OCTOBER, 1935 RESEARCH BULLETIN 230

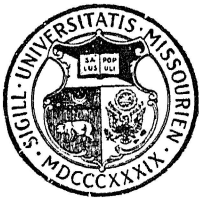
UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION

F. B. MUMFORD, *Director*

Hypophysectomy of the Goat

R. T. HILL, C. W. TURNER, A. W. UREN, AND E. T. GOMEZ

(Publication Authorized October 1, 1935)



COLUMBIA, MISSOURI

UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE

Agricultural Experiment Station

STATION STAFF, OCTOBER, 1935

FREDERICK A. MIDDLEBUSH Ph.D., President

F. B. MUMFORD, M. S., D. Agr., Director S. B. SHIRKY, A. M., Asst. to Director

MISS ELLA PAHMEIER, Secretary

AGRICULTURAL CHEMISTRY

A. G. HOGAN, Ph.D.
L. D. HAIGH, Ph.D.
E. W. COWAN, A.M.
LUTHER R. RICHARDSON, Ph.D.
S. R. JOHNSON, Ph.D.
VIRGIL HERRING, B.S.

AGRICULTURAL ECONOMICS

O. R. JOHNSON, A.M.
BEN H. FRAME, A.M.
F. L. THOMSEN, Ph.D.
†C. H. HAMMAR, Ph.D.

AGRICULTURAL ENGINEERING

J. C. WOOLEY, M.S.
MACK M. JONES, M.S.
G. W. GILES, M.S. in A. E.

ANIMAL HUSBANDRY

E. A. TROWBRIDGE, B.S. in Agr.
L. A. WEAVER, B.S. in Agr.
A. G. HOGAN, Ph.D.
F. B. MUMFORD, M.S., D. Agr.
F. F. McKENZIE, Ph.D.*
J. E. COMFORT, A.M.*
H. C. MOFFETT, A.M.
VICTOR BERLINER, M.S.
C. S. WILLIAMS, B.S.
C. E. MURPHEY, B.S.

BOTANY AND PATHOLOGY

W. J. ROBBINS, Ph.D.
C. M. TUCKER, Ph.D.
C. G. SCHMITT, A.B.

DAIRY HUSBANDRY

A. C. RAGSDALE, M.S.
WM. H. E. REID, A.M.
SAMUEL BRODY, Ph.D.
C. W. TURNER, Ph.D.
H. A. HERMAN, A.M.
E. R. GARRISON, A.M.
WARREN C. HALL, A.M.
E. P. REINEKE, B.S.
E. T. GOMEZ, A.M.
C. W. McINTYRE, M.S.
LLOYD E. WASHBURN, M.S.
RALPH P. REECE, M.S.
R. C. CUNNINGHAM, B.S. in E.E.
W. R. GRAHAM, Ph.D.

ENTOMOLOGY

LEONARD HASEMAN, Ph.D.
T. E. BIRKETT, A.M.
H. L. KOCH, B.S.
LEE JENKINS, B.S.
C. H. BALDWIN, B.S.

FIELD CROPS

W. C. ETHERIDGE, Ph.D.
C. A. HELM, A.M.*
L. J. STADLER, Ph.D.*
B. M. KING, A.M.*
E. MARION BROWN, A.M.*
MISS CLARA FUHR, M.S.*

HOME ECONOMICS

MABEL CAMPBELL, A.M.
JESSIE ALICE CLINE, A.M.
ADELLA EPPLE GINTER, M.S.
BERTHA BISBEY, Ph.D.
JESSIE V. COLES, PhD..
BERTHA K. WHIPPLE, M.S.
MINERVA GRACE, A.M.
MARY I. SHELL, A.M.
ADELIA WEIS, A.M.
ELIZABETH DYER, A.M.

HORTICULTURE

T. J. TALBERT, A.M.
A. E. MURNEEK, Ph.D.
H. G. SWARTWOUT, A.M.
GEO. CARL VINSON, Ph.D.
H. F. MAJOR, B.S.
R. A. SCHROEDER, B.S. in Agr.
GEORGE E. SMITH, B.S. in Agr.
AUBREY D. HIBBARD, M.A.

POULTRY HUSBANDRY

H. L. KEMPSTER, M.S.
E. M. FUNK, A.M.

RURAL SOCIOLOGY

E. L. MORGAN, Ph.D.
MELVIN W. SNEED, B.S. in B.A.

SOILS

M. F. MILLER, M.S.A.
H. H. KRUSEKOPF, A.M.
W. A. ALBRECHT, Ph.D.
HANS JENNY, Ph.D.
L. D. BAVER, Ph.D.
H. F. WINTERKORN, Ph.D.

VETERINARY SCIENCE

A. J. DURANT, A.M., D.V.M.
J. W. CONNAWAY, D.V.M., M.D.
CECIL ELDER, A.M., D.V.M.
O. S. CRISLER, D.V.M.
ANDREW UREN, A. M., D.V.M.
HAROLD C. McDOUGLE, A.M.
P. L. PIERCY, D.V.M.

OTHER OFFICERS

R. B. PRICE, B.L., Treasurer
LESLIE COWAN, B.S., Sec'y of University
A. A. JEFFREY, A.B., Agricultural Editor
L. R. GRINSTEAD, B.J., Ass't. Agr. Editor
J. F. BARHAM, Photographer
LEON WAUGHTAL, Assistant Photographer
JANE FRODSHAM, Librarian

*In cooperative service with the U. S. Department of Agriculture.

†On leave of absence.

Hypophysectomy of the Goat*

R. T. HILL,† C. W. TURNER, A. W. UREN, AND E. T. GOMEZ

INTRODUCTION

In this bulletin a method is described by which the hypophysis (pituitary) can be surgically removed from the goat.

The hypophysis or pituitary body is a tiny endocrine gland located at the base of the brain. It is divided into two chief parts, the anterior and posterior lobes. The hormones secreted by the posterior lobe have been recognized for a number of years. It is only recently, however, that the great importance of the endocrine activity of the anterior lobe has begun to be appreciated. Extracts of the anterior hypophysis have been shown to stimulate general body growth, the development and luteinization of ovarian follicles, the activity of the thyroid and adrenals, carbohydrate metabolism, and milk secretion. Other functions have been ascribed with less definite experimental evidence.

The discovery of the lactogenic hormone of the anterior pituitary was made by Stricker and Grüter (1928). They observed that rabbits at the end of pseudo-pregnancy could be stimulated to lactation following the injection of a pituitary extract for four or five days. These observations have been confirmed by Corner (1930), Turner and Gardner (1931), Nelson and Pfiffner (1931), and others. It has been shown that the lactogenic hormone, called galactin, will stimulate lactation in the properly conditioned mammary gland of the rabbit, guinea pig, dog, cat, ferret, sow, goat and cow. For some as yet unknown reason the rat and mouse do not respond in the same manner.

These studies are believed to indicate that the anterior lobe of the pituitary secretes a hormone which initiates the lactation process during the latter part of pregnancy and early post partum. There is still the question, however, whether the lactation process, once started, can be carried on without further mediation or stimulation of the lactogenic hormone. In other words, is the pituitary secreting the lactogenic hormone continuously to maintain lactation and is the persistency of secretion during the declining phase of the lactation curve dependent upon this hormone?

In order to answer this question it would be necessary to remove the pituitary of lactating animals and determine whether in the absence of the secretion of the lactogenic hormone milk secretion would continue. During recent years, a number of species

*Aided in part by a grant of the Committee on Grants-in-Aid of the National Research Council.

†Dept. of Anatomy, Yale University Medical School, Visiting Research Assistant Professor of Dairy Husbandry during summer of 1935.

of the smaller mammals have been hypophysectomized successfully (Table 1). In most of these species there follows a rather rapid return to an apparently normal condition insofar as the general well-being of the animal is concerned. It thus appears that the loss of the pituitary is not fatal and while there are severe effects upon subsequent growth, the gonads, the thyroids, and adrenals, they are not usually of a nature to produce early death.

TABLE 1.—HYPOPHYSECTOMY OF MAMMALS

Species	Route	Authority
Mouse	Parapharyngeal	Selye, Collip and Thomson (1933)
Rat	Parapharyngeal	Smith (1930)
Rat	Auditory canal	Koyama (1931)
Rat	Parapharyngeal	Thomson (1932)
Guinea Pig	Parapharyngeal	McPhail and Parkes (1933)
Ferret	Parapharyngeal	Hill and Parkes (1932)
Hedgehog	Parapharyngeal	McPhail and Parkes (1933)
Rabbit	Transbuccal	Smith and White (1931)
Rabbit	Transbuccal	White (1933)
Rabbit	Intra-orbital	Firor (1933)
Dog	Temporal	Crowe et al. (1910)
Dog	Transbuccal	Aschner (1912)
Dog	Zygomatic arch	Sweet and Allen (1913)
Cat	Transbuccal	McLean (1928)
Cat	Parapharyngeal and transbuccal	Allen and Wiles (1932)
Monkey	Not reported	Hartman, Firor and Geiling (1930)
Goat	Parapharyngeal	Present paper

The effect of hypophysectomy upon the mammary gland and milk secretion has received only limited study. Allen and Wiles (1932) reported that hypophysectomized cats never suckled their young, but did not report on the condition of the mammary gland. Collip, Selye, and Thomson (1933) reported that the removal of the pituitary from rats in all stages of lactation promptly led to a cessation of milk secretion. Later, Selye, Collip and Thomson (1933) reported similar observations with lactating mice. McPhail (1935) likewise observed the cessation of lactation in the ferret and cat after hypophysectomy.

While these observations appear to indicate that the maintenance of lactation requires the continuous secretion of the lactogenic hormone by the pituitary, it should be pointed out that the operation is rather severe and the post-operative condition is not conducive to lactation. As a consequence it is not impossible that the cessation of lactation observed has been due in part to the shock of the operation and the limited consumption of feed for a time following. Further, in small mammals, the milk can be removed satisfactorily only by the young and if there is a temporary cessation of milk it may cause their death before normal lactation would come back.

Replacement Therapy

It might be argued that hypophysectomy so alters the entire endocrine coordination of the animal that the suspension of lactation may be due to a general physiological upset of the animal. If this were true it would be necessary to furnish to the hypophysectomized animals all the pituitary hormones aside from the lactogenic. At present this is impossible as they are not available in suitable form. It is possible to obtain evidence as to the importance of the other pituitary hormones in relation to lactation by replacement therapy with the lactogenic hormone. In the hypophysectomized rat it has not been found possible to maintain lactation with the lactogenic hormone. On the other hand, hypophysectomized dogs have been brought into lactation by Lyons, Chaikoff and Reichert (1933), and Evans (1934). Recently McPhail (1935) was able to stimulate lactation by means of the lactogenic hormone in a ferret and cat which failed to lactate after hypophysectomy in late pregnancy. It should be pointed out, however in none of these experiments was an attempt made to maintain lactation by the use of nurslings.

Advantages in the Use of the Goat

In continuing a study of the relation of the pituitary to lactation, the advantages in the use of the goat as the experimental animal may be mentioned. As the goat may be milked, an exact record of production may be obtained following hypophysectomy. It would thus be possible to eliminate the effect of operative shock and subsequent decline of milk production from interfering with an estimation of milk production gauged by the response of nurslings. Similarly, the effect of replacement therapy could be measured quantitatively if it were shown that lactation was suppressed. In addition it should be possible to determine the response in milk production at various levels of hormone administration.

The attempt to hypophysectomize the goat was also considered desirable from the point of performing this operation on a larger mammalian form and a ruminant. As endocrine study has shown so many species differences, it was thought possible that the hypophysectomized goat might bring to light additional individual differences in their physiological response to the loss of the pituitary.

It is the object of the present bulletin to give in detail a method which has been found successful in removing the hypophysis of the goat. The results of a study of the physiological effect of hypophysectomy in relation to lactation will be reserved for a later report.

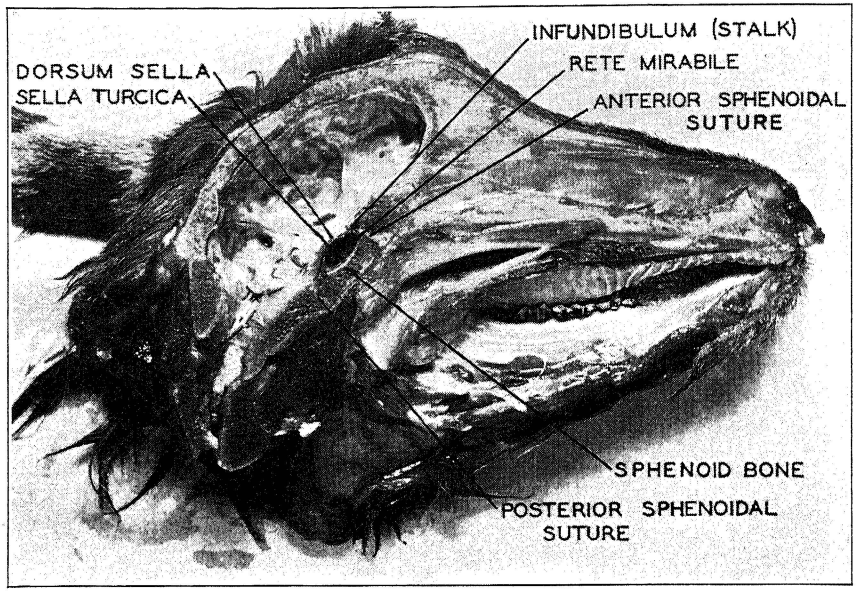


Fig. 1.—Sagittal section of goat head. The hypophysis has been removed, exposing the rete mirabile.

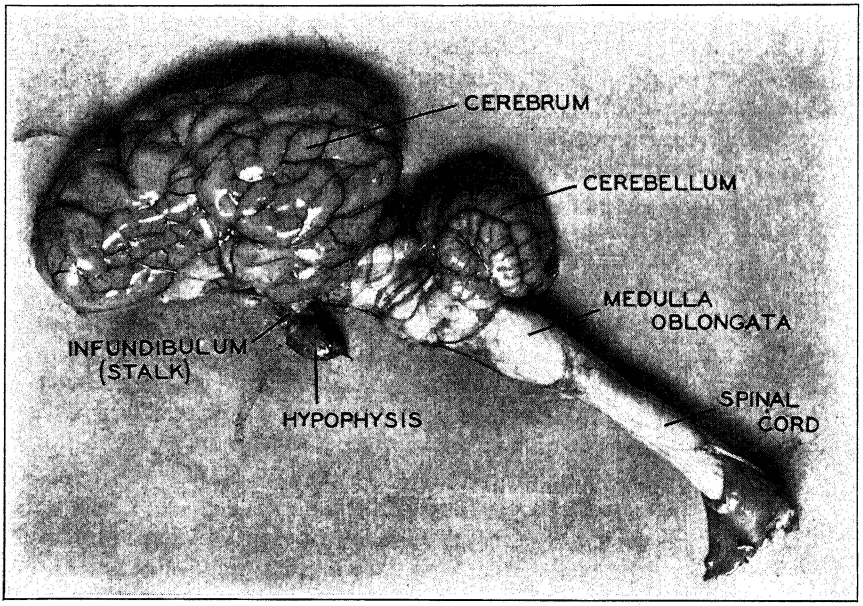


Fig. 2.—Lateral view of goat brain showing pituitary attached by stalk to brain.

Location and Structure of Goat Pituitary

In mammals the pituitary is located ventral to the brain, and in a depression in the base of the skull known as the sella turcica (Fig. 1.). The sella turcica is situated in the sphenoid bone, in the midline, and about equidistant from its anterior and posterior sutures. Dorsal to the pituitary, in the goat, and between it and the brain, is a tough sheet of membranous cartilage, the dorsum sella. Anteriorly the pituitary stalk (infundibulum) passes through the dorsum sella and connects with the brain just posterior to the optic chiasma (Fig. 2).

The pituitary proper is composed of a large anterior lobe (pars anterior), a small posterior lobe (pars nervosa) and separating these two portions is the intermediate lobe (pars intermedia). The pars nervosa lies in a ventral and longitudinal groove in the pars anterior. The pars intermedia usually bears a cleft in part of its extent, and in the present problem is relatively unimportant both physiologically and anatomically. The pars intermedia is of a tubular nature, and passes to some extent within the substance of the posterior lobe.

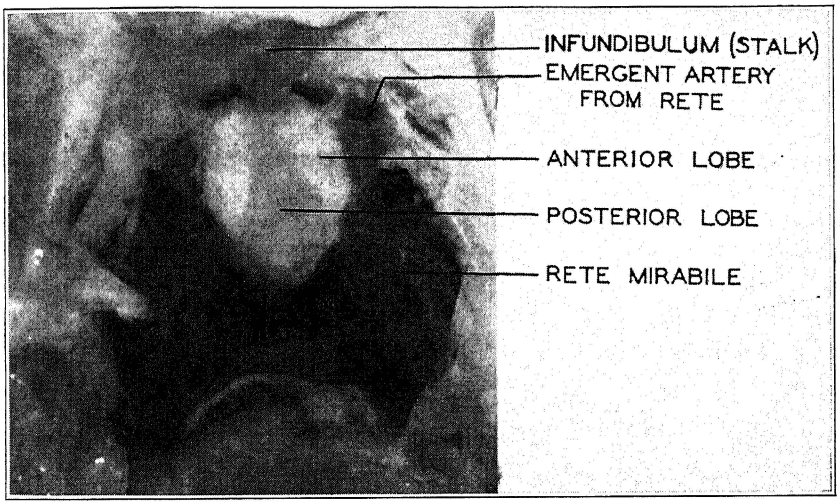


Fig. 3.—Goat head. Brain and dorsum sella dissected away, showing dorsal view of the hypophysis in the sella turcica, and its closely associated dense arterial network, the rete mirabile.

Perhaps the most notable thing encountered in the surgical removal of the goat pituitary is the abundant blood supply. The vertebral artery gives off a branch, the cerebrospinal artery, running anteriorly to unite with the condyloid artery and several branches of the internal maxillary artery to form the rete mirabile

(Fig. 3). The extent of the rete is considerably greater than that of the pituitary itself, and connects directly with the pituitary on both sides and posteriorly as well as to some extent ventrally. The connections between the pituitary and the rete are so intimate and intricate that it was found impossible to successfully remove the pituitary without the use of an electrical high frequency cautery described later.

OPERATIVE TECHNIQUE

Anesthetic

In searching for a suitable surgical anesthesia for the goat, nembutal was tried on several animals. The dose of this drug, per pound of body weight, which produces deep sleep, is quite variable, depending a great deal on the general condition of the animal. The lighter and thinner animals required only 1 grain per 5 pounds body weight, when given intraperitoneally, while in heavier animals double that amount was not always sufficient. Although the operation required from one to three hours, nembutal will often keep the animal asleep for a much longer time and such extended anesthesia is rather disadvantageous. Nembutal has been supplemented with ether, and chloroform alone works very well for the time of operation, but both drugs have led to serious lung damage, resulting in pneumonia and death in 24 to 48 hours.

The best results have been obtained by the use of chloral hydrate. A 10 per cent solution is injected into the jugular vein, until the eye pupils undergo a dilation followed by a secondary constriction. The amount necessary for a goat weighing 70 to 100 pounds is from 7 to 10 grams. Although the sleep produced was not as deep as with the above mentioned anesthetics, it was sufficient for surgical purposes and the prevention of any great amount of shock.

The goat, being a ruminant, normally secretes a large volume of saliva. When it is placed in an inverted position on the operating table and under the influence of an anesthetic, it was found that a large amount of saliva would flow into the trachea and lungs. To control the secretion of saliva and prevent its flow into the trachea, it was found advantageous to inject subcutaneously every 20 to 30 minutes during the operation about 4 cc. of a 1 per cent solution of atropine sulphate. In addition it was often necessary to remove accumulated saliva from the mouth by the use of a metal canula and negative pressure.

A tracheal canula is essential as the site of operation and retraction of the nasal pharynx temporarily occludes normal respiration. In some instances a metal tube was introduced into the trachea through the mouth, while in others a rubber tube was inserted between two cartilage rings of the trachea just below the

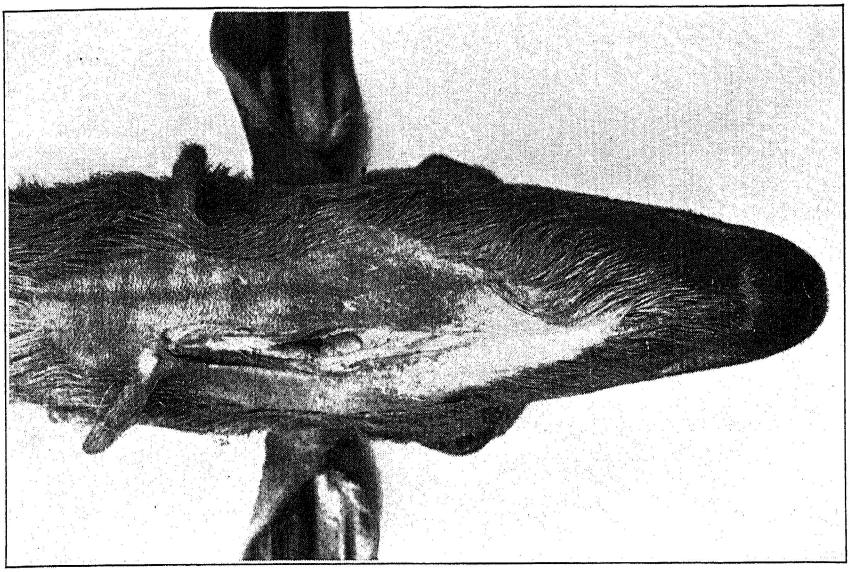


Fig. 4.—Ventral view of goat head showing location of skin incision. The sphenoid bone is exposed by blunt dissection through fascia and muscles.

larynx. In the latter case it may be left for several days if so desired, but probably is best removed as soon as the animal can resume normal breathing.

Position of Animal

The animal is placed on its back on a V-shaped table of proper height, and securely fastened with an adjustable tie on each leg. One end of the table is fitted to hold the head in a firm position. It was found desirable to tie the jaws together so that mandibular movement would not seriously interfere with the operator and cause possible damage at a critical period.

Instruments

Several hemostats of fairly small size are necessary to clamp any small blood vessels which may be cut in making the incision through the skin and fascial layers. They are also used to hold sterile towels in place by clamping the edge of the towels to the cut edge of the skin. Forceps of several sizes are always handy. A good dental chisel as well as a periostium scraper is essential to clear the sphenoid at the place to be drilled. Several probes and a good dental pick are handy at certain stages of the operation. A Spencer scalpel (detachable blade type) was used for cutting the skin, and the handle was used in conjunction with the fingers for blunt dissection in approaching the base of the skull. A retractor

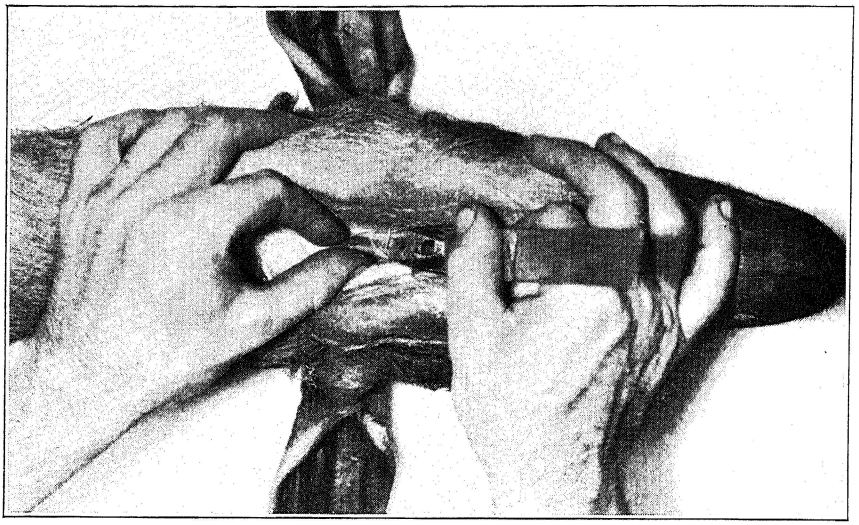


Fig. 5.—Ventral view of goat head, showing special retractor in place, drill hole in sphenoid bone and hypophysis in sella turcica.

of heavy brass was designed especially for the need at hand, and is well illustrated in place in Fig. 5.

A good pencil beam headlight is very necessary in all but the first stages of the operation, to facilitate an unobstructed view at all times.

Operative Technique

A longitudinal skin incision about four inches in length is made, slightly to one side of the midline, and running posteriorly from a point about 1 inch ahead of the angle of the jaw (Fig. 4). The fascial are penetrated, exercising care to avoid any major blood vessels. Certain neck muscles then come into view, and are separated by blunt dissection, going lateral to the omo-hyoideus and sterno-thyro-hyoideus, but median to the sterno-cephalicus. At this point in the operation it is advisable to dissect the oesophagus and clamp it to prevent any regurgitation of paunch contents into the mouth. Such regurgitation has caused the death of some animals by food being inhaled into the lungs, thereby causing suffocation, or almost inevitable death within a few days from pneumonia.

Further blunt dissection in the direction of the sphenoid and feeling with the finger tip will locate the muscular processes of the temporal bone. The posterior suture of the sphenoid lies between these prominences. The bone can be quite readily cleared by scraping with the dental chisel and periostium scraper. When the sphenoid is quite well cleared the retractor can be introduced and the remainder of the tendonous ends readily removed (Fig. 5).

The sphenoid bone is penetrated by a large, long oval dental bur, run by a foot controlled electric dental drill (Fig. 6). There are sufficient variations in the markings and shape of the sphenoid bones of different animals to make an accurate description of a point to start drilling rather difficult. Also, the operator must take into consideration the angle at which the animal's head is being held as well as the angle of approach to the sphenoid. In gen-

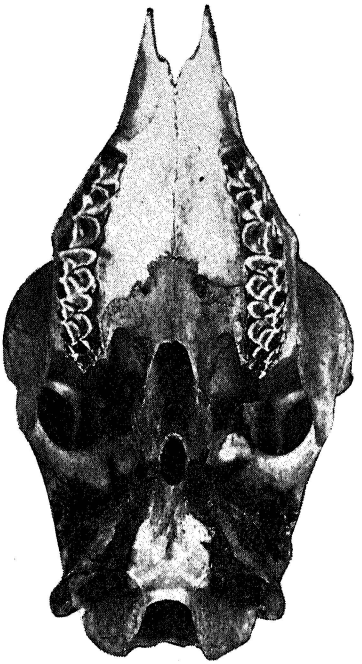


Fig. 6.—Ventral view of goat skull showing drill hole through sphenoid bone into sella turcica.

eral, the sphenoid bone is from ¼ to ⅜ of an inch thick, and the posterior extent of the drill hole usually coincides more or less with the posterior sphenoidal suture. The substance of the sphenoid is quite well supplied with blood, and in consequence drilling must not be too fast, and frequent use of bone wax may be necessary. The central part of the pituitary usually comes into view first, and is generally cleared of bone by enlarging the hole in all directions (Fig. 7). Extreme caution and a good sense of touch are necessary to remove the last part of the bone which is in contact with the pituitary in order to avoid serious bleeding.

Fig. 7.—Dorsal view of same skull as in Fig. 6. Dorsum sella has been removed.

The difficult part of the operation still remains. The pituitary of ruminants has a most formidable blood supply, and is almost completely encapsulated in a sheath of arteries known as the rete mirabile. This rete is shown in part in Fig. 3, and is fully described and pictured in Sisson's Anatomy of Domestic Animals. Because of this uncommonly large blood supply, the simple removal of the hypophysis by lifting it out in a single piece, or by removal in parts by vacuum, is impossible. The hemorrhage is so great under those conditions that in the space of a few seconds from a pint to a quart of blood may be lost. The blood also makes the operation of a "blind" nature, and removes any certainty of complete ablation. Accordingly, the technique used successfully in the smaller mammals, i. e., removal by suction, was abandoned.

Thermal cautery in conjunction with silver nitrate coagulation was used on the pituitary, but the time of operation was prolonged so greatly as to prove unsatisfactory with the animals later dying from either shock or pneumonia, or a combination of both.

The most successful operations have occurred when a high frequency electrical surgical unit*, which delivered either coagulating or cutting current, was used. Hemorrhage was easily stopped, and the substance of the pituitary was readily coagulated and charred by burning. Most of the burned material can be removed, but care should be exercised not to remove or disturb any material which is likely to cause hemorrhage. Definite though fairly narrow limits are allowed the operator in the use of such electrical current, as the pituitary is separated from the brain by a strong and heavy membrane, the dorsum sella. With care, damage to the central nervous system is not likely to result, except possibly at the stalk.

Immediate Post-operative Symptoms

Those animals which have survived the operation have shown remarkably quick recovery and walked around within an hour after removal from the operating table. They begin to ruminate, take some food and water within two or three hours, and in general act very normal. Urine is passed frequently, sometimes as often as every 30 to 40 minutes. In all surviving animals the site of operation healed in about two weeks with a minimum or complete absence of infection.

A Typical Operation

Goat No. 4. Weight 115 lbs. Milking about 4 pounds daily.

9:15 a. m.	12.5 grams chloral hydrate (10% solution) given intravenously. Anesthesia produced immediately. 4 cc. 1 per cent atropine given subcutaneously.
9:20	Animal on table, upper neck and throat shaved. Tracheal canula inserted. Skin incision made a little to one side of mid-line, starting 1 inch ahead of jaw angle, and extending 4 inches posteriorly. Sterile cloths clipped to edge of skin. Fascial layers penetrated and oesophagus dissected out, and clamped to prevent regurgitation.
9:30-35	4 cc. atropine given. Muscular processes of temporal bone located by feel and blunt dissection, and sphenoid scraped bare. Retractor inserted.
9:35-45	Large oval hole drilled in sphenoid with dental drill, and rete mirabile and ventral surface of pituitary partially cleared. Bone bleeding stopped with wax.
9:45-10	Part of rete mirabile which is exposed is burned with high frequency cautery and removed.

*The above unit was most kindly loaned by Dr. D. A. Robnett of Columbia. The authors wish to take this opportunity of expressing their sincere thanks and appreciation for his cooperation.

10-10:15	4 cc. atropine given. Pituitary coagulated with same cautery and removed in several charred pieces.
10:15	Site of operation painted with iodoform-ether solution, and clips and towels removed. Skin clipped together with metal clips, leaving clamp on oesophagus.
10:20	Animal removed from table, and oesophagus clamp taken out. 4 cc. atropine given.
10:30	Animal gets up, with aid, and walks about. Takes food and water in 2 or 3 hours, urinates excessively, but otherwise shows no deleterious effects.

Discussion

The hypophysectomy of the goat is a difficult operation. Anyone trying to follow the method outlined should expect a fairly high percentage of failures either in the loss of the animals or in incomplete removal of the pituitary. In the earlier trials, the chief difficulty appeared to lie in the use of the anesthetic nembutal. The animals varied greatly in their response to the standard dosage and when sufficient of the drug was administered to produce adequate surgical anesthesia, the effects continued for a long period after the operation was over. This might be considered desirable, but in ruminants the regurgitating reflex is so easily aroused even under partial anesthesia that there is a great danger of the fluid contents of the stomach passing into the lungs. Several of our animals died as a result of regurgitated food being inhaled into the lungs while under partial anesthesia. It is of primary importance, therefore, to have the anesthesia acting for as short a time as possible so that the animal will be able to get up soon after the operation.

Even with a suitable anesthetic such as chloral hydrate, it is desirable to clamp off the eosophagus to prevent regurgitation. It is best to remove the clamp only when the animal is about ready to get up.

Our observations on the advantages of a tracheal canula as compared to a metal tube introduced into the trachea through the mouth were not of such a nature as to determine definitely the relative merits. As the animals operated upon in which the tracheal canula was used recovered rapidly there is a preference for that method. There are difficulties in its use due to the danger of the canula opening gradually becoming closed with dry mucous. If the animal can breathe without difficulty after 24 to 36 hours, it is best to remove the tube and clip the skin together.

The rich vascular supply is believed to quite definitely eliminate the use of suction in the removal of the pituitary. Not only

is the flow of blood very great, but the numerous attachments make difficult its removal by suction even were the blood flow controlled. As the blood to the pituitary comes in large part from the vertebral artery clamping the carotids was of little or no help in limiting the blood flow.

Attempts were made to control the blood supply by chemical means. Of the various coagulants used, silver nitrate proved to be most satisfactory but its action was slow and the period of the operation was extended. As a consequence the operated animals died for various reasons. Thermal cautery alone or in combination with silver nitrate also resulted in failure because of a too greatly extended operative period.

Finally a high frequency electric surgical unit delivering a coagulating current was tried. With this equipment it was possible to coagulate the vascular network around the pituitary with a minimum of bleeding and remove it as charred remnants. At first this material was taken for the pituitary, but further examination revealed its true nature. The pituitary is thus exposed and the burning is continued to destroy the pituitary as completely as possible without injuring the dorsum sella.

Postmortem examinations reveal that the pituitary can thus be removed in toto although frequently some parts will remain. The remaining parts are usually burned so that future physiological activity is believed to be destroyed. As the greatest caution in burning is exercised at the stalk end, it is here that residual tissue is usually found.

Physiological evidence of the removal of the hypophysis is now available. Data is also available on four lactating goats which were operated upon but the pituitaries not removed successfully. In every case lactation declined from 50 to 75 per cent for a day or two after the operation, but soon returned to almost the previous level of production. In two goats where it was believed that the pituitaries were successfully removed, lactation declined to practically nothing by the second day, only a few cubic centimeters being secreted. Only upon postmortem examination can it be definitely stated that the operation was completely successful, but the cessation of lactation in these cases is taken as presumptive evidence.

SUMMARY AND CONCLUSIONS

In order to secure further information on the relation of the hormones of the hypophysis to the physiology of lactation, especially as they relate to the maintenance of lactation, an attempt was made to hypophysectomize the milking goat. While many difficulties were encountered during the course of the work, a method was finally evolved which appears to be successful. The pituitary is approached by a parapharyngeal route, exposing the gland through an oval hole drilled through the sphenoid bone. The rete mirabile which surround the pituitary are coagulated with an electrical high frequency cautery. It is then possible, practically without hemmorrhage to coagulate the pituitary and remove it in a charred condition.

Postmortem examination reveals that the pituitary can thus be removed in toto although frequently some parts will remain. In lactating goats, the operative technique has caused a decline in milk flow of from 50 to 75 per cent for a day or two after the operation. However, the milk flow soon returned to approximately the previous level of production.

Two goats in good lactation, practically ceased to secrete milk by the second day after the operation. They quickly returned to an apparently normal condition, ate, and drank well, but during the course of a month following, secreted only a few cubic centimeters of milk at each milking. The cessation of lactation in these cases is taken as presumptive evidence that the operation was successful until a postmortem examination can be made.

BIBLIOGRAPHY

Allen, H., and Wiles, P. 1932 *The role of the pituitary gland in pregnancy and parturition. I. Hypophysectomy.* J. Physiol., vol. 75, p. 23.

Aschner, B. 1912 *Über die Funktion der Hypophyse.* Pflüger's Arch. f. d. Ges. Physiol., vol. 146, p. 1.

Collip, J. B., Selye, H., and Thomson, D. L. 1933 *Further observations on the effect of hypophysectomy on lactation.* Proc. Soc. Exp. Biol. Med., vol. 30, p. 913.

Corner, G. W. 1930 *The hormonal control of lactation. I. Non-effect of the corpus luteum. II. Positive action of extracts of the hypophysis.* Am. J. Physiol., vol. 95, p. 43.

Corkill, A. B., Marks, H. P., and White, W. E. 1933 *Relation of the pituitary gland to the action of insulin and adrenaline.* J. Physiol., vol. 80, p. 193.

Crowe, S. J., Cushing, H., and Homans, J. 1910 *Experimental hypophysectomy.* Bul. Johns Hopkins Hospital, vol. 21, p. 127.

Cushing, H. 1912 *The pituitary body and its disorders.* J. B. Lippincott Co., Phil.

Evans, E. I. 1934 *Virgin animals secrete milk after injections of pituitary hormone.* U. S. D. A. Yearbook, p. 360.

Firor, W. M. 1933 *Hypophysectomy in pregnant rabbits.* Am. J. Physiol., vol. 104, p. 204.

Hartman, C. G., Firor, W. M., and Geiling, E. M. K. 1930 *The anterior lobe and menstruation.* Am. J. Physiol., vol. 95, p. 662.

Hill, M., and Parkes, A. S. 1932 *Studies on the hypophysectomized ferret. I. Technique.* Proc. Roy. Soc., London, B., vol. 112, p. 138.

Koyama, R. 1931 *Experimentelle Untersuchungen uber die Hypophysenextirapation on Ratten und die Wirkung des Vorderlappenextrakts.* Jap. J. Med. Sci. Tr., IV. Pharmacol., vol. 5, p. 41.

Lyons, W. R., Chaikoff, I. L., and Reichert, F. L. 1933 *Experiments with hypophyseal lactogenic hormone on normal ovariectomized and hypophysectomized dogs.* Proc. Soc. Exp. Biol. Med., vol. 31, p. 303.

McLean, A. J. 1928 *Transbuccal approach to the encephalon.* Ann. Surg., vol. 88, p. 985.

McPhail, M. K. 1935 *Studies on the hypophysectomized ferret. IX. The effect of hypophysectomy on pregnancy and lactation.* Proc. Roy. Soc. London, B., vol. 117, p. 34.

McPhail, M. K. 1935 *Hypophysectomy of the cat.* Proc. Roy. Soc. London, B., vol. 117, p. 45.

McPhail, M. K., and Parkes, A. S. 1933 *The adaptation of parapharyngeal hypophysectomy to the guinea-pig and hedgehog.* Proc. Roy. Soc., London, B, vol. 114, p. 10.

Nelson, W. O., and Pfiffner, J. J. 1931 *Studies on the physiology of lactation. I. The relation of lactation to the ovarian and hypophyseal hormones.* Anat. Rec., vol. 51, p. 51.

Selye, H., Collip, J. B., and Thomson, D. L. 1933 *Anterior pituitary and lactation.* Proc. Soc. Exp. Biol. Med., vol. 30, p. 588.

Selye, H., Collip, J. B., and Thomson, D. L. 1933 *Effect of hypophysectomy upon pregnancy and lactation.* Proc. Soc. Exp. Biol. Med., vol. 30, p. 589.

Selye, H., Collip, J. B., and Thomson, D. L. 1933 *Effect of hypophysectomy upon pregnancy and lactation in mice.* Proc. Soc. Exp. Biol and Med., vol. 31, p. 82.

Sisson, S. 1914 *The Anatomy of the Domestic Animals.* 2nd ed. W. B. Saunders Co., Phil.

Smith, P. E. 1930 *Hypophysectomy and a replacement therapy in the rat.* Am. J. Anat., vol. 45, p. 205.

Smith, P. E., and White, W. E. 1931 *The effect of hypophysectomy on ovulation and corpus luteum formation in the rabbit.* J. Am. Med. Asso., vol. 97, p. 1861.

Stricker, P., and Grüter, F. 1928 *Action du lobe anterieur de l' hypophyse sur la montee laiteuse.* Compt. rend. Soc. de biol., vol. 99, p. 1978.

Sweet, J. E., and Allen, A. R. 1913 *The effect of the removal of the hypophysis in the dog.* Ann. Surg., vol. 57, p. 485.

Thompson, K. W. 1932 *A technique for hypophysectomy of the rat.* Endocrin., vol. 16, p. 257.

White, W. E. 1932 *The effect on ovulation and pregnancy of blocking the pituitary circulation in the rabbit.* Am. J. Physiol., vol. 102, p. 505.

White, W. E. 1933 *The effect of hypophysectomy of the rabbit.* Proc. Roy. Soc. London, B., vol. 114, p. 64.

Turner, C. W., and Gardner, W. U. 1931 *The relation of the anterior pituitary hormones to the development and secretion of the mammary glands.* Mo. Agr. Exp. Sta. Res. Bul. 158.

Van Dyke, H. B., and Wallen-Laurence, Z. 1930 *On the growth promoting hormones of the pituitary body.* J. Pharm. and Exp. Ther., vol. 40, p. 413.