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Behavioral Aspects of Feigned Death in the Opossum *Didelphis marsupialis*

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ABSTRACT: Behavioral aspects of feigned death were studied in captured opossums (*Didelphis marsupialis*). Feigned death was induced by grabbing and shaking the opossums by "predators" (either human or dogs). It is a stereotyped behavior pattern characterized by a ventral flexure of the body, flexure of the digits, and grasping of the substrate. The opossum lies on its side with its feet visible. Corners of the mouth are retracted initially and then usually relaxed. The eyes remain open. During sleep, in contrast, the opossum keeps the mouth and eyes closed and its dorsum uppermost with the feet out of sight. Sham attacks rarely caused opossums to feign death; almost invariably tactile stimulation (grabbing) was necessary. Opossums feigning death may twitch the ears at sharp noises, retract the lips when prodded, or claw the air when picked up by the tail.

Opossums raised in cages could not be induced to feign death even by grabbing. But when females with pouch young were captured and kept in a large indoor enclosure, their young showed the ability to feign death at 120 days of age. The feigned death response develops near the time of weaning.

When six animals were stimulated daily, all continued to feign death for at least 12 days and one was still responding at 60 days. Generally the duration of feigned death increased with daily stimulation. Adult opossums responded less readily than ones under 8 months of age.

INTRODUCTION

The North American Opossum is the most primitive living representative of marsupials. Colbert (1955) has said, "This animal can be taken as representing in essential features the ancestor of the marsupials." It has remained virtually unchanged morphologically since the Cretaceous. It has entered North America from South America since the Pleistocene and is still extending its range northward, establishing itself in southern Canada within recent history (for a review see Peterson & Downing, 1956).

The opossum, although primitive, has maintained many advantageous features. Undoubtedly its generalized structure and physiology have allowed it to flourish in a variety of habitats and climates. Behavior, however, can also play an important role in maintaining a species and the well-known ability of the opossum to feign death has afforded it one means of lessening mortality due to predators. The present work examines some of the behavioral characteristics of feigned death in the opossum. Physiological aspects will be discussed in a subsequent paper.

Hartman's book, *Possums* (1952), gives the best discussion of feigned death in this species and also describes the phenomenon in a variety of other species. In spite of numerous anecdotal references, only two investigations have been made of feigned death in the opossum. Norton *et al.* (1964) compared electroencephalographs in

the feigned death state to ones taken while in the normal state. It was shown that although a slight flattening of the EEG waves and an increase in the high frequencies during feigned death occurred, the changes were not unique to the response since they continued after the opossum returned to the normal state. Also, no changes in EEG's were noted if the animals were caused to feign death from a highly aroused state. James (1937) confined opossums in a box and by administering shocks through an electric grid in the floor caused the animals to "play 'possum" even though an escape box was provided. When prevented from this response by suspension above the grid, the animals would raise their legs alternately in a slow forward movement. Further analysis in the opossum has not been made.

METHODS

Subjects.—Opossums were trapped in the vicinity of State College, Pennsylvania, and in the Finger Lakes area of New York State. Some animals were collected by professional trappers and donated by the Division of Fish and Game of the New York Conservation Department. Twelve were obtained through a commercial source in Florida. These latter animals represent a different subspecies, *D. m. pigra* Bangs, but since they are also known to feign death there appeared to be no reason not to include them in the studies. All work was done on the northern subspecies, *D. m. virginiana* Kerr unless otherwise stated.

The opossums were fed commercial laboratory chow in indoor cages for the duration of most of the work. Adults were housed separately except for females with young, which were kept with their respective litters. Young animals were kept two or three to a cage until some sort of antagonism suggested that they be separated. Deviations from the above are described in the pertinent sections.

Inducing the response.—The technique used to induce the feigned death response was to grab and shake the opossum. In some cases, particularly with adults, dogs were used as the grabbing agent. The dog would grab the animal, lift it into the air usually with a shake of the head, and then drop it.

It was neither practical nor convenient to use dogs throughout the work as suitable ones were not readily available, or they ceased to be cooperative after a few trials. Also the use of different dogs introduced uncontrollable variations in the level of stimulation. For most of the work, therefore, the opossums were stimulated by hand; the animal was grabbed by the nape of the neck and by the sacral region of the back, shaken, and placed on the ground.

RESULTS

The feigned death response.—Feigned death is a highly stereotyped behavior pattern. Typically, if non-tactile stimuli were applied, no feigned death response occurred. But when it did occur, the animal would "freeze" momentarily with its head pointed straight ahead. It

then flexed ventrally by bending the head toward the chest, contracting the abdominal and ventral tail muscles, and fell onto its side. At times the tail was curled between the hind legs. The corners of the mouth were drawn back simultaneously with the flexure and the tongue often extended either between the incisors or out one side of the mouth. The digits of the forefeet were flexed and the animal would grab pieces of grass, leaves or other material on which it was lying and hold on with some tenacity when lifted. The eyes remained open though usually not so widely as when the animal was normal. When a response occurred from grabbing and shaking the animal, the sequence could not be followed but the typical feigned death attitude was seen when the animal was dropped or placed on the ground. Again, if lifted, it had seized the underlying material. Shortly after the initial reaction, the retracted corners of the mouth were relaxed somewhat, so the teeth were less exposed. If picked up while feigning death, the opossum remained flexed and was therefore not limp as are some other species in immobility (Holmes, 1916).

In sleep, on the other hand, the opossum kept the eyes and mouth shut and, although flexed ventrally, maintained its dorsum uppermost rather than its lateral aspect. Its feet were tucked under and therefore hidden instead of being visible as when the animal was on its side. Sharp sounds of low intensity elicited no response during sleep. As will be discussed later, such sounds evoked a response from the animal feigning death. Loud sounds, a prod or blowing on the sleeping opossum caused it to wake with a start and turn its head toward the disturbance in a groggy manner as is seen in most other mammals. Similar actions during feigned death yielded no response. Table 1 compares the behavioral differences between feigned death and sleep in the opossum.

TABLE 1.—Comparison of behavioral differences between sleep and feigned death

Sleep	Feigned death
1. Eyes and mouth closed	1. Eyes and mouth open
2. Dorsal aspect upward	2. Lateral aspect upward
3. Feet tucked under	3. Feet visible and toes usually flexed
4. No response to sharp sounds	4. Ears twitch at sharp sound
5. Arouses with a start and turns head toward source of prodding or blowing	5. No response to prodding or blowing; may retract lips slightly

Hartman (1952) indicates that the opossum does not feign death while in its den in spite of prodding and attempts at removal. In the present study grabbing so rarely caused opossums to feign death in the laboratory that it was necessary to do almost all experiments out-of-doors. The only reliable positive responses obtained in a building were those obtained inside a barn-like chicken coop where wood

shavings were spread on the floor. In these cases, however, the opossums had been raised in this environment since leaving the mothers' pouches. Animals raised from the pouch in a well lighted laboratory room with wood shavings on the floor did not respond when stimulated in the laboratory.

Stimuli causing feigned death.—The effects of various stimuli as inducers of feigned death were investigated. Anecdotal literature describes many cases of opossums feigning death in response to visual, auditory or other non-tactile stimuli. In this study none of 37 weaned opossums feigned death during the normal course of removal from the trap, transfer to a burlap carrying bag or a cage. Six adult opossums, which had been in captivity for periods ranging from 2 days to 3 months, were harassed by yelling, hand clapping and prodding with objects toward their heads for 10 minutes. One animal, captured only two days prior, feigned death after 5 minutes of such treatment. Although the others showed typical defensive behavior of facing the aggressor, opening the mouth, retracting the lips and growling as well as attempts at flight, no other feigned death responses occurred. The harassment evidently affected the opossums because they defecated and released flatulence in nearly all cases. Each of the animals had the ability to feign death as shown by a positive response to grabbing by a dog at a later time.

A more critical test was made on seven animals. Four of these were tested immediately after capture and the others after they had been in captivity for up to 2½ months. All animals were harassed for 5 minutes. At the end of this time if they had not responded by feigning death they were grabbed by the back and shaken. In a total of 24 tests none of these opossums feigned death during the period of harassment, but in 16 cases did so when they were subsequently grabbed. Of the four animals tested just after capture, only one failed to respond to the tactile stimulus the first time tested. On later occasions, however, this one also exhibited a positive response to grabbing. Loose defecation occurred during nearly all periods of harassment.

To provide information on responses of opossums to a more natural predator than a human, 14 dogs were used as stimulus animals on 19 different opossums over the period of study. Only four dogs provided an "active stimulus." In these cases the dog would approach while barking or feinting, and snapping at the opossum's rump. In most cases it would grab the opossum with full jaws. This treatment is opposed to a "passive stimulus" which is the mere presence of the dog with perhaps sniffing of the opossum but no intense aggressive behavior. Information was obtained on a total of 39 dog/opossum interactions with 29 of these being an active stimulus situation.

Harassment by the dogs before actual biting lasted as long as 7 minutes, the only contact with the opossum being nips which at most slightly lacerated the skin. In 17 cases there was less than a minute of harassment before the dog grabbed with a full bite. In only four

cases were harassments not followed by biting although at times the dog needed some encouragement before biting the opossum fully (Table 2).

None of the passive-stimulus dogs caused feigned death. All of the 25 opossums that were fully grabbed feigned death although one required grabbing three times before responding. One response lasted for only 2 seconds, but most were considerably longer and one was timed at 60 minutes. In most cases the opossums were not timed for the full duration of their response.

In one case an opossum feigned death at a time other than while being grabbed by the dog. In this instance the dog had induced a response a few minutes before, which had lasted for 10 seconds. At this time, the opossum got to its feet and began to flee. The dog, which had left the immediate area, was called back and began nipping the opossum at the back and the base of the tail, lacerating the skin. After about 2 minutes the opossum suddenly straightened its body and appeared to look straight ahead for an instant. It immediately flexed in the typical feigned death position and lay down on its side. It remained in this state for one minute when it raised its head, looked around, then stood up for 3 minutes and slowly began to walk away. The dog, which was watching from a distance, was called but showed no further interest in the opossum.

To test whether extremely harsh situations that would not normally be encountered by opossums in the wild would cause them to feign death, five animals were briefly subjected to ammonia fumes using a nose cone and five to intermittent electric shocks supplied by an apparatus used on fences. Neither of these treatments evoked feigned death.

Reactions while feigning death and recovery.—Opossums are not refractory to external environmental factors while feigning death in spite of the many accounts from anecdotal literature describing a complete indifference to gross mutilation or other less severe abuse. Quantified data on such responses are not available but the present study offers some relevant observations. Opossums placed in awkward positions, as on their back or even on their head, rolled back onto

TABLE 2.—Duration of harassment of opossums by dogs with subsequent response of opossums if bitten

Duration of harassments before biting (minutes)	Cases	Harassments followed by biting	Feigning death when bitten
<1	17	16	16
1-2	2	2	2
2-3	2	1	1
3-4	4	4	4
4-5	0	0	0
5-6	3	2	2
6-7	2	1	1

their side when released. If the limbs or tail were manually straightened and then released they would return to their flexed position.

Pricking the feet often caused an increase in the muscular contraction. Cutting the tail or skin caused no noticeable response while feigning death, although the opossums, especially adults, responded with surprising indifference to such treatment while in the normal state. (It was seldom necessary to restrain them while inserting subcutaneous thermistor probes or incising the tail for blood samples.) On the other hand, the opossums feigning death responded to a sharp noise such as a squeak or kissing sound by twitching the ear whereas less sharp sounds such as the human voice seldom evoked a visible response. Electric shocks, administered at 1-second intervals, produced a convulsive twitch whether applied to the tail, foot, ear, or body proper. This response may have been due at least in part to direct stimulation of muscles or the efferent neural pathways as well as to the animal's reflex originating from afferent receptors. In all cases, five of these shocks were sufficient to bring the animal to its feet. Waving a hand or other object in front of the opossum's eyes usually caused an increased retraction of the corners of the mouth. Walking around them caused the same response or, less often, caused them to lift their head.

The "recovery" from the feigned death state is rarely rapid. After lying motionless on its side for a time, the opossum raises the uppermost ear if it had been flattened. The next movement, lifting of the head, may occur immediately or up to 20 minutes later. The head is slowly raised and the opossum looks around. It then cautiously gets to its feet and walks off with deliberation. Stimulation at any time during this recovery again causes the feigned death response. When observations on an animal were terminated it was usually picked up by the tail and returned to a carrying box. This treatment invariably brought it to an alert state with feet clawing for support and head held up. These observations clearly indicate that the normal slow recovery is not physiologically dictated but that the recovery can be immediate.

Reactions of opossums to predators.—The general pattern of behavior was the same for all opossums whether the "predator" was a human or a dog. The opossum attempted to flee when the predator approached to within about 5 m if clapping or barking accompanied the approach. Otherwise the predator could approach to within 1.5 m. When the predator came closer than this critical distance, the opossum turned to face him with mouth open, teeth bared and often growling. Growling in the opossum has no vocal quality but rather sounds like a vibration of the soft palate and base of the tongue as in clearing one's throat.

The opossum seldom lunged toward the predator and never bit it even though a dog at times stood sniffing with its nose only a few centimeters from the opossum's. There were several near misses, however, when the experimenter grabbed the opossums if the grip

was faulty. As the antagonist circled or moved around, the opossum stayed in almost the same place merely rotating with such speed as was required to face him. In this way less energy was expended by the prey than the predator, which was forced to attempt to get by the opossum's threat defense. Diarrhea was noted and a green mucus-like exudation was released from the paired glands lateral to the shallow cloaca. In addition, the penis of the males was often fully distended from its sheath though it remained flaccid. If the opossum was grabbed the initial rapid reaction was to bend the head back toward the aggressor or to feign death immediately.

Females with pouch young.—Six females with pouch young were tested after they had been shipped from Florida. One of these females responded once to hand stimulation. Of four females with pouch young locally trapped, one responded to hand stimulation. None of these females was tested with dogs.

The effect of isolation from humans on later responses in opossums raised in captivity.—The most efficient way of collecting young opossums in numbers is to trap adult females while the young are still in the pouch. As stated below, however, development in captivity increases the threshold of the opossum above a level practical to work with for many purposes. For this reason it would be helpful to devise a method of raising opossums without increasing their threshold. The following experiment was designed to test whether the daily visual, auditory, and tactile contact of young opossums with humans during the normal course of animal care was the critical factor in reducing their feigned death response to human stimulation (grabbing).

Four adult females with pouch young were trapped during July. Each female with her litter was housed in an individual cage. The first two, whose three and seven young served as control animals, were kept in a room with other opossums although there was no visual contact with them; the other two, with six and nine young, were each caged in a room used for no other purpose. These latter females with young (the experimental opossums) were kept from human contact by turning the front of their cage away from the door. A black curtain was arranged as a shield against visual contact with the caretaker. Cleaning was limited to what could be done without disturbing the experimental setup.

On 3 September, when the young opossums were approximately 90 days old, each was hand-stimulated. Of seven control animals surviving (three males and four females) one female responded by feigning death. None of the 15 (nine males and six females) experimental animals showed a positive response. All animals were returned to their respective cages and retested 26 days later. Again all failed to respond whereas younger wild-trapped opossums had feigned death without exception.

It thus appeared that factors other than visual, tactile and auditory contact with humans were responsible for the absence of the feigned death response in opossums raised in captivity.

The increasingly crowded conditions caused by growth of the young opossums confined in a small cage suggested that space limitations might have a deterring effect on the development of feigning death even though isolated from human contact. To examine this, two adult females with two and four pouch young, respectively, were confined together in a larger room and allowed to raise their young. The room, an unheated converted chicken coop, measured 15×30 ft. Light was limited to that which entered through windows. The floor was covered with wood shavings and boxes were provided for shelter. No attempt was made to avoid human contact although the opossums were usually hidden in the boxes during the times of feeding and cleaning. The animals were handled a few times for weighing or other examination. Fifty per cent showed a positive response at 120 days of age and all by the time they were 165 days old (Table 3).

Age considerations.—At what age is the young opossum able to exhibit feigned death through reason of nervous, hormonal or other maturation? This study sheds some light on the problem. Opossums brought into the laboratory while still in the mother's pouch failed to feign death to a hand stimulus when old enough to leave the teat and move about, *i.e.*, approximately 65 days, but whether this failure was due to age or the results of captivity is not clear. Young opossums begin their independent lives at 90 to 100 days (Petrides, 1949). From Petrides' method of aging, the youngest weaned animal trapped in the present work was about 4 months old and weighed 250 g. This opossum, plus 19 others estimated to be less than 8 months old on the basis of weight and incomplete dentition, responded to hand stimulation. Of 16 adults trapped, only five feigned death. Comparison of the number of responding animals younger than 8 months with that of older animals shows a difference significant beyond the 0.1% level ($\chi^2 = 16.63$ 1 d.f., Table 4). Four other adults responded to the

TABLE 3.—Feigned death responses to hand stimulation of young opossums of different ages raised in chicken coop

Approximate age (days)	Negative response	Positive response
65	3	0
75	4	0
120	3	3
165	0	2

TABLE 4.—Incidence of feigned death responses of trapped opossums of two age groups to hand stimulation

Age groups (months)	Positive response	Negative response	Total tested
3-8	20	0	20
>8	5	11	16

stimulation of a dog although failing to respond to a human and six did not respond to a human stimulus but were not tested with a dog. The last one responded to a dog but was not stimulated by hand.

Of 12 adult opossums obtained from a commercial source in Florida, only one responded to hand stimulation. This animal, a female, showed a rather weak response with less than complete flexure. She maintained this position for 30 minutes but in subsequent tests failed to show a positive response. Experience of these animals with predators before capture is not known. Factors such as period of captivity could not be critically examined because animals were being trapped continuously and durations of captivity were therefore unequal. The inference is clear, however, that the threshold of effective stimulus at least is higher in adults than in young weaned animals.

By allowing females to raise their young in the large chicken coop until postweaning, a more critical examination of the ontogeny of feigning death was made (Table 3).

Effects of daily stimulation on length of feigning death.—Six animals born between about 20 February and 20 March 1965 were trapped and taken into the laboratory during the period 28 June to 28 July. The initial intent was to compare these wild-raised animals with ones that had been raised in the laboratory from the time they were in the female's pouch in the following way: each animal would be stimulated by the hand-grasp technique every day and the duration of its response recorded from the time of stimulation until the head was lifted. Fifteen animals so raised in the laboratory failed, as previously mentioned, to exhibit the response at ages similar to that of those caught in the wild. The tests were nevertheless made on the wild-raised animals and the results plotted graphically. The opossums were allowed to remain in the feigned death state for a maximum of 30 minutes, at which point the observations were terminated.

The least number of consecutive days of stimulation was 31 and the most 60. Results vary considerably (Fig. 1). Four animals ceased responding after 11, 23, 30 and 35 days, respectively, although daily stimulation was continued for at least 10 days more. When the experiment was terminated two animals were still responding, one after 33 days of stimulation and the other after 60. The latter animal was still responding for or close to the maximum allowed 30 minutes. This individual showed great variation in durations of response throughout the experiment.

Repeated stimulation for the time periods used in this experiment does not then extinguish the feigned death response in all animals. In fact the duration of response considerably increased in all animals except one. In no case was the length of response greatest on the first day. One animal increased its duration of response generally from the 9th to the 23rd day, when it feigned for the maximum 30 minutes allowed. The responses then lasted for 30 minutes with some fluctuation over a period of 30 more days and then diminished.

DISCUSSION

Interpretation.—The suggestion of immobility as a response to fear has been discussed by a number of authors (Ratner and Thompson, 1960; Hinde, 1966: 242) particularly since “taming” procedures and the raising of species such as the opossum in captivity diminish or prevent the response (Gilman *et al.*, 1950; Glickman *et al.*, 1965). However, attempts to induce “fright” by human harassment or with dogs, although eliciting avoidance and threat behavior and colon evacuation associated with responses to fear, rarely caused the animals to feign death. Although some opossums in the present study and more commonly those seen by competent observers in the wild, feigned death without tactile stimuli, the incidence of the response in the present work was far less without predator contact than with it. When daily stimulations were applied, opossums according to the fear

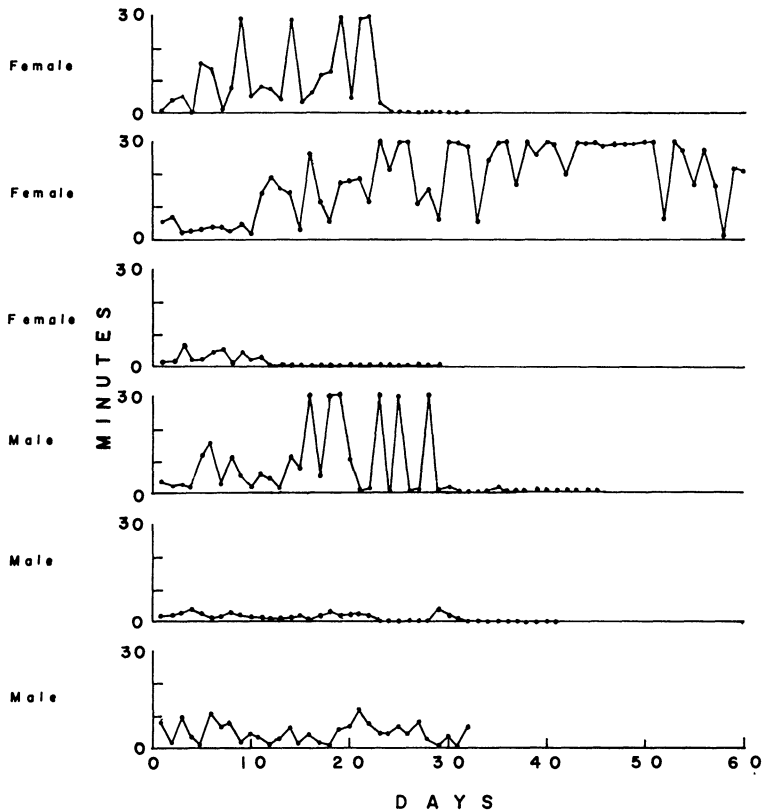


Fig. 1.—Duration in minutes of feigned death in six opossums (aged 100-160 days) when stimulated by hand on successive days. Observations were terminated after 30 minutes in each case.

hypothesis might be expected soon to habituate and cease responding. Instead, they continued to respond for up to 60 days. A possible explanation is that the response was reinforced through its "success" in preventing more severe abuse by the predator. An explanation other than fright must then be sought.

Because of relative indifference to surroundings and the resemblance of stupor, shock would seem to be a possible explanation for the mechanism. A rigid definition of that is lacking, however, as is basic agreement as to its nature and cause. Some confusion stems from a loose application of the term to a variety of conditions. Symptoms that are suggestive of shock include ashen skin resulting from circulatory impairment. Such a color can be seen around the snout and on the naked feet of the opossum in death, but it does not occur during feigned death.

While autonomic response might reasonably be expected to cause feigned death, concomitant symptoms normally associated with autonomic discharge are lacking. Release of flatulence, loose diarrhea and engorgement of erectile tissue of the penis may be mediated by the parasympathetic nervous system and usually occurred during harassment or chasing of the opossums but was often seen without accompanying feigned death and conversely did not always occur with it.

The rapid onset of the condition as well as the immediate recovery when picked up by the tail appear to exclude the possibility of hormonal causation. In addition, consideration of the age of onset in the opossum fails to offer evidence in this direction. The present study shows development of the response around the 120th day of age. With the exception of reproduction, all hormonal functions are active by this time. Reynolds (1952) found sperm in the epididymis in opossums as young as 240 days and has record of a male successfully breeding at 250 days. The earliest breeding age of a female was 185 days. Thus physiological and behavioral sexual maturity does not appear to be a necessity for feigning death.

The age of development of feigned death (about 120 days) substantiates views summarized by Ratner and Thompson (1960) that animal immobility develops near the age of physical independence. Young opossums spend more than two months in the pouch and travel with the mother for an additional period of about 30 days. At 90-100 days of age the young leave the female and attain independence (Hartman, 1928). As might be expected, this age is somewhat later than that for the maturation of temperature regulation, which Morrison and Petajan (1962) found to be about 90 days. The small size of the young opossum before independence would more likely make the predator contact fatal, thus nullifying any advantage of feigned death and increasing the advantage of immediate attempts at escape.

Survival value.—The survival value of feigning death is clear when it occurs before the predator makes contact with the prey. It is

well documented and further shown by the present study that a moving prey is more likely to be attacked than if quiet (see also Clark, 1962). Indeed, at least in intraspecific aggression, the yielding of the subordinate individual in some species is characterized by "freezing," often in a vulnerable position (Matthews, 1964). It is not necessary that such a mechanism be completely effective nor even occur 100% of the time to have a survival value. Ratner and Thompson (1960) discuss the possible function of feigned death caused by predator contact with the prey as stated by Armstrong (1955), *i.e.*, the prey, by being treated like a dead animal, will have more opportunities for escape than if it is treated as alive. In animals such as chickens which terminate their immobility with a sudden burst for freedom this interpretation is reasonable. In the opossum, however, which arises slowly, even cautiously, before moving off, it is more difficult. The slowness of the opossum and its main defense in the wild of taking refuge down a hole, up a tree, or into the brush, probably allow the slow recovery to be more advantageous than in birds, which rely more on headlong flight, whether aerial or terrestrial.

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