18.

Some Observations on the Feeding Methods of the Vampire Bat.

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(Plates I-III).

Many superstitions and curious beliefs have been associated with the vampire bat. Anaesthetic, depilatory and anti-coagulant properties have been attributed to the saliva of the vampire. Even at this date the true vampires, *Desmodus*, *Diaemus* and *Diphylla*, are described in dictionaries and encyclopedias as "blood-sucking" animals. In recent years the work of Dunn (1), Clark (2), Urich (3) and Ditmars (4) has done much to afford scientific information as to the habits of the vampire and to discredit erroneous statements as to its behavior.

For the past five years Ditmars has been making a detailed study of *Desmodus rotundus* in New York City. Observation by him in the natural locale of *Desmodus* gave an opportunity for viewing the results of its work. When humans were bitten during the night, blood stains were always apparent. Ditmars reports a case of a ten year old boy bitten during sleep five times within a week. "He had bled profusely and the earthen floor beneath his slatted bed was blood stained each morning." Cattle frequently showed large blood stains on their hides. "Ropes" of coagulated blood were seen hanging from the necks of horses attacked in their stalls. Such observations were indicative of profuse bleeding. The possibility that saliva of the vampire bat contained an anti-coagulant which might be used for studying some aspects of the phenomena of blood coagulation seemed worthy of consideration. It is well known that certain of the hematophages secrete such substances.

Bier (5), in 1932, reported a fibrinolytic and anti-coagulant action of an alkaline alcohol-ether extract of macerated salivary gland of *Desmodus*. He states that a similar extract of the salivary glands of a single specimen of *Phyllostoma* did not reveal such properties. Bier states that aqueous extracts of the glands of *Desmodus* had no anti-coagulant properties. Samples of rabbit blood to which the aqueous extract were added showed the same coagulation time as the control samples. This does not appear to afford a strong evidence for the implied significance of his observations.

During the preparation of this article the attention of the authors was called to a paper by Pawan (6) in which he states: "Bleeding may be profuse, probably due to an anti-coagulant, which was found present in both the dry and fresh powdered salivary gland substance, and which is capable of hindering coagulation of human blood in greater dilution than 1 in 1,000." Pawan does not give the details of preparation of this extract.

An opportunity for further observation on the method of feeding was made possible by the availability of four specimens of *Desmodus* at the New

York Zoological Park. Four additional specimens were obtained from Trinidad for the investigation of the possible anti-coagulant properties of their saliva, through the kindness of Professor Urich.

The vampires were housed in a large cage, well protected from drafts, without any special attention to maintenance of a constant temperature. The cage was kept scrupulously clean. A fresh supply of drinking water was constantly at hand. The bats were fed defibrinated blood two or three times a week. On the remaining days, except on Sundays when they were starved, they were allowed to feed upon either live fowl, rabbits, guinea pigs or a goat. There was ample room in the cage to permit putting the various animals in with the bats, and yet allow the bats sufficient space to take flight and attain a safe roost if their host became restless.

In order to determine whether an anti-coagulant was normally present in the saliva of *Desmodus* while it was feeding, (1) coagulation time was determined for samples of blood from the bat wounds, (2) the bleeding time of the wounds was noted, (3) the effect of washings from the bats' mouths was tested on freshly drawn cat's blood and (4) the mouths of the bats were examined for clots following the feeding of human blood by means of an eye-dropper.

METHOD OF OBTAINING SAMPLES FOR DETERMINATION OF COAGULATION TIME.

The method of presenting the experimental animal to the bats varied for the species. Where fowl were used the initial practice was to bind the wings and legs. The movements of rabbits and guinea pigs were restricted by bandaging them to an animal board. A halter was placed on the goat to prevent it from throwing its head back and injuring the bats with its horns.

It soon became apparent, however, that the vampires were well able to take care of themselves. They were able, in all except a few instances, to bite and feed without disturbing their hosts. Fowl were completely indifferent to their enforced role so that the binding was soon discontinued. In one instance when feeding was interrupted by turning on the light, a rooster got on its feet and walked a few steps, while a bat, standing on its hind legs, its thumbs braced against the leg of the rooster, continued to lap blood from the wound. The goat displayed some curiosity as to the bats when they were moving about, but showed no indication of being aware of being bitten. Occasionally, during the feeding, the goat would contract its panniculus carnosus muscle, causing its hide to quiver, as it might do to shake off flies. Since rabbits and guinea pigs are fairly active in the dark, it was deemed advisable to continue restricting their movements.

After placing the host in the bat cage, the lights were extinguished and a sufficient time was allowed for the bats to get under way with their feeding. Feeding was then interrupted and the animal removed from the cage. An attempt was then made to secure a sample of freely flowing blood either in a small phial or in a capillary tube such as is ordinarily used for determination of coagulation time.

At the outset, it was apparent that the presence of an anti-coagulant would be indicated only if coagulation were delayed for relatively long periods. The experimental conditions were far from ideal. The wounds were frequently contaminated with hair and other foreign material during the process of feeding. In addition there was considerable unavoidable variation between the actual time of the bite, which could not be accurately determined, and the time of collecting the samples. Control experiments for comparison of coagulation time could be of only minor significance since the bites could not be adequately imitated.

Fowl.

The results on fowl were equivocal. All but one of the samples of blood taken from two fowl clotted in 3 to 7 minutes. Blood from a wound made by cutting a small crater with a scalpel clotted in 2 to 6 minutes. One sample from the bat wound did not clot for 50 minutes. Such a result might indicate either that there was a sufficient quantity of active saliva to retard coagulation in only one sample or that there was something unusual in that sample. Blood of fowls does not contain cephalin, and clotting depends upon the addition of tissue cephalin so that there exists the possibility of obtaining samples without "contamination" of the tissue fluid. The use of fowls was discontinued for this type of test so as to rule out such a possibility.

The results of observations made on other species are summarized in Table I.

TABLE I.

Range of coagulation times for the samples of guinea pig, rabbit and goat blood.

Animal.	No. of Animals.	No. of Experiments.	No. of Samples.	Source of Samples.	Range of Coagulation times (Min.).
Guinea Pig.	1	1	5	Incised marginal ear vein.	4-5
			3	Bat wounds.	3-8
Rabbit.	2	2	10	Incised marginal ear vein.	3-10
			6	Bat wounds.	3-10
			1	From blood dripping on wax paper from incision on toe.	5-17
			1	From blood on wax paper from bat wound.	9-20
Goat.	1	3	19	From bat wounds.	1-10

A typical protocol of a test on the goat is given below.

7 P.M. Goat placed in cage; lights extinguished.

9:40 P.M. Feeding interrupted. Two bats were seen feeding on the goat. One old wound on its side had been reopened. Another fresh wound had been made on its back. The old wound was oozing blood; the wound on the back was relatively clean and dry with only a minute amount of blood in the crater-like wound. Samples were taken from site of old wound.

Sample.	*Clotting Time.*
1	3'45"
2	3'50"
3	6'45"
4	6'20"
5	5'17"
6	5'01"
7	3'50"
8	3'50"

10 P.M. Wound on back showed small amounts of clot around edges of crater; no bleeding. The wound was opened by gentle massage of the surrounding area.

Sample.	*Clotting Time.*
1	2′
2	1′10″

After the bats had been feeding, small pools of blood were seen on the floor of the cage; frequently the pelage of the host was streaked with blood. In spite of the evidence of a free flow of blood during feeding, the efforts to obtain adequate blood samples for determination of coagulation time were frequently unsuccessful. On removing the animal from the cage the wounds were usually either relatively dry or showed a slow oozing which filled the crater of the bite, but did not drip from the wound. Occasionally, however, the oozing was sufficient to result in some dripping.

When the flow was inadequate for sampling, gentle massage around the area of the wound would reestablish a slight flow. Clots formed, in the undisturbed wounds and in wounds in which the flow had been reestablished by massage, in 4 to 35 minutes.

In contrast to these results, a wound, inflicted by inducing a leech to feed on the goat, bled for more than an hour. Samples collected from the leech wound showed coagulation times of 7 to 13 minutes.

THE EFFECTS OF WASHINGS FROM THE MOUTHS OF *Desmodus* ON COAGULATION TIME OF CAT'S BLOOD.

After repeated handling the bats would remain quiet when held lightly in a gloved hand. Occasionally they would bite the glove once or twice and then become quiet and feed contentedly from a pipette. When they had become accustomed to handling, washings were obtained from their mouths with the view that if an anti-coagulant were present, it might be possible to obtain a solution of their saliva of sufficient concentration to retard or prevent coagulation of freshly drawn blood.

5 cc. of distilled water was measured into a small container. A few drops were taken up in an eye-dropper and injected into the mouth of a bat. The washings were recovered from the mouth or the lips, returned to the original 5 cc. container and the dropper rinsed in the mixture. The process was repeated six to ten times for each of the four bats. A half-hour

TABLE II.

Coagulation time: cat's blood (carotid artery) and washings from mouths of *Desmodus*.

Sample.	CC. of Blood.	Solution Added.	Am't Solution.	Coagulation Time.
1	3	Saline "washings."	5 drops	4′28″
2	3	" "	3 "	3′33″
3	3	" "	1 "	3′50″
4	3	Distilled Water "Washings."	5 "	2′31″
5	3	Distilled Water "Washings."	1 "	4′53″
6	3	Saline only.	5 "	5′03″
7	3	" "	1 "	6′47″
8	3	NONE (clean & dry).	.....	5′51″
9	3	" " "	.....	6′08″

rest period was allowed and the process was repeated, using 5 cc. of saline solution. Small portions of the 5 cc. of saline washings and the 5 cc. of distilled water washings were added to 3 cc. of freshly drawn cat's blood. Coagulation time was taken when the test tubes could be inverted without spilling the mixture. The results are summarized in Table II. It is apparent that the addition of washings decreased the coagulation time. Similar results have been obtained with human and dog saliva, by Bellis, Birnbaum and Scott (7). Human saliva reduced coagulation time when added to blood in proportions of 1 to 400.

Results of Examination of the Mouths of *Desmodus* after Feeding Freshly Drawn Blood with Pipettes.

To obtain freshly drawn blood for the feedings, the fingers of one of the observers were washed thoroughly with soap and water and then alcohol. Time was allowed for the fingers to dry and a puncture was made with a blood lancet to a depth to permit a generous flow of blood. A portion of the blood was drawn into a clean dropper and transferred to the mouth of a bat. If the bat fed rapidly, two or three portions could be transferred to the bat's mouth in about a half a minute. A clean dropper was then taken, a fresh puncture was made and the process was repeated. The mouths of the bats were forced open gently at frequent intervals and examined for clots.

Results: April 17. Pipetted blood from finger puncture into mouth of bat. Surface of finger was repeatedly cleaned, using a new drop of blood and a clean pipette after 2 or 3 feedings. Bat's mouth gently forced open with forceps. Several small clots were noted and removed.

May 4. Male bat fed on blood from finger punctures. No clots were seen on examination of buccal cavity. A small clot was allowed to form on a finger puncture and was offered to the bat. He ate it readily.

Female—Did not feed well. Only occasional movement of tongue. Swallowing infrequent. As a result some blood collected in mouth. Examination revealed some fluid blood in the rugae palatinae. Small clots were seen on the tongue, hard palate and on the buccal surfaces of the cheeks.

May 10. Male—Fed blood from finger puncture. Examination revealed small clots in mouth.

May 15. Male—Fed blood from finger puncture. Examination revealed good clot after first 3 feedings (less than 1 minute).

Female—Fed for 3 minutes. Clot seen in mouth.

May 20. Two bats fed on blood from finger puncture. Clots seen in mouths after feeding.

Depth of the Bat Bites.

Tissues surrounding wounds at which bats had been feeding were removed and fixed for sectioning and histological examination. Sections were made of the wounds in a pigeon, a chicken and a guinea pig.

The bite in the guinea pig extended through the four layers of the epidermis and the two layers of the dermis but did not involve the panniculus adiposus. Thus, the bite may be said to be skin deep.

The combined thickness of the dermal and epidermal layers in the guinea pig are from two to four times as thick as they are in the pigeon. The panniculus adiposus in the guinea pig was of a fairly constant depth but in the pigeon it was variable although always present in some degree. In the pigeon the panniculus adiposus and even a few of the outermost muscle bundles were removed. Although a greater number of differentiated

layers were removed in the pigeon, the bite was of approximately the same depth as in the guinea pig.

The bite in the chicken extended into the stratum reticularis of the dermis. As the dermis of the chicken in that area was thicker than that of either the guinea pig or the pigeon, a bite of approximately the same depth did not reach the adipose layer.

Conclusions.

While it has been reported that extracts of the salivary glands of *Desmodus* have anti-coagulant properties, the results of these experiments fail to reveal any evidence that an anti-coagulant plays a part in the normal feeding process of the vampire. The difficulty in obtaining adequate samples of the blood, the relatively rapid clot formation in the wounds after feeding has been interrupted, and the presence of clots in the mouths after dropper feedings, are strong indications that the rapid flow of blood during feeding is due to the nature of the bite and the massage by the tongue.

The view that since vampire bats are hematophages they are supplied with a saliva having anti-coagulant action may have arisen through teleological reasoning. Slicing the highly vascular dermis insures a fairly good flow of blood. If the flow is free, the bat laps the blood scarcely touching the tissues; if scant, the bat licks the wounds (1). The blood stains on the pelage and on the ground may be accounted for by dripping of the wound when the flow is kept going during the feeding.

Acknowledgement is due Dr. R. L. Ditmars for his whole-hearted cooperation in carrying out these studies. Dr. Ditmars offered his own specimens of *Desmodus rotundus* for the preliminary observations in which he collaborated; he assisted in helping obtain the additional specimens from Trinidad and made many helpful suggestions as to their handling and care. The authors also wish to express their indebtedness to Professor Ernest L. Scott for the photographs and to Mr. William Bridges for his encouragement and helpful suggestions.

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EXPLANATION OF THE PLATES.

PLATE I.

Fig. 1. Training a vampire bat to feed from a medicine dropper, using defibrinated blood. The bat is held lightly between the thumb and the first two fingers.

Fig. 2. The bat feeds contentedly from the dropper. It may be noted that the mouth is open and the lips are not in contact with the pipette. The tip of the tongue may be seen touching the end of the dropper.

PLATE II.

Fig. 3. Lapping blood from the site of a blood puncture. The bat evidences no annoyance at the handling. All his efforts are directed toward obtaining the blood.

Fig. 4. Finishing the drop of blood. The spear-shaped tongue is well extended in lapping the blood.

PLATE III.

Fig. 5. Microphotograph of a vampire bat bite in the guinea pig. The bite extended through the epidermis and the dermis.

Fig. 6. Microphotograph of a bite in the pigeon. The epidermis, dermis, panniculus adiposus and even a few of the outermost muscle bundles were removed.

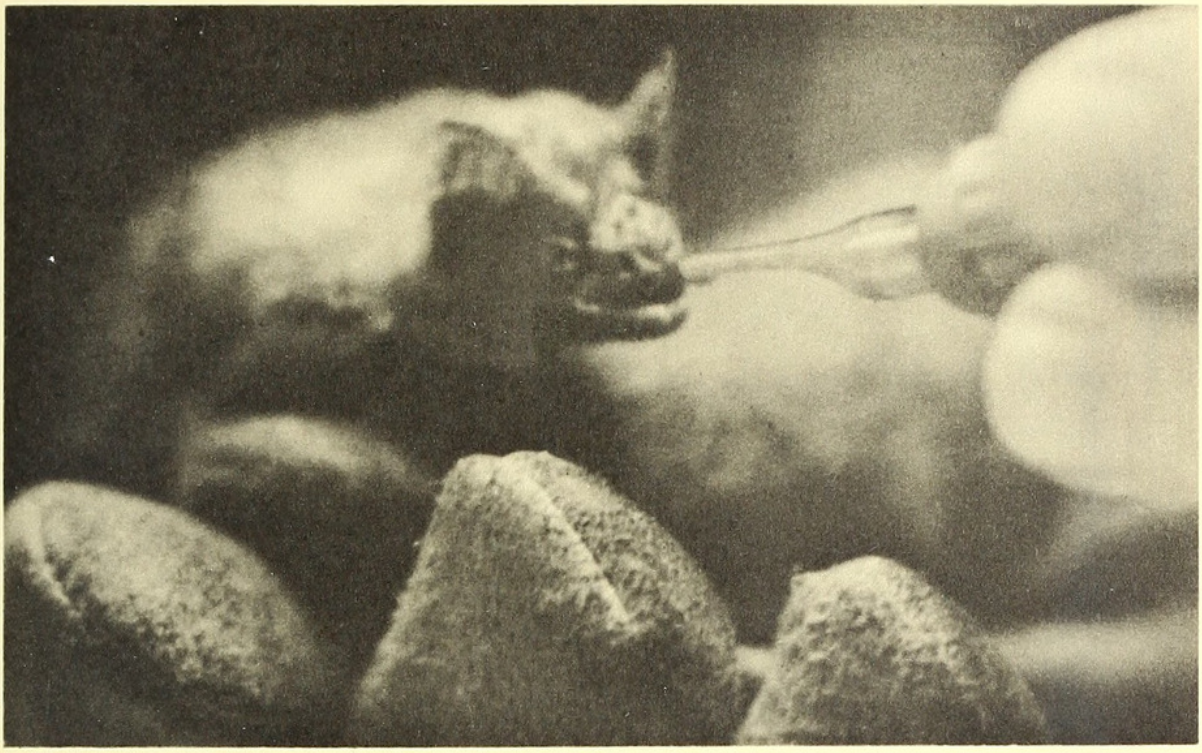

FIG. 1.

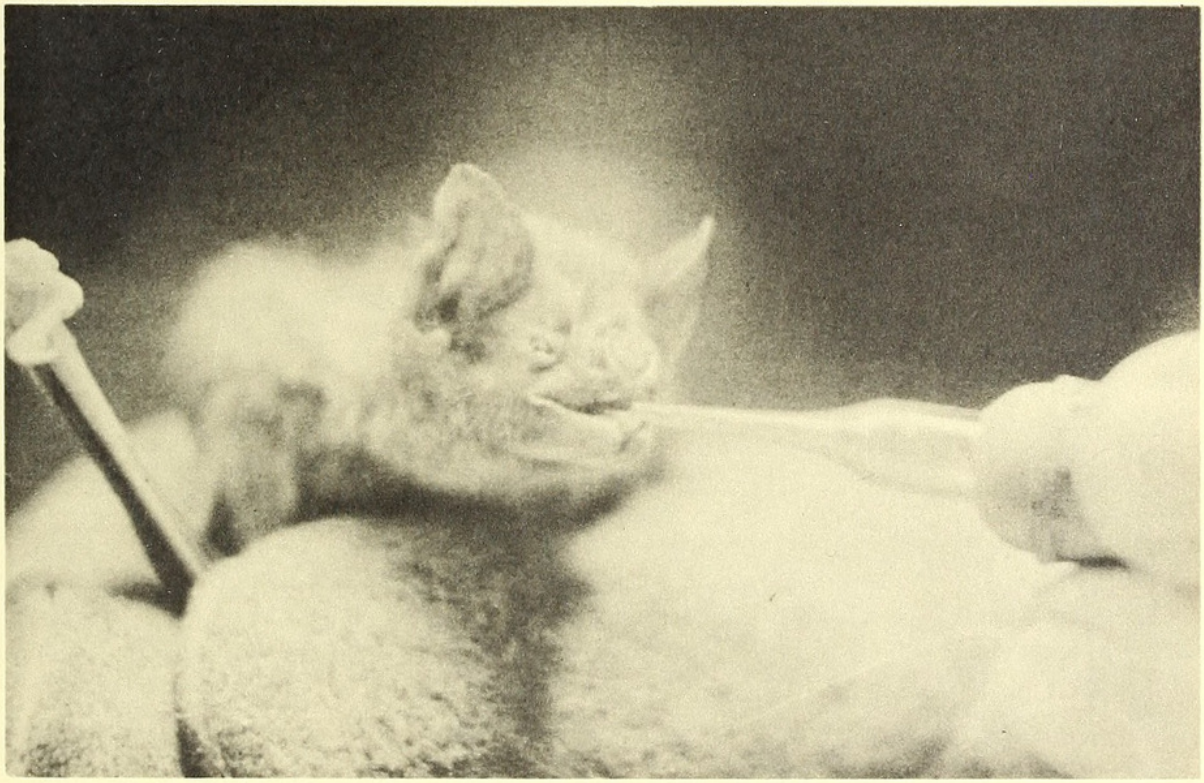

FIG. 2.

SOME OBSERVATIONS ON THE FEEDING METHODS OF THE VAMPIRE BAT.

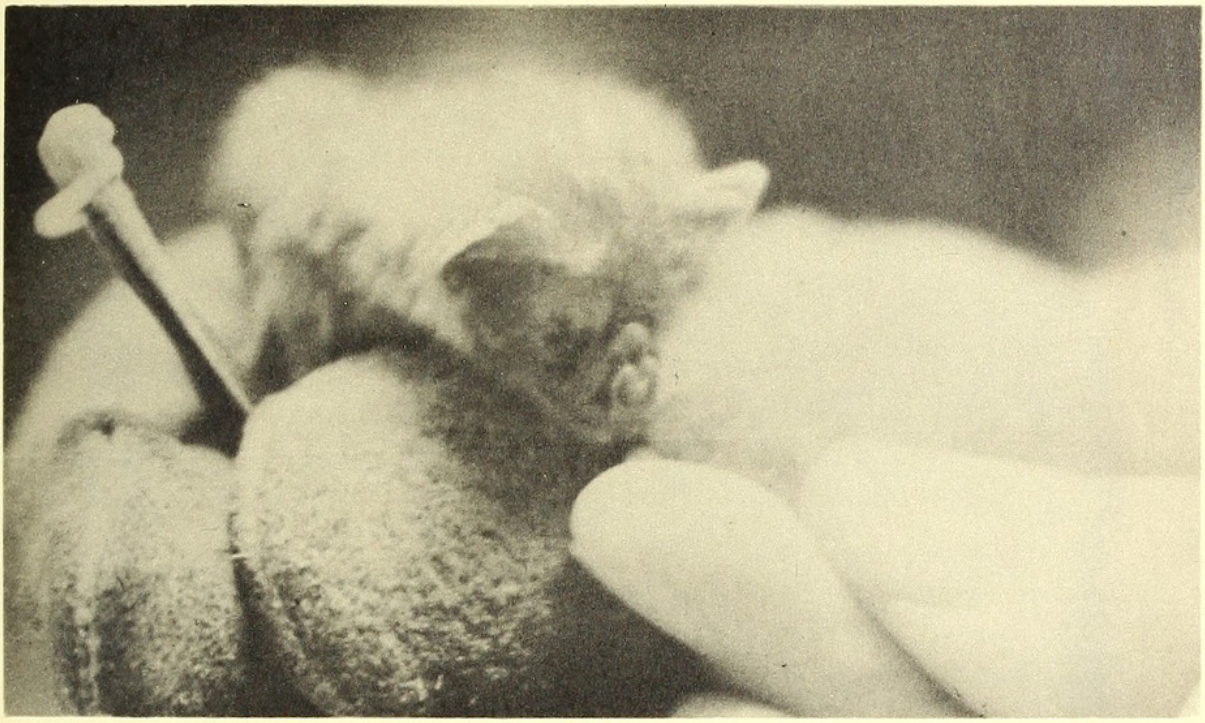

FIG. 3.

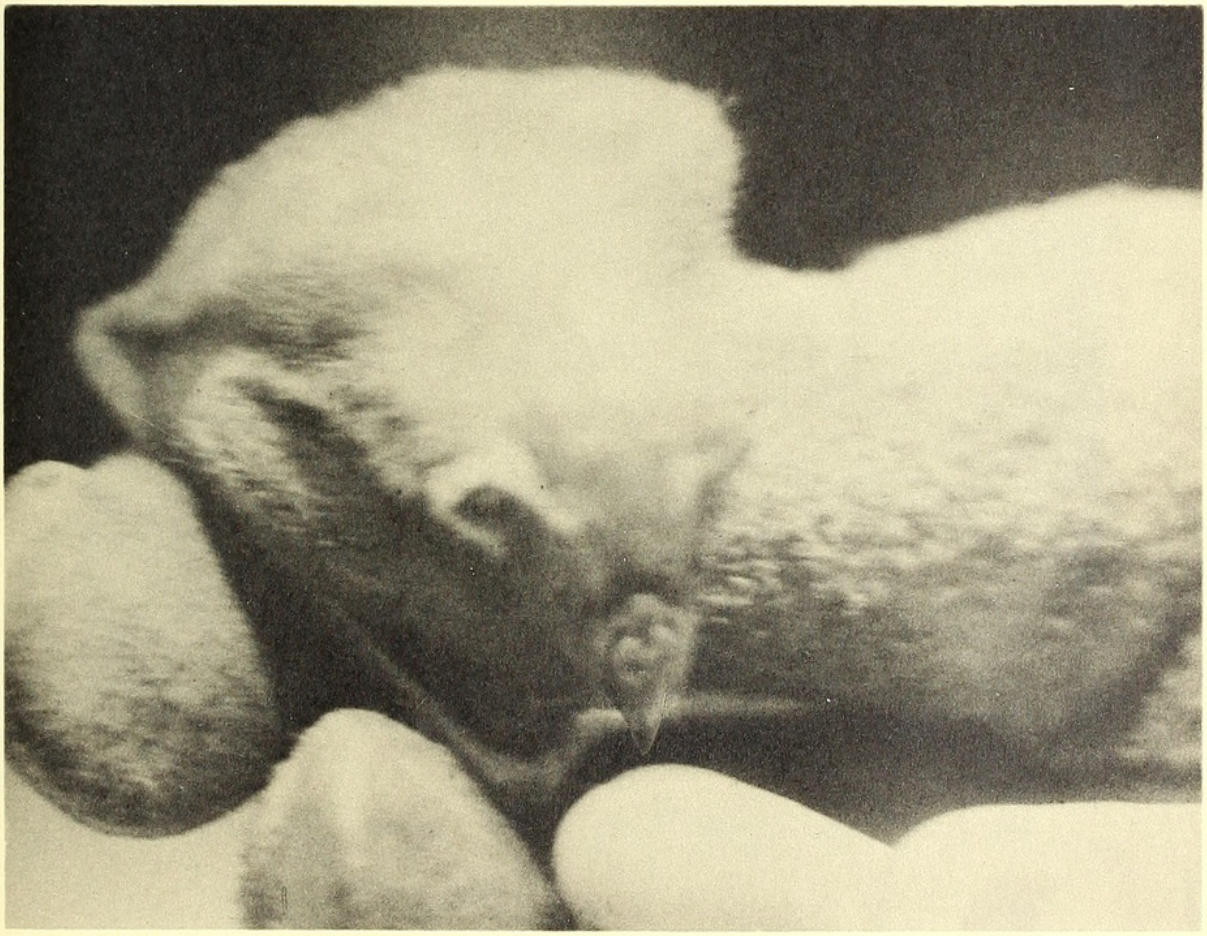

FIG. 4.

SOME OBSERVATIONS ON THE FEEDING METHODS OF THE VAMPIRE BAT.

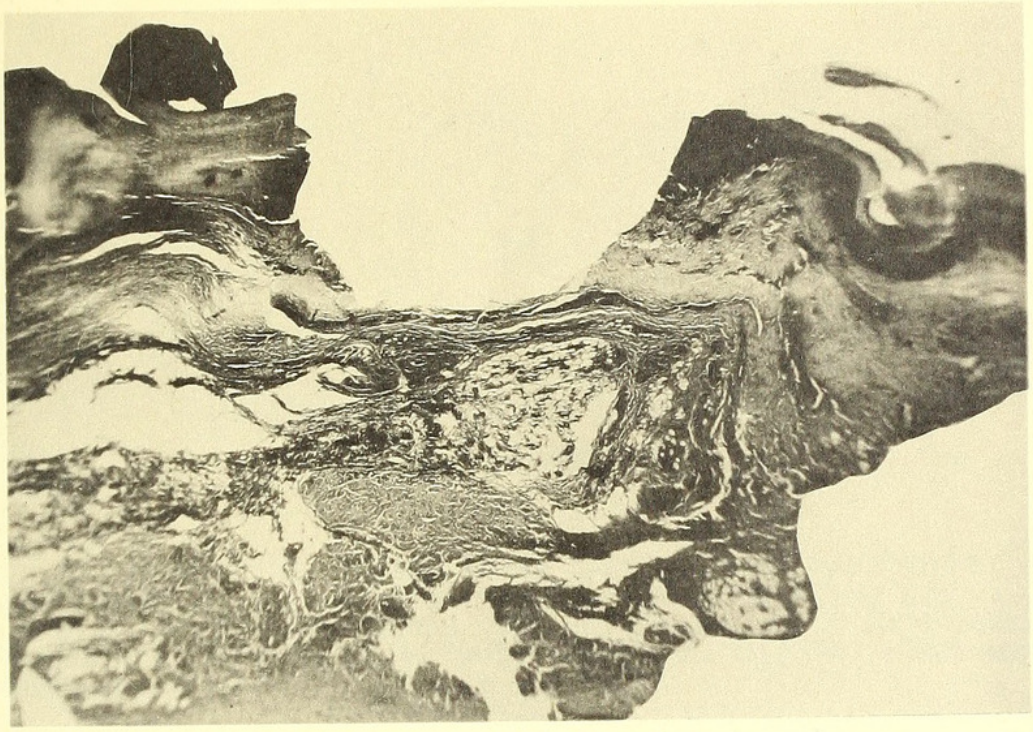

FIG. 5.

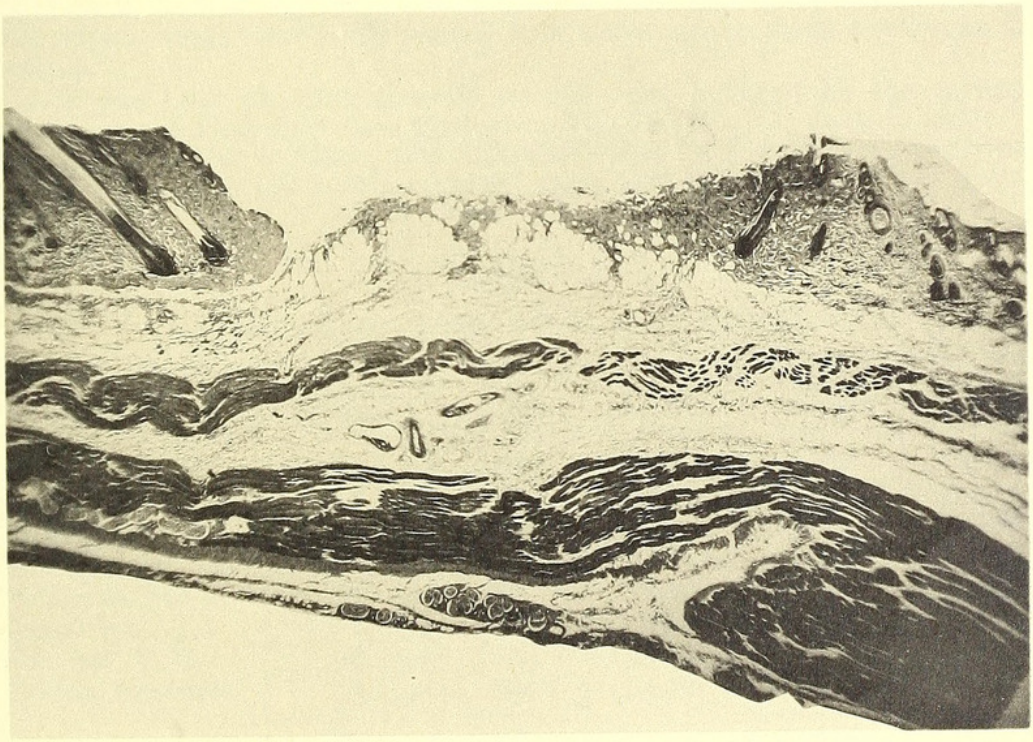

FIG. 6.

SOME OBSERVATIONS ON THE FEEDING METHODS OF THE VAMPIRE BAT.