGraw-Hill, New York, xii + 775 pp.

Phillips, C. J. 1971. The Dentition of Glossopaginae Bats: Development, Morphological Characteristics, Variation, Pathology, and Evolution. Univ. Kansas Publ., Mus. Nat. Hist., Miscel. Ser., No. 54, 136 pp.

Rouk, C. S., and B. P. Glass. 1970. Comparative Gastric Histology of Five North and Central American Bats. J. Mamm., 51(3):455-472.

Schultz, V. W. 1970. Eingie Bemerkungen zum Bau Verdauung straktes und der systematischen Stellung des Spitzzahnflughundes, *Harpionycteris whiteheadi* Thomas, 1896 (Megachiroptera). Zeit. für Saügetierkunde, 35, Heft 2: 81-89.

Smith, J. D. 1971. Biosystematics of the Chiropteran Family Mormoopidae. Univ. Kansas Publ., Mus. Nat. Hist., in press.

Vaugh, T. A., and G. C. Bateman. 1970. Functional Morphology of the Forlimb of Mormoopid Bats. J. Mamm., 51(2): 217-235.

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