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OBSERVATIONS ON THE CARNIVOROUS HABITS OF THE SPEAR-NOSED BAT, PHYLLOSTOMUS HASTATUS PANAMENSIS ALLEN, IN PANAMA

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Little is definitely known concerning the feeding habits of many of the bats of Central and South America and it is believed that the following observations on the carnivorous habits of the spear-nosed bat, *Phyllostomus hastatus panamensis* Allen, in Panama, may be of interest.

It is evident that the food habits of this bat have been under question for a number of years. Elliot (1), writing of the genus "*Phyllostoma*," mentions the possibility of these bats being of carnivorous habits, as follows: "Like some of the large insectivorous bats, the species of this genus may possibly feed on smaller bats, which fact may have given them the reputation, long borne by *P. hastatum*, of being sanguineous."

My first observation that indicated this bat was a killer and flesh eater occurred on April 27, 1929. On the day previous to this date I visited the Chilibrillo Caves, located about fifteen miles from Panama City, and captured 34 bats. Seven of these were *Phyllostomus hastatus panamensis* and 27 were the smaller bats, *Hemiderma perspicillatum aztecum*. Since the only route by which these caves could be reached at that time was a rather difficult one to travel, only one cage in which to place the bats was carried. This was a light, wooden box large enough to hold two five-gallon tins of kerosene, for which purpose it had formerly been used. The wood on one side had been removed and replaced by small-meshed wire netting. Owing to a late return to the laboratory the bats were left all together in the cage for the night. The following morning there were but eight bats left alive. This number included the seven *Phyllostomus* and one of the *Hemiderma*, the latter being so badly injured that it died a few hours later. The other 26 *Hemiderma* evidently had been killed during the night by the seven larger bats. The wings, feet, legs and shreds of flesh were all that remained of five of the dead *Hemiderma*. Four others were mangled and partly eaten. The remaining 17 were somewhat crushed and torn but were not badly mangled.

Subsequently, while engaged in studies in connection with the susceptibility of bats to various human and animal diseases, I had occasion to keep a number of *Phyllostomus* in captivity for periods varying from a few days to three months and more. They were caged in the laboratory animal house and readily responded to captivity. Not much attention was paid to their diet other than to give them plenty of fruit of various kinds and an occasional piece of meat. It was noted that the latter was always quickly eaten.

On July 4, 1932, an adult female *Phyllostomus h. panamensis*, weighing 104 grams, that had been captured in a stable in the Canal Zone, was received at this laboratory. It was decided to make use of this specimen in conducting some observations on the food habits of the species and she was, therefore, placed in a wood and screen cage, 20 x 20 x 20 inches, and kept in my office where she could be closely observed. Ripe banana was placed in the cage daily but during the first few days the amount eaten was comparatively small for a bat of this size.

On the evening of July 9 a small dish containing 5 cc. of defibrinated blood was placed in the cage. The next morning the dish was empty. The following night the bat drank another 5 cc. of blood, ate a good sized piece of monkey liver and also some banana.

Five cockroaches, *Periplaneta americana*, each of which was more than an inch and a quarter in length, were placed in the cage on July 17th. A piece of the hard outer wing, or tegmina, of one of the roaches was all there was to be found the following morning. At 10 a.m. July 18, eight more of these roaches were put in the cage. About five minutes later a snapping and crunching sound was heard in the cage and the bat was found to be feeding on one of the roaches. She was hanging from the top of the cage by her feet and holding the roach to her mouth by means of her thumbs and ends of the forearms. The noise made by her chewing would lead one to suspect that she was deriving keen pleasure from her lunch on the roach. On the morning of July 19 all that remained of the eight roaches was a small part of the posterior end of one, four outer wings and a few small fragments. Ten large roaches were then put in the cage. During the night of July 19 seven of these were consumed, except for a few small pieces of the outer wings, two others were partly eaten and the tenth was still alive. This last roach was devoured during the following day.

On the evening of July 21 a live, adult mouse, *Mus musculus musculus*, of medium size was placed in the cage. The following morning it was found that the mouse had been killed and eaten, with the exception of the hind quarters and the tail. The skull and all the bones of the fore and middle part of the body had been consumed. During the following four consecutive days a live mouse was placed in the cage each day; these were killed and the head and anterior half of the body eaten by the bat each night. The hips, hind legs, tail and sometimes part of the entrails were not consumed.

Owing to the difficulty in securing live mice no more were obtained until August 19. During this period of twenty-five days the bat fed only on banana. Defibrinated blood was placed in the cage on several occasions but it was not taken.

At 10 a.m. on August 19 a large mouse was captured and placed in the cage. A few minutes later the sudden noise of a struggle was heard and on investigation it was found that the bat had caught the mouse and was holding it with her mouth and wings. Her teeth were gripped on its back just in front of the hips. The mouse was still struggling and squeaking and apparently was attempting to bite the bat on the thumbs and ends of forearms. It was evident from the vigorous exertions of the mouse that the bat was holding it only by the skin on its back and did not have a sufficient grip on its body to crush it. The bat was hanging from the ceiling of the cage by one foot, the other leg being

bent over with the foot resting on one of the wings. After several attempts at what seemed to be efforts to hold the head of the mouse with her thumbs and ends of forearms the bat put her head, with the mouse in her mouth, inside her wings, which were held partly extended in front of her to form a pocket, and after making several quick movements with her head and wings she straightened out to hang with her head downward again. She now had the back of the head of the mouse in her mouth. The mouse was motionless and apparently was dead. In putting her head between her wings the bat evidently had made use of the wings to aid in holding the mouse until she could shift her mouth hold to its head and crush the skull. The bat now began eating the mouse, beginning at the head, with a chewing, crunching sound. The wings of the bat were partly extended in front of the under surface of her body with the ends of the forearms held together and the second and third metacarpals of one wing held together and in close contact with those of the other wing. This formed the wings into a trough-like pocket which probably helped to support the carcass of the mouse while the bat was feeding on it. At the end of sixteen minutes the head, shoulders, and breast of the mouse had been consumed and the remainder dropped to the floor of the cage. Approximately six hours later the bat descended to the floor of the cage and after taking the remaining part of the carcass in her mouth climbed up, again to hang head downward and enjoy another meal. Only the tail and a few small pieces of entrails were left when she finished eating.

On the afternoon of August 20 a large adult mouse was put in the cage. This mouse was very active and although the bat evidently caught it with her teeth several times and squeezed it hard enough to bring forth a squeal of pain each time, she did not succeed in holding it. After eluding the bat for about fifteen minutes the mouse took refuge in one of the folds in the cloth sleeve that formed one side of the cage. The bat had been crawling rather clumsily about the cage in pursuit of the mouse and now proceeded very quietly to creep up the cloth of the sleeve and push her head down in the fold in which the mouse had hidden itself. The bat almost immediately withdrew her head but she now had the head of the mouse firmly gripped in her jaws. This mouse was partly eaten during the next eleven minutes and in the early evening the remainder was consumed. Only the tail was left after the second meal and during the night even that was devoured.

On each of the following days, August 21 and 22, a mouse was consumed. A small piece of entrails and the tail of one was left but even the tail of the other was eaten.

No more mice being available at this time it was decided to see if birds would be killed and accepted as an article of diet by the bat. On August 24 an adult bird, a honey creeper, *Cyanerpes cyaneus cyaneus* (Linnaeus), about four and a half inches in length, was placed in the cage. The bat immediately became markedly excited and made numerous attempts to catch the bird. The cage being too small to permit the bat to use her wings she could only crawl about on the screen of the cage with her feet and thumbs and the bird had little difficulty in evading her. Twice the bat dropped from the side wall of the cage in unsuccessful attempts to alight on the bird. After repeated fruitless attempts to capture the bird the bat ceased her efforts and during the rest of the day remained quietly hanging from the top of the cage whence she continued to watch the movements of the bird. Her efforts during the night evidently were more successful and the following morning all that remained of the bird were 46 of its larger feathers, from wings and tail, and ten smaller ones. The beak, claws, and even all other feathers had been consumed. On the following day a second bird of the same species and size as the first one was placed in the cage at 9:30 a.m. The bat captured this bird about 4:40 p.m. and began feeding on it. All that seemed to escape its jaws were the feathers that dropped while the bird was being eaten. At the end of twenty minutes a number of feathers, the beak and the fleshy terminal end of the body bearing the tail feathers were all that remained of the bird. During the night the flesh on the piece of rump was also eaten. The next morning 28 of the larger feathers and 17 small ones and the beak were all that was left of the bird.

A mouse placed in the cage on August 31 was completely consumed, not even a piece of the tail being left.

Wishing next to determine if the *Phyllostomus* would kill and devour smaller bats an adult female long-tongued bat, *Glossophaga soricina leachii*, was put in the cage on September 4. The *Phyllostomus* did not appear to show much interest in the smaller bat and the latter did not exhibit any marked evidence of fear of the larger one. The smaller bat selected a site at the top of the cage from which to hang scarcely more than six inches distant from the *Phyllostomus*. The wings and the joined legs represented all that remained of the *Glossophaga* the following morning. The smaller bat had been killed and its head and body, including the skull, ribs, and vertebrae, had been eaten. During the night of September 5 a second bat of the same species also was killed and the head and part of the body eaten.

An adult short-tailed bat, *Hemiderma perspicillatum aztecum*, placed in

cage on September 8, was killed during the night and the greater part of it eaten. The wings, legs, and a small mass of skin and flesh were left, but all bones of the head and trunk were consumed. A second bat of this species that was placed in the cage on September 9 was not killed until the night of September 11. The head and most of the body were then consumed.

Another *Glossophaga soricina leachii* was placed in the cage at 4 p.m. September 15. Two hours later all that remained of this bat were the wings, and during the night the greater part of these also was eaten. The pieces left consisted of the ends of the forearms, with a few small pieces of bones of the fingers, and shreds of wing membrane attached. One thumb also was left at the end of one of the forearms. It was rather surprising to note that the long bones of the forearms, the claws of the feet, and one thumb with its nail attached had been consumed.

An adult house wren, *Troglodytes musculus inquietus* (Baird), more than four inches in length, was offered the bat at 4 p.m. September 1. The bird flew about in the cage for nearly a minute before it appeared to notice the bat. It then alighted on the floor of the cage at the side opposite from that on which the bat was hanging, where it remained very quietly with its gaze directed toward the bat. Its behavior would lead one to suspect that it recognized danger from the bat and showed fear. At the end of five minutes a slight tapping of my fingers on the side of the cage near the bird caused the latter to take flight again. After darting about the cage for a few seconds it struck the screen below where the bat was hanging. The latter with unexpected rapidity seemed to straighten her legs and to stretch down and grasp the bird by the side of its breast with her mouth. As the bird struggled the bat quickly turned her head to one side to hold the bird with her right wing while she shifted the grip of her jaws until she grasped the neck of the bird. The wren was killed immediately. The bat then began a steady chewing which was accompanied by the usual snapping and crunching sounds. This was continued for 21 minutes. The bat ate the bird from the neck downward toward its tail. Nothing fell to the floor of the cage except some feathers until the chewing ceased and the appetite of the bat apparently was satisfied for the time. Four pieces of the bird were then dropped. These consisted of (1) foot, leg, and piece of thigh, (2) foot and part of lower leg, (3) head with beak intact, and (4) part of a wing with feathers attached. No blood nor any liquid was in evidence. These pieces were left in the cage and the following morning only 26 large feathers from the tail and wings and 14 small ones from other parts of the

bird were present. The rest of the pieces, including the beak and both feet, had been eaten during the night.

At 10 a.m. October 1 an adult female bat, *Uroderma bilobatum*, was placed in the cage. In four minutes the *Phyllostomus* caught the smaller bat and was holding it in her mouth. The *Uroderma* was voicing shrill squeaks and struggling vigorously and after about twenty seconds it apparently bit the larger bat, since the latter gave a sharp squeak of either pain or anger and dropped the *Uroderma* to the floor of the cage where it landed with wings outstretched and remained motionless. The *Phyllostomus* immediately ran down the side of the cage and when close to the small bat paused to watch it for a few seconds and then extended a forearm to touch the small bat with her thumb. After repeating this movement several times she took the *Uroderma* in her mouth and ascended to hang from the ceiling of the cage while she devoured it. This stealthy investigation on the part of the bat to ascertain if the *Uroderma* was dead was extremely interesting and might be likened to the actions of a big game hunter in examining his kill to make certain it is dead or whether another shot need be given before relaxing his caution or laying aside his gun. The head and shoulders of the *Uroderma* were eaten at this time. At 4:15 p.m. the *Phyllostomus* began her second meal of the day and fed on the carcass for 19 minutes. The wings of the small bat were all that remained after the second meal.

A large, adult male little bull dog bat, *Dirias albiventer minor*, was next tried out. This was a robust bat with a forearm length of more than 60 mm., and it was considered probable that the *Phyllostomus* would not attack it. The *Phyllostomus* appeared to show a considerable amount of interest in the other bat as soon as the latter was placed in the cage. The *Dirias* has the most offensive odor of any species of bat that I have handled in Panama. The males especially emit an extremely strong scent of musk. It would appear that this odor had a strong attraction for the *Phyllostomus*, whether from a sex standpoint or for some other reason it was not possible to decide. She moved to where the *Dirias* was hanging and seemed to smell him over very closely and at times appeared to be rubbing her snout about on his back. As it became dusk, the evening of the same day, the *Phyllostomus* again moved near the other bat and after smelling him over for a few seconds opened her mouth and slowly advanced to bite him. As her mouth was about to close on the neck of the *Dirias* the latter moved to another location in the cage. This was repeated a number of times while I was watching but each time the large bat seemed to be very slow about gripping the other.

The following morning the *Dirias* was found to be dead and the greater part of its head and the abdomen and entrails had been eaten. The lower jaw and the upper tooth row on either side had been cleaned of all flesh but apparently the teeth were not suitable for food and had been discarded. None of the thorax or abdomen was eaten and it is suspected that this was due to a small amount of soft, oily, wax-like substance having a very objectionable odor that was present just beneath the axillae of the *Dirias*.

Late in the afternoon of October 2 a male Coiba Island mastiff bat, *Molossus coibensis*, was placed in the cage. At dusk the *Phyllostomus* was heard chewing and she was found to be feeding on the bat. Only one wing and a small piece of flesh remained of the *Molossus* the following morning. Two days later another bat of this species was eaten until only a small piece of one wing was left.

Another large male *Dirias* was offered on October 9. With the coming of dusk the *Phyllostomus* began her attack on this bat. She adopted the same tactics as those used with the previous specimen of this species, following it about the cage and without any haste approaching it and snapping at it with her teeth. The bites seemed to hardly more than touch the skin at times but at each bite the smaller bat changed to a different position in the cage only to be followed by the larger one. With the exception of a few short periods when the large bat stopped to clean and comb herself this stalking was continued for at least an hour while I remained to watch it. Whether the repeated toilet performed by the *Phyllostomus* signified attempts to rid herself of the odor or taste of the other bat that she may have acquired while biting it I am unable to say, but it would seem as though this might be the case. The large bat seemed simply to be wearing out the other by chasing it about and possibly trying to disable it with a single snap of her teeth without attempting to hold it. She may have been afraid to try to hold the smaller bat or else may have disliked the smell of the other so much that she did not want to hold it too close to her. During the night the smaller bat was killed and like the previous one of this species only the head, abdominal region, and genitalia were consumed. The breast and back were not eaten. Two small pieces of the lower tooth row with no flesh attached were found to have been discarded as before. During the next seven days the bat killed three more *Dirias a. minor*, these being females, and ate about the same parts and amount of each one as of the previous two. Most of the teeth were discarded on each occasion.

A mouse was killed and eaten by the bat on October 25 and another on October 27.

It was noted that a mouse, bird or bat was seldom entirely consumed by the *Phyllostomus* unless she was very hungry for flesh. Usually she fed a second time on her kill about six or seven hours after the first meal. This would lead one to believe that under natural conditions she would feed twice and possibly three times each night. In considering this my curiosity became aroused over the question of whether under natural conditions the *Phyllostomus* makes one or two kills during the night. The actions of the bat in captivity indicated a fear or dislike at being on the floor of the cage; she devoured each kill only while hanging head downward suspended by her feet and with her prey grasped in her jaws. If this occurs under natural conditions, as seems probable, the part of the animal or bird not consumed at the evening meal would be dropped to the ground beneath where the bat happens to be hanging. It may be surmised that the bat would prefer a fresh kill for each meal, if obtainable, rather than to feed on the part of the carcass that may have been lying on the ground six or seven hours, if not already destroyed by ants or rodents. Should the bat make a fresh kill each meal it would mean two or more small birds or mammals killed each night while if the bat be more or less of a scavenger in feeding more than once on the same animal only one kill would be made nightly.

In an attempt to gain some information on this question two adult mice were given to the bat at 4:45 p.m. November 1. She captured and killed one of these mice in less than two minutes and immediately began feeding on it. The second mouse in seeking a place of concealment several times jumped into the pocket formed by the wings of the bat. She promptly ejected it each time but without interrupting her feeding upon the first mouse. At the end of 13 minutes she had consumed the head and anterior half of the first mouse. She then dropped the rest of the carcass and captured the second mouse and began feeding on it. Sixteen minutes later the fore parts of the second mouse were eaten and the rest dropped. The next morning only the tails, hind legs, thighs, and entrails of the two mice remained.

Three mice were offered at 4:30 p.m. November 5. The bat killed one and began feeding on it within a few seconds. After eating the head of this first mouse she dropped the remainder and killed a second one and began feeding on it. The tail of one mouse and the tail and hind quarters of each of the other two remained the following morning.

Two mice that were given the bat on November 9 were killed and nearly all consumed.

Between November 10 and December 19, the bat killed and ate seven more mice. Undoubtedly she would have devoured many more had they been given to her.

This *Phyllostomus* died on December 19, after 168 days in captivity.

During all the time this bat was in captivity a supply of fresh, ripe banana was placed in her cage daily, and each night, with but one exception, some of the fruit was eaten. When there was flesh to feed on the bat usually took only a small amount of the banana. When there was no mouse, bird, or bat on which to make a meal more of the fruit was eaten. On the night the three mice were devoured the banana was not touched.

The completeness with which the bat devoured the bones of her victims spoke well for the crushing force of her teeth and jaws and also for the disintegrating properties of her digestive juices. In order to observe how thoroughly the bones were digested all fecal pellets excreted by the bat throughout the period extending from October 1 to October 19 were removed from the cage each day and saved. At the end of the nineteen days these pellets were lightly macerated in water until dissolution occurred. This suspension was then passed through a sieve made of metal gauze having eighteen meshes to the inch. A comparatively small amount of hair was the only substance that did not pass through the sieve. No pieces of bone were found despite the fact that the *Phyllostomus* had eaten eight bats during the period that the fecal pellets were being collected.

If we may judge the *Phyllostomus* by its behavior in captivity, we must conclude that this bat seeks a flesh diet under natural conditions. If so it may destroy many small birds that are active at night and may even seek out those of diurnal habits at their roosting places and nests. It may also devour many mice and other small rodents of nocturnal habits. The seeking of prey of this kind may account for specimens of this species of bat being occasionally captured in barns and stables.

So far as I have been able to learn from the limited amount of literature dealing with the Chiroptera that is available to me at this time the only other bat known to be of carnivorous habits is the *Megaderma lyra* Geoffroy of India. This species also appears to feed on birds, bats, mice, and other small vertebrates. Some very interesting information concerning this bat in Ceylon has been given by Green (2) who states: "In a previous number of this Journal I have called attention to the carnivorous habits of bats of the genus *Megaderma*. I have found frequent signs of its depredations in the remains of birds and small bats dropped

in my verandah. I have since seen the fragments of a mouse (consisting of the feet and part of the head, mingled with the characteristic excreta of a bat) that had evidently been captured and devoured by the same animal. But, until quite recently, I have never come to close quarters with the bat itself. Examination of a loft above the Royal Botanic Gardens Laboratory has, however, revealed a stronghold of *Megaderma lyra*. * * * * The destruction of small birds, due to these vampire bats, must be enormous. Day after day, for weeks together, I have found my verandah strewn with the wings and feathers of small birds, principally of the dainty little honey-sucker (*Cinnyris zelonicus*)." Gleadow (3) informs us: "Referring to Mr. Ernest Green's query on p. 835, vol. 17 of this Journal, there is no doubt whatever that *Megaderma lyra* habitually feeds on birds and mice. These verminiferous vermin (the bats) used to annoy me greatly by catching mice about my house, and fetching birds out of their comfortable nests in the night and chewing them up in the corners of rooms or verandahs. We are spared the use of our inductive and deductive faculties (which would perfectly suffice) by the simple fact that I have seen them do it many times. The well known zoologist, Mr. F. Finn, was living with me at the time. We caught and caged the bats and he fed them on small birds brought for sale by the natives." Primrose (4), in writing of this bat tells us: "For the past three years I have been puzzled to know whether my surmise that the Indian Vampire Bat (*Megaderma lyra*) was responsible for the remains of small birds, chiefly of the Indian Bush Chat (*Pratincola maura*), small bats and insects, which are always picked up from the floor of my front verandah every morning in the cold weather, and which is at times quite strewn with them. * * * * To-night, however, I have been able to confirm the fact that undoubtedly small birds do form a portion, and here a substantial one, of *M. lyra's* food, having just killed one in the act of eating a small bird, and the bat and its victim lie before me as I write."

Our present knowledge of carnivorous bats now appears to include two widely separated species, *Megaderma lyra* Geoffroy of the southern part of Asia and *Phyllostomus hastatus panamensis* Allen of tropical America.

SUMMARY

Observations on *Phyllostomus hastatus panamensis* in captivity demonstrate this bat to be of carnivorous habits. One specimen kept in captivity for 168 days killed and ate 25 mice, 13 bats and 3 birds.

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