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STUDIES ON REARING THE OPOSSUM (DIDELPHYS VIRGINIANA)[1]

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Scientific reports should in a sense be news. That is, they should be made promptly when the work is completed. On the other hand some things always have interest, and time does not detract from their scientific value, which may only appear after perhaps years have elapsed. Such, I believe, is the case with this report, at least with reference to certain parts which relate to records of many years standing.

During my professorship in Denison University, the Ohio Academy of Science gave me fifty dollars from the McMillan fund to defray the expenses of studying the life history of the opossum, particularly to experiment on breeding and rearing the animals in confinement. The following year it added twenty-five dollars to the grant for me to continue the work, but, while I reported my results in a paper before the Academy, I never published my findings because they seemed too incomplete at the time, and only last season did I have an opportunity to go on with the study. In making my report before the Academy I used lantern slides made from photographs, and, inasmuch as they represent phases of the life history that I have never seen illustrated photographically, some of them are reproduced in this paper.

The opossums were confined in pens—a large one to accommodate a number of animals, and small ones, sixteen feet square, for individual females. These pens were constructed of poultry netting surmounted by strips of "valley" tin. The lower edge of the wire was buried in the ground and the upper edge was made fast to the tin by means of wire loops. The tin was supported above by strong wire bound to it with wire loops.

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This wire and tin construction was nailed to posts, which were on the outside so that the animals could not use them for climbing. This proved to be a satisfactory fence. That is, it

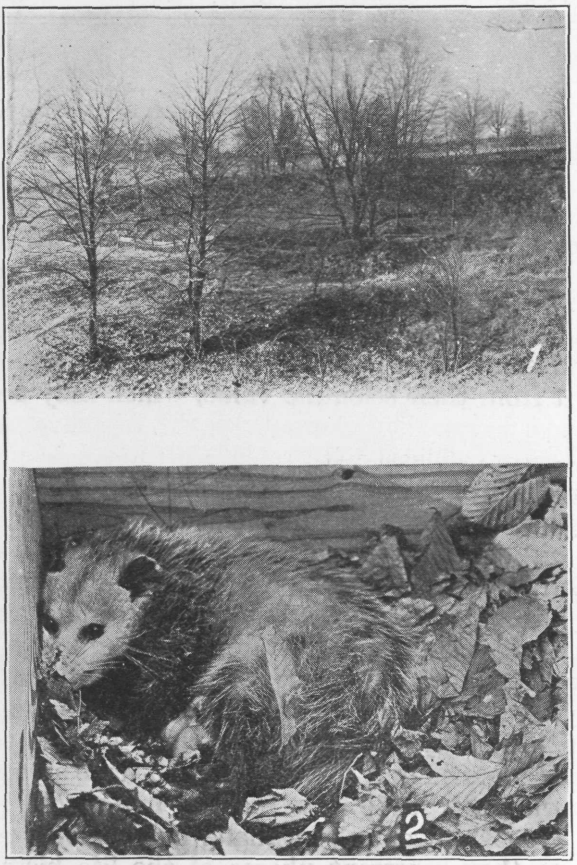
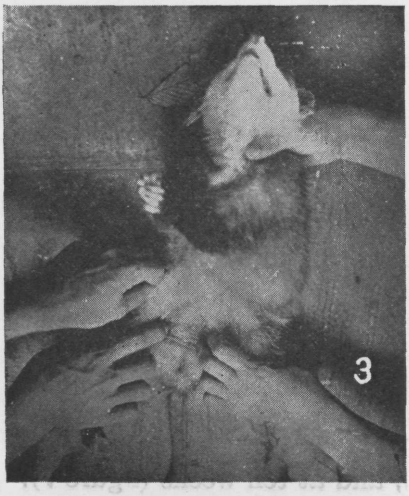
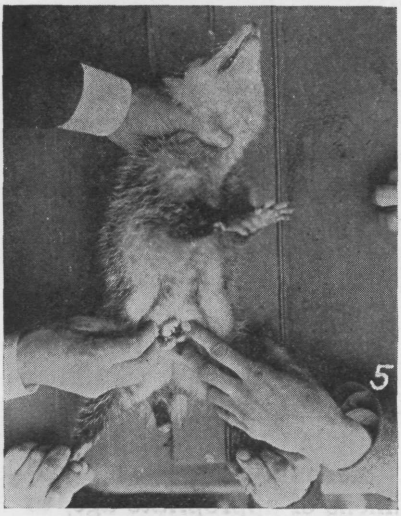


Fig. 1. The larger pen used for opossums in Granville. The fence is in view to the left of center. This shows also the natural environ preserved for the animals.

Fig. 2. A photograph of a mother opossum in the nest box from which the lid had been removed with very little disturbance of the animal. The young can be seen with their bodies outside the pouch while they still hold to the teats. The leaves of the nest were gathered and arranged in the box by the mother as they are seen in the picture.

confined the animals within the pens but it did not keep wild animals out, for they could gain entrance by climbing the posts. Pens constructed in this way, while confining the animals, gave them a close approximation to their natural habitat, in the way





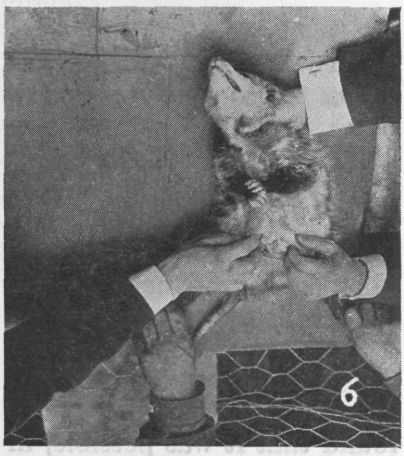


Fig. 3. A photograph of the pouch of the opossum with young of the first day. The pouch is lined with a dense coat of hair, in which the young opossums are barely visible.

Fig. 4. Photograph of the pouch and young at three weeks. The mother was held in position on the lid of the nest box for the picture.

Fig. 5. The mother and young at four weeks photographed on the lid of the nest box.

Fig. 6. The young at nine weeks photographed in the pouch.

of the fresh air of the woods and considerable freedom to move about (figure 1).

In the pens were movable nest boxes, twenty-four inches square and twelve inches high on one side and eighteen inches on the opposite side, and the roof was removable for inspection of the animals (figure 2). A door of suitable size was provided for the animals and the houses were constructed with a substantial floor to protect against moisture. In these pens and nest boxes the animals lived in a healthy condition, and young were born and reared.

In one instance copulation was observed by a competent attendant, and the gestation period was proved to be twelve days. The litter resulting from this insemination was photographed in the pouch on the first day (figure 3). This litter was photographed also at three weeks (figure 4), at four weeks (figure 5), at nine weeks (figure 6), and at ten weeks (figure 7). The young adult animal that grew up in confinement was photographed in its natural environment of the large pen (figure 8). This animal exhibited a form of nest building that, so far as I know, has never been described excepting in my report before the Academy. On an inspection tour of the pens on an autumn day I was unable to find the specimen until I noticed a conical pile of leaves which seemed too regular in form and structure to be accidental. On inspection by carefully moving the uppermost leaves to one side I discovered my opossum, which was in perfect concealment in an otherwise relatively open and exposed place. I replaced the leaves as nearly as possible as I had found them, and called the photographer. The accompanying photographs are made from lantern slides I used in my report to the Academy over twenty-five years ago (figures 9 and 10).

The purpose of my earlier work on rearing the opossum in confinement was primarily for the study of the nervous system. In my study of the cranial nerves of Amblystoma (1) I had found that it was possible, in specimens of appropriate age, to select a stage in which the eleventh cranial nerve is medullated when the other components of vagus ganglion through which it passes are not medullated, and by that means of differentiation I demonstrated for the first time that this nerve was actually the spinal accessory of higher vertebrates. The relatively precocious development of the eleventh nerve was the key to its identification. Therefore, it occurred to me, the relatively precocious development of the visceral sensory and motor sys-

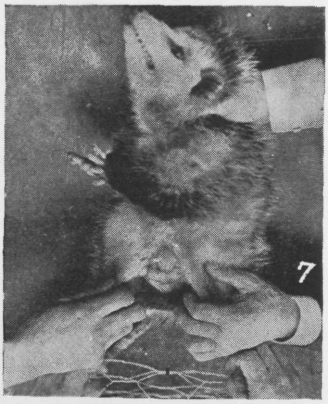


Fig. 7. In this picture the young, photographed at ten weeks, snugly fill the pouch.

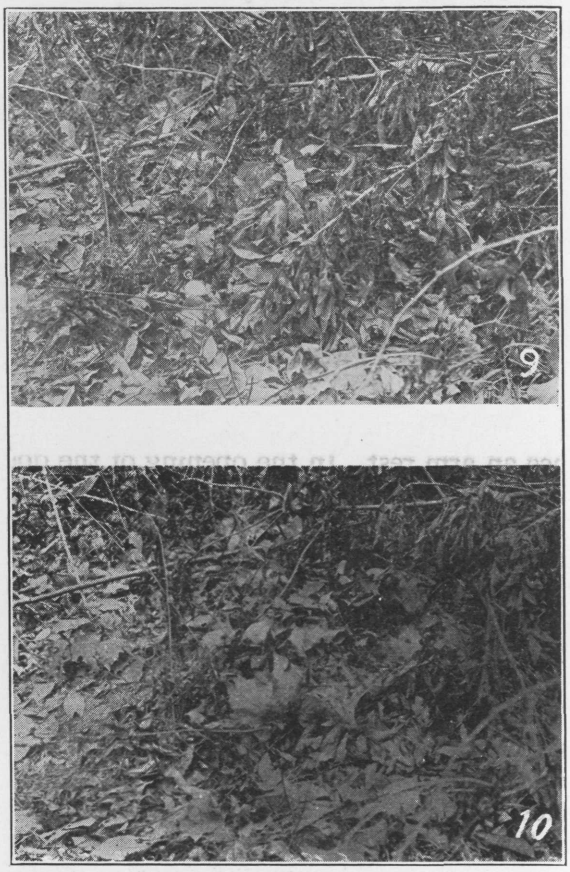
Fig. 8. An opossum thirteen months old which was reared in the pen illustrated in Fig. 1. The six-inch measure gives an idea of the size. Observe the cavern in the rocks and the natural environment.

tem in adaptation to early feeding in the opossum should enable one to differentiate these components within the brain. And with this as a point of departure I hoped to study the development of the nervous system and, possible, the development of behavior. However, I was then engaged in studies on the correlation of structure and function of the nervous system of Amblystoma in development, which demanded more and more of my time; and in 1913 I left the State of Ohio and had to abandon the project of rearing opossums.

Meanwhile the interest that has developed in the opossum since my experiments on rearing the animal has proved that they were timely. Since that time Hartman (2) has published his excellent studies on the development of the opossum and on the behavior of the young. He discovered that the young actually crawl into the pouch, and was first to describe the process. He was very emphatic, however, in his opinion that the opossum would not breed, at least in a satisfactory way, in confinement, and that development would not be normal if it did. Following Hartman, Rogers (3) studied the physiology of the cerebral cortex, Gray and Turner (4) studied especially the motor cortex, Langworthy and Weed (5) and Langworthy (6) investigated the brain physiologically and structurally. Also, more recently, Larsell, McCrady and Zimmerman (7) have reported on the structural development of the ear of the opossum, both with regard to the auditory and vestibular functions.

Following my residence in Ohio I had no opportunity to continue the work on the opossum till I came to Florida, where thanks to the Josiah Macy, Jr., Foundation, I was able to build pens and procure specimens for the breeding season of 1938. Again I used box-houses in the open and individual pens, but of a somewhat different design from those I used in Ohio. My housing is on the apartment plan, and the houses contain four apartments designed to accommodate one specimen each. Two houses, with the separate runways between them, form a unit. The houses are thirty inches by forty-eight inches, and the apartments, twelve inches by thirty inches, each with its hinged lid (roof) for inspection, and a door giving the animal access to the runway. The runways extend between the two houses of a unit, but are divided by a partition in the middle in such a way that the eight animals of a unit may be fed and watered at one operation. The runways are essentially tunnels made with two six inch boards for floor and two for roof, and frames

of wire cloth (one-half inch mesh) for the sides and partitions. The frames and boards are ten feet long, and the sections are held in place by suitable supports. At the adjacent ends the



Figs. 9 and 10. Photograph of the nest of the opossum which is shown in fig. 8 from directly above. The nest is not in view as a whole, so that its conical shape can not be recognized but only the top-central portion is in the field. Fig. 9 shows the original structure as nearly as I could reconstruct it after discovering its occupant. Fig. 10 shows the nest sufficiently opened to expose the head of the opossum slightly to right of center.

frames of wire cloth are held to the posts of the supports by a bolt in the middle so that there is considerable flexibility of the system in the vertical plane. The length of the runways is a multiple of ten feet, and by using an odd number of frames and

placing the partition in the middle of a section, the eight animals may be fed and watered by the removal of four boards of the roof. If desired the floor can be constructed of wire cloth and the runways elevated so that they can be cleaned with a hose. In feeding I have used successfully a well-known brand of dog food. This system of houses and runways is a success in that opossums bred in them and had healthy young, which were removed from the pouch and their behavior studied. Furthermore, a part of a litter may be removed from the pouch and the rest left for later observation.

Upon withdrawal from the pouch the young cling tenaciously to the teat (figure 11). Sometimes a drop of blood appears near the mouth, but I did not determine its source, whether from the mother or from the young. Immediately after removal from the pouch the young were placed in an incubator designed for the purpose. It is thirty inches long, sixteen inches wide and thirty inches high over all. In the upper part is a chamber for observation five inches high, covered with plate glass and with a door in front that swings down to the horizontal position and furnishes an arm rest. In the opening of the door is a curtain which drops over and around the wrists of the observer when he inserts his hands for manipulating the specimens. From the rear of the chamber a well, eighteen inches deep and five inches wide, extends the whole length of the incubator and is covered with fine wire screen. In the bottom of this well, attached to a removable floor, are electric lights as heating units. In each end of the well and chamber are three round windows which can be opened or closed at will for ventilation. The well, chamber and door are lined with insulating board.

In the incubator the young are placed on outing flannel in shallow dishes. The flannel is saturated with mineral oil, which soon covers the skin completely, due to the almost continual activity of the young, and prevents desiccation of the skin. The flannel, also, furnishes a fibrous surface on which the claws can take hold for the young to right themselves to an upright position and crawl. Under these conditions in the incubator the young of the first day after birth will live as long as seven hours, and those three days old as long as twelve hours, dying apparently from inanition. It is not certain that the young live longer in the incubator than they would at room temperature but they are much more active in the incubator. At room temperature they soon become cold to the touch and pale, and

are very inactive. Their reactions can not be normal when they are in a stupor from cold.

My interest in the opossum now centers, not primarily in the nervous system, for I cannot hope to do the requisite microscopic work, but in the development of its behavior. During the breeding season of 1938 I made exploratory studies

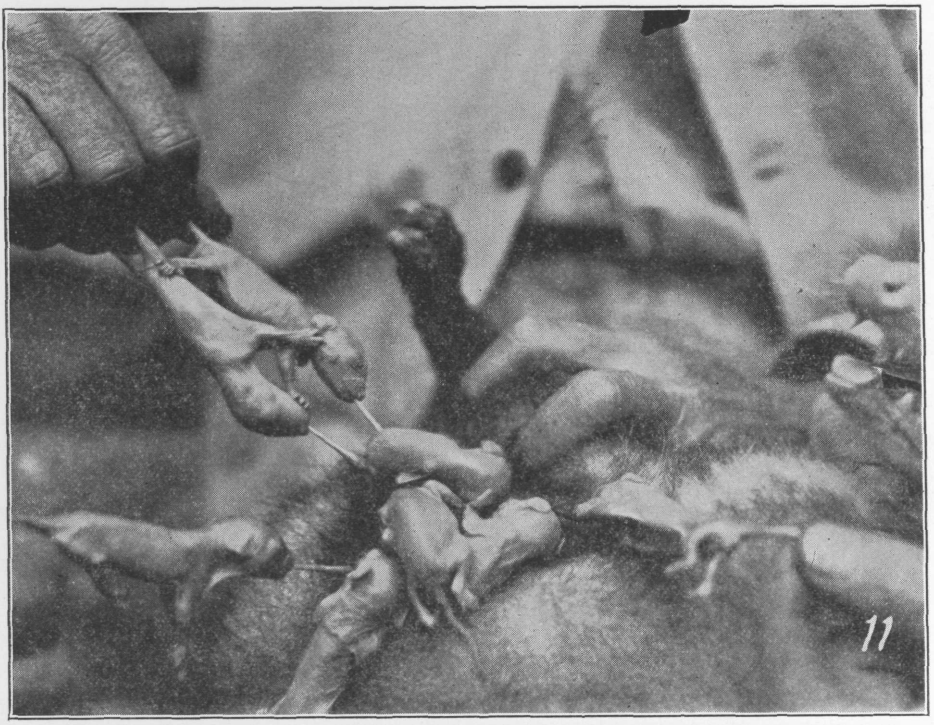


Fig. 11. A photograph of the young opossums being drawn forcibly from the mother. This photograph was given me by Mr. C. D. Bunker, Curator of the Museum of the University of Kansas, and is published with his permission.

which yielded definite results on a few points, particularly upon the movement of the legs and walking. A brief report of this work is published elsewhere (8), but it is appropriate here to give an account of it in greater detail.

The opossum at birth has the unusual ability of standing upright (righting reaction) on a suitable surface by thigmotactic response. This action has been known simply as a behavior pattern since the studies of Hartman, but only since the observa-

tions by Larsell, McCrady and Zimmerman has it been known that the vestibular system is not developed at this time. It cannot, therefore, be a factor in this response.

In this righting reaction the fore limbs and snout are the chief factors, and probably the snout is most important as a sensory organ for transmitting the tactile stimuli, for the young animal is constantly rooting deeply into the flannel or moving the snout from side to side high in the air as if searching for contact. The result of this behavior under natural conditions would be to find the teat in the pouch. Meanwhile the fore limbs are the chief effector agents in the righting reactions. The claws of the fore feet are very strong and catch upon any suitable object with which they come in contact, such as the hair of the mother or the fibers of a rough cloth. By this means the young can swing suspended from the under surface of flannel if the cloth on which it lies is gradually inverted. In this performance the claws of the hind feet participate, although at that time the hind foot barely projects beyond the contours of the body, and is perfectly immobile. The part that the hind feet play in the performance is, therefore, wholly passive, but that the fore feet actively take hold of the fabric is certain, for in the reaching movement of the fore leg and foot the flexion of the toes is plainly visible as the arm begins to withdraw. By this action of the limbs and claws in co-operation with the movements of the snout the young animal can right himself and walk. In the absence of the vestibular system this righting reaction and walking is purely thigmotactic.

Probably the most important thing about the behavior of the young opossum is the retarded development of the hind limbs relative to the fore limbs and head. When the young one is born, and for about a week thereafter, it can not move the hind limbs, in response either to external stimulation or to internal conditions (spontaneously). For this reason the behavior of the hind limbs, and their participation in the behavior of the whole animal, can be observed from the first in the born animal, whereas, in animals other than the marsupials, this phase of behavior can be studied only in the embryo. Furthermore, embryos are very fragile and require special methods and refined technique to be brought under observation and kept alive in a condition that approximates the normal. The young opossum, on the other hand, is easily accessible and is very hardy. The simple expedients of keeping it warm and

preventing the skin from drying are all the precautions necessary to insure lively behavior, and one can handle them roughly apparently without injuring them, so that one does not question whether or not the behavior is normal. By taking advantage of this condition I have been able, for instance, to prove satisfactorily to myself, that the hind limbs become co-ordinated with the fore limbs in the walking gait before they are capable of reflex action in response to stimulation on the foot. This means that there are two components of locomotion: the action of the total pattern, which establishes gait; and reflex action, which maintains the appropriate relation to surfaces. This is simply and directly seen in the young opossum whereas it would require special precaution and elaborate technique to see it in the embryos of Eutheria. In Amblystoma, however, I have definitely established this principle (9). That it applies to marsupials, also, is important to physiology.

In conclusion, the work that was begun over twenty-five years ago with the aid of the Ohio Academy of Science has been confirmed and supplemented by recent work. The opossum will breed in confinement if a close approximation to its normal habitat is maintained. Expensive buildings and luxurious laboratories are not necessary. They are, on the other hand, probably a hindrance rather than a help, in that they subject the animals to extremely abnormal enivronment. Simple nest houses and runways out of doors is all that is necessary.

For the excellent photographs of figures 1 to 10 I am greatly indebted to Mr. Howard Clark, who was a student in Denison University at the time of my earlier work in Granville. For the photograph of figure 11 I wish to thank my friend, Mr. C. D. Bunker, of the University of Kansas.

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