Comprehensive analyses of food habits could not be determined for the specimens taken. The stomachs and intestines of all four least weasels were examined and all were empty except one, which contained a small bone fragment and a few hairs of a Baird mouse in the small intestine. A dead mole (*Scalopus aquaticus*) was found at the entrance of a burrow used by one of the weasels but there was no apparent evidence that it was a weasel kill. Two of the weasels lived within 40 rods of one another, the two others lived within 60 rods of one another, and the range of one of these was overlapped by that of a long-tailed weasel.

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ECOLOGY OF THE OPOSSUM IN EASTERN TEXAS

BY DANIEL W. LAY

The opossum (*Didelphis virginiana* L.) has received much intensive laboratory study but little has been published on its ecology as the most numerous fur animal in the southern forests. The low pelt and sport value of individual opossums may justify this neglect in management programs for limited areas, but the wide distribution and general use of opossums for fur and food calls for more consideration of the species in state-wide programs. The present paper is a summary of field observations on opossums made in eastern Texas between June 1938 and September 1940.

The more intensive data were obtained on an 86-acre live-trapping plot in an undisturbed part of Tyrrell Park, 5 miles southwest of Beaumont, Jefferson County, where 278 captures were made of 117 individuals. Through cooperation of the National Parks Service, two Civilian Conservation Corps enrollees with special interest in wildlife attended the traps that were operated almost continuously for two years. The work was supervised by frequent (weekly to bimonthly) inspections of records and trapline. A duplicate set of records was kept by me and these were brought up-to-date at each inspection. Records kept were the simple and obvious facts of appearance at trap stations, sex, number of young in pouch, presence or absence of external parasites, and general description of physical features. Further details were not required and no pressure was exerted to stimulate catches. The wildlife trapping job was considered a choice position among enrollees and inaccuracy of detail was understood to mean the substitution of a new man from the waiting list. With these precautions there remained a minimum chance for error.

Traps used were of the Biological Survey house-cat-trap design; the first six of wood were less durable (because of damp weather and wood rat damage) than the 20 metal ones that were added to the trapline later. Baits consisted of fermented fish scents and the more satisfactory fresh meat scraps. Dry corn and various fresh vegetables were tried without success. The scarcity of fresh meat scraps seriously limited catches occasionally.

Animals were marked by several methods. The first trial was of ear punches made with a baby-chick toe punch. These holes were not permanent as the cartilage refilled them in a few months or they were ripped out. Toe clipping on the two fore feet was the most permanent method of marking found and proved useful up to the number 99. The toes healed quickly and no more than two were removed from a foot. Circular ear brads were used in conjunction with toe clipping on the majority of the animals marked, but these occasionally were lost.

The trapping plot was of the poorly drained coastal pine-hardwood type, undisturbed by timber cutting for twenty years. In addition to the common trees such as loblolly pine (*Pinus taeda*), water oak (*Quercus nigra*), red oak (*Q. rubrum*), red maple (*Acer rubra*), and sweetgum (*Liquidambar styraciflua*), the fertile Lake Charles clay loam soil supported a luxuriant understory of fruiting vines and shrubs, particularly: blackberry (*Rubus flagellaris*), mayhaw (*Crataegus* sp.), bluehaw (*C. brachyantha*), blackhaw (*Viburnum molle* and *V. rufidulum*), French mulberry (*Callicarpa americana*), grape (*Vitis* sp.) and rattan (*Berchemia scandens*). The area had a more abundant and varied food supply for opossums than most of the pine woodland on sandy soils, but there were certain other factors definitely limiting its carrying capacity for opossums. One was the scarcity of water during dry periods. The animals seemed to move about considerably during droughts, leaving the area for surface water several hundred yards distant. During rainy seasons all ground dens were flooded causing a reduction of den supplies.

HOME RANGE

Of the 117 individual opossums marked during the two-year period, 58 or 49 percent were taken only once (Table 1). Twenty-two were taken only twice and 31 were taken three or more times. Of the 31, only 29 visited three or more stations thus providing a basis for mapping home ranges. Of the 29 home ranges the records are most complete for no. 19, taken 48 times at 11 stations; no. 14, taken 30 times at 13 stations; and no. 29 taken 20 times at 7 stations (see figs. 1, 2, and 3.).

The minimum home range indicated by the records was measured by connecting the outlying stations visited. The mean minimum home range, thus measured, was 11.5 acres, but the range among the 29 records was considerable (from about $\frac{1}{3}$ acre to 58 acres). The record of no. 19, which shows the greatest home range, suggests that for any one period of weeks the home range was much nearer 11.5 acres than 58 acres. After the first two visits to the traps, this female

settled down in the vicinity of stations 7 and 26, which are 400 feet apart, and made 17 repeat visits to the two stations.

The mean of the greatest distances traveled between trapping stations was 1,460 feet. This is a mean travel radius of 730 feet, which would form a theoretical, circular range of 38.4 acres. Since the record for no. 44, which forms the most complete and symmetrical range, gives an area of 39 acres, it is perhaps true that the average opossum's normal range falls between 11.5 and 38.4 acres. During extremely dry periods when no surface water was available on the plot many of the opossums apparently moved out. This abnormal extension of range, however, cannot be considered as a part of the home range.

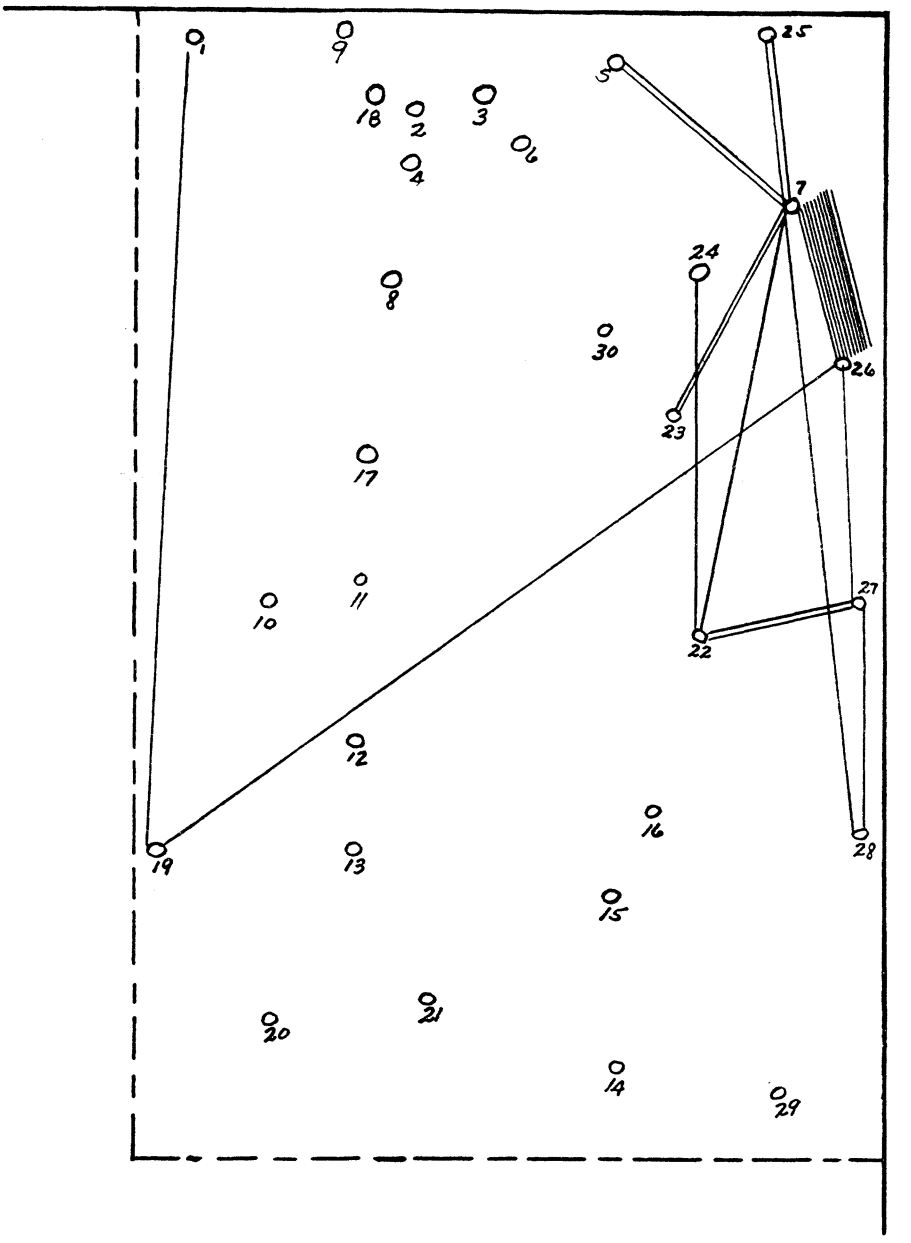
The ranges of individual opossums overlapped so frequently that no discernible tendency towards establishment of individual territories could be

TABLE 1.—*Frequency of catch for 117 opossums*

TIMES CAUGHT	NO. OF INDIVIDUALS	PERCENTAGE
1	58	49.6
2	22	18.8
3	13	11.1
4	8	6.8
5	5	4.3
6	1	.8
7	3	2.5
9	1	.8
14	2	1.7
16	1	.8
20	1	.8
30	1	.8
48	1	.8
	117	99.6

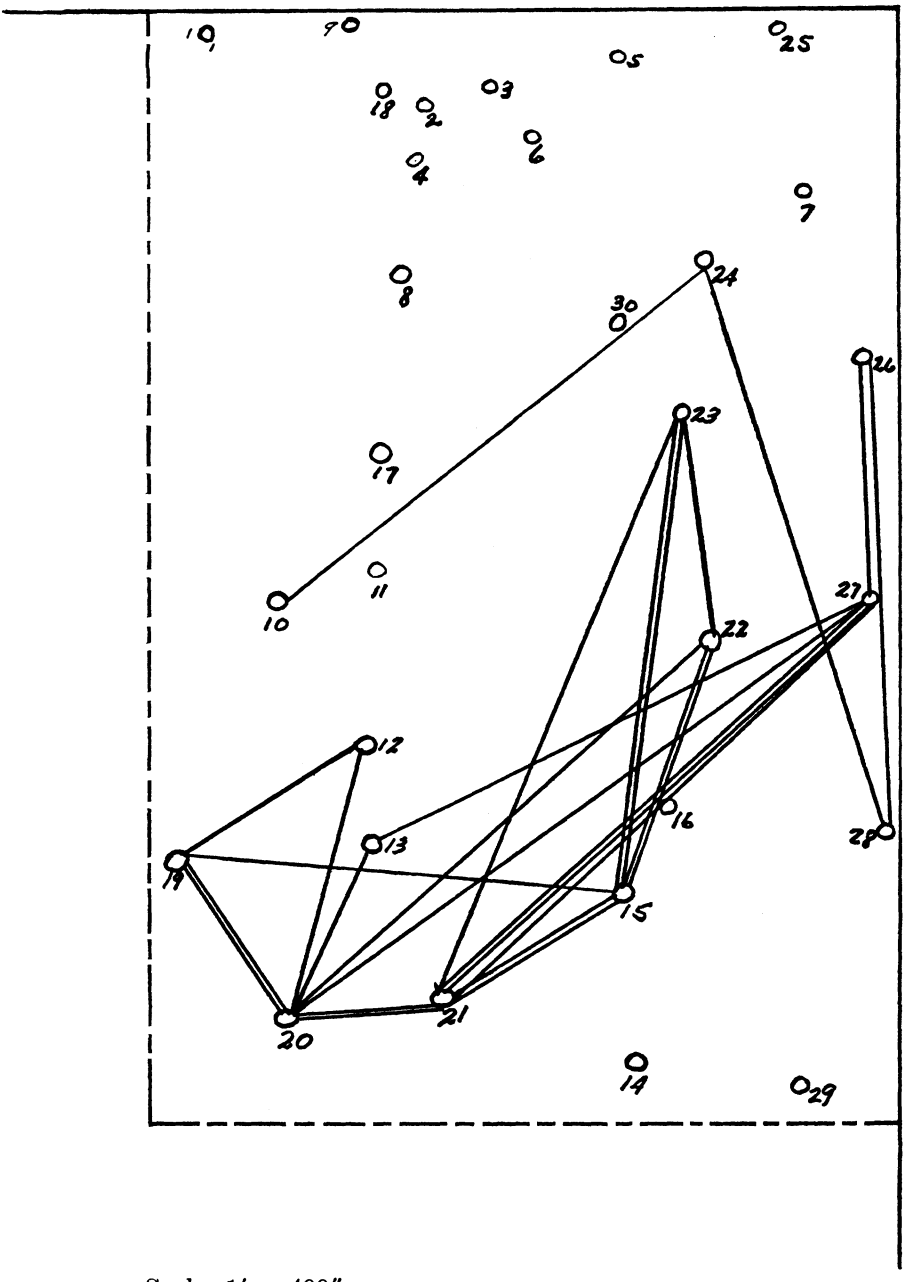
detected. On the contrary, tracks rarely showed that two or more opossums traveled together. Family groups seem to break up rapidly after the young cease to ride on the mother. Apparently opossums generally den and feed alone, but are tolerant to neighbors. Yeager (1936) reports that 6 of 36 opossums in day-time dens were in pairs but not of mixed sexes. I found a large male and a small female in the same den in Chambers County, February 3, 1939. There were 2 young in the pouch of the female.

The wandering habit may be more pronounced in opossums than in some species. Forty-nine percent of the individuals marked were captured only once. A few may have been trap-shy and present on the area as residents, but the evidence suggests that almost half of the population on a given area are distinctly itinerants. Seasonal food and water changes cause definite movements and may account for some of the apparent wandering. The record of no. 19 (fig. 1) shows an early wandering habit and a later more sedentary life.



Scale: 1″ = 400′

FIG. 1. Trap stations at Tyrrell Park and catch records of animal no. 19, a female, first trapped January 26, 1939, at station 1 and last trapped October 25, 1939, at station 26, taken a total of 48 times. Lines indicate assumed routes of travel between stations where taken; also, the number of known trips between such stations.



Scale: 1′ = 400″

FIG. 2. Trap stations at Tyrrell Park and catch records of animal no. 44, a female, first trapped May 31, 1939, at station 22 and last trapped March 4, 1940, at station 10, taken a total of 30 times.

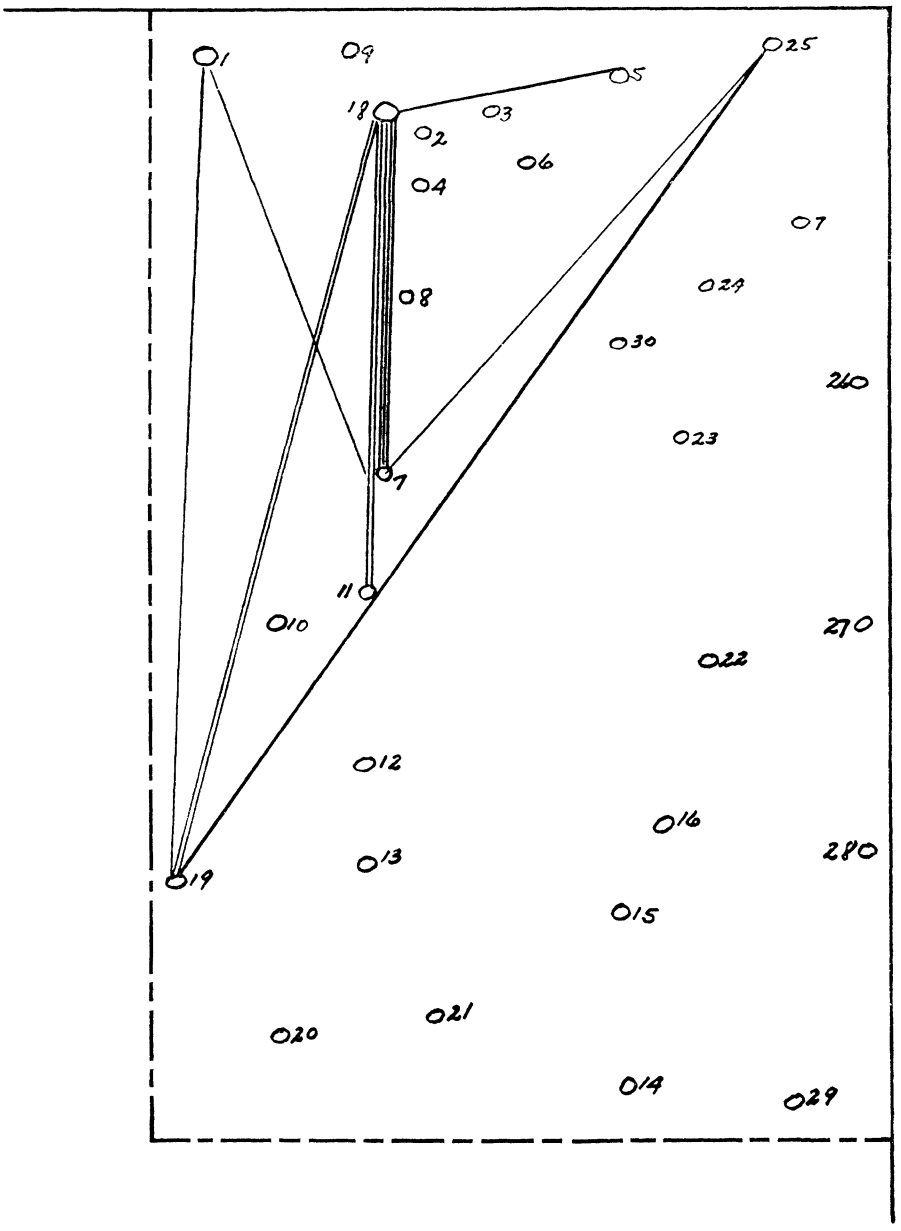


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FIG. 3. Trap stations at Tyrrell Park and catch records of animal no. 29, a male, first trapped March 14, 1939, at station 18 and last trapped July 5, 1939, at station 5, taken a total of 20 times.

SEX RATIO

Among the 117 animals trapped (66 males and 51 females) the sex ratio was 57 to 43. No significant differences were found in the sex ratio between the groups retrapped one or more times and those trapped only once.

POPULATION DENSITY

The records are not complete or numerous enough to permit monthly tabulation of populations on the 86-acre study area. Table 2 is a quarterly tabulation showing an average of 21.1 (16–36) individuals trapped in each three months period. The data show an average of 12.3 animals captured only once and 8.8 taken more than once each three months period. All animals taken only once during a quarter were not transients because some were caught regularly during other quarters. Some of the quarterly periods have reduced catches due to cessation of trapping operations, lack of suitable bait supplies, or severe drought.

TABLE 2.—*Density of opossums on 86-acre plot by quarters*[1]

QUARTER	TAKEN ONCE DURING QUARTER	TAKEN MORE THAN ONCE	TOTAL
Jan.–March, 1939	11	7	18
April–June, 1939	19	17	36
July–Sept., 1939	15	9	24
Oct.–Dec., 1939	12	4	16
Jan.–March, 1940	10	7	17
April–June, 1940	11	7	18
July–Sept., 1940	8	11	19
Averages	12.3	8.8	21.1

[1] Young in pouches of females were not counted.

The records show the minimum populations and it is deduced that the actual population of opossums was probably more than one to four acres.

The average interim between the first and last dates of capture of the 56 individuals taken more than once was 83 days, which further validates the quarter year as an arbitrary basis for estimating population densities.

Trapping of 16-acre quadrats (outside the Tyrrell Park study area) with 24 no. 1½ single spring steel traps baited with a uniform fish scent produced one to four animals the first night on five plots during September and October, 1938. The use of such quadrats for population estimates was abandoned as impracticable. Catches on second and third nights suggested that few resident opossums escape the first night of trapping, but the amount of influx was a serious variable. The quadrats in Jefferson County near Tyrrell Park and in Walker County, rolling pine woodland type, each produced four opossums the first night. That the population density in favorable habitat approaches one to four acres seems more evident with this check of live-trapping results.

Walker County in 1936–37 produced an estimated crop of 5,296 opossums

pelted for fur and an additional 4,610 animals used for meat only, or a county-wide crop of one to 52 acres. The fur crop was determined by means of an interview with one fourth of the 84 licensed trappers. The meat crop was calculated from census figures of rural Negroes after the Negro Civilian Conservation Corps enrollees at the Lufkin and New Waverly camps disclosed that 57.6 percent of 2,098 Negroes living in eastern Texas eat an average of 4.9 opossums to the family a year. Only 13 percent of these animals are skinned so the pelt may be sold. Of Negro families living on farms, 76.2 percent eat an average of 5.6 opossums a year. Of those living in towns with a population of less than 10,000, 49.1 percent of the families eat an average of 3.4 opossums a year. The density of the opossum population that produces this annual county-wide harvest of one opossum to 52 acres might easily be the density of one to 4 acres indicated for favorable habitat by other observations.

Population density of opossums on 102 acres of sandy coastal prairie in Chambers and Jefferson counties in February 1939, was one to 14.6 acres. The census was made by excavation of all dens found on measured 4-acre sample plots. The prairie seems to be less productive of opossums than woodland.

LIFE SPAN

All but one of the 56 opossums having an average trapped-life span of 83 days were weaned from their mother before being trapped the first time. Some were full grown, but all, with one exception, were more than three months of age. Although traps were operated more than 24 months, the trapping span of only one individual exceeded 11 months. In consideration of the high breeding potential, a relatively short life span would be expected and the trapping data bear this out.

The most vulnerable period, other than the one at parturition when the 13-day-old opossums struggle through long hair to find a nipple in the mother's pouch, seems to be the early days after the young are weaned and leave the mother. Only one litter was marked in the Tyrrell Park study. The nine young were toe-clipped when about ready to leave the mother, no. 49, but only one of the nine was ever found again although the mother remained on the area a full year.

Opossums seem to lead a reckless life with little concern for the commonplace parasites, cuts, scratches, broken legs or tail, lost toes, ripped ears, and broken teeth. Only 5 of the 56 animals were free of ticks. Ticks found on the opossums were identified by Dr. R. A. Cooley, U. S. Public Health Service, Division of Infectious Diseases, Hamilton, Montana, as *Dermacentor variabilis*. Four of those with ticks carried fleas and two also had red bugs. The fleas were determined by William L. Jellison, U. S. Public Health Service, Division of Infectious Diseases, Hamilton, Montana, as *Rhopalopsyllus* sp., probably *gwyni*. This genus is uncommon in the United States, but is abundant in South America, according to Jellison.

Some animals with heavy infestations of ticks were fat; others with ticks attached only to the ears, or completely absent, were not in good flesh. Animal

no. 22 had numerous ticks and was fat when first caught (May); four months later she had none but was still fat. No apparent correlation between condition and presence of external parasites was found. No. 29 died in the trap after frequent visits and, although the carcass was not preserved or examined, the field notes from the trapline suggest a combination of contributing factors: "May 4, 1939 very full of ticks, poor, left ear running, rotten smell. May 5 same. May 6 slight skinned place on back and tail. May 8 same and ear still sore. May 13 same. May 15 hair almost gone, full of ticks. May 27 half through molting, toe cut. May 29 same. June 12 skinned place below eyes and on hip. June 15 full of ticks, molting, skinned on back and hip, also very bad smell. June 23, 25, 27 same. June 28 no. 5 toe ripped off, still bleeding. June 30 full of ticks, skinned place on back, no. 5 toe swollen. July 2 dead in trap." These observations by the untrained enrollees who attended the traps provide a graphic, if incomplete, description of this male opossum.

The only other opossum found dead was no. 132, an immature female reported as "sick and poor, with few ticks" on May 31, 1940, and found dead near station 20 on June 11.

BREEDING HABITS

The beginning of the opossum's breeding season has been well described by Hartman (1928). The modal point for ovulation occurs in the third week of January. The gestation period is 13 days from coitus to parturition and the postnatal period of dependence on the mother is 90 to 100 days. The Tyrrell Park live-trapping operations revealed some incomplete details of reproduction in the wild. Table 3 summarizes the monthly proportion of females with young in the pouch found between September 1938 and September 1940, both on the Tyrrell Park project and elsewhere in southeastern Texas. Only adult or subadult females were examined.

The 7-month period of January to July inclusive was the only time when young were found in the pouch. The percentage of females with young varies from the lows of 29 in January and 45 in April to peaks of 60 in February and 96 in June. The end of the period is well defined. Seventeen or 74 percent of the females examined in July carried young, whereas none of the 28 examined in August was with young. The 64 females examined between September and December were likewise without young.

Two litters a season were produced by three individual live-trapped females and in no instance did the records reveal that a female carried less than two litters during the breeding season. Hartman (1928, p. 154) states there are at least two litters of young a year in the southern states and that it seems probable that a third is produced by a small percentage of unusually fecund females. His deductions are based on weight groupings of 117 mature females and about 12 litters of pouch young after May 1, one of them in August and two in September. The present investigation substantiates Hartman's deduction of two litters being normal, but fails to disclose any evidence of a third litter.

Number 19 had nine young in her pouch on January 26, 1939. When she was

taken again on April 23 she had 10 very small offspring in the pouch, which were observed 11 times before July 12 when only one remained. On July 13 it was gone. Number 23 had 8 small young on January 26, six larger ones March 10 and five very small ones April 13. Number 24 had two young in her pouch on February 6 and 7; new ones on April 19, 1939. In September and again in October when she was retrapped there were no young in the pouch. The probability that two litters a year are normally produced is further indicated by the length of the breeding season, which is approximately double the period the young remain in the pouch or crawl on the mother, and by the presence of two peaks of breeding percentage in February and June with a low in April.

The second litters appear in the pouch from early in April to as late as May 20 to 23, according to the six records that show a definite period in which late young were born. Four of the records are for April. Allowing 90 or more days

TABLE 3.—*Opossum breeding summary*

MONTHS	FEMALES EXAMINED	NO. WITH YOUNG	PERCENT WITH YOUNG
January	7	2	29
February	10	6	60
March	10	5	50
April	11	5	45
May	22	14	64
June	28	27	96
July	23	17	74
August	28	0	0
September	32	0	0
October	11	0	0
November	11	0	0
December	10	0	0

for development before the end of July, it would be expected that most second litters would be born in April. Two of the six records, however, are of litters born about May 1 and between May 20 and 23.

Sixty-five litters averaged 6.8 individuals. The January to March litters were 6.4 as compared with the May to July litters of 6.9. The difference is not statistically significant, although it is interesting that the more abundant supply of spring fruits coincides with the period of larger litters.

FOOD HABITS

The species has little trouble finding food because a great range of substances is acceptable. All of 16 stomachs taken in September 1938 were more than half full. Volume estimates of the contents of these stomachs were: Insects and worms, 45 percent; fruit, 11.8 percent; green leaves, 11 percent; trash (leaf and log litter), 10.6 percent; mammals, 7 percent; acorns, 4.7 percent; birds, 4.3 percent; crayfish, 3.3 per cent; snails, 0.75 percent; grass seeds and cellophane, traces. The fruits included French mulberry and grape. At other

seasons blackberry, bluehaw, and persimmon fruits have been noted as opossum foods. The limiting effects of food supply could rarely be operative on the opossum.

DENS AND ASSOCIATES

In the den census of 102 acres of prairie the ratio of other animals to one opossum was 1.43 armadillos, 1.14 striped skunks, 0.29 spotted skunks, and 0.14 mink. For every occupied den there were four empty dens and two blind traps or short holes. Distribution of opossum dens on the census areas showed a rather close correlation with woody cover in the form of wax myrtle bushes and blackberry. Although two of the opossums were found in dens not protected by any woody cover, five others were located under the roots of small bushes.

The seven opossum dens excavated in the prairie den census indicated something of the relationship of opossums to armadillos. One large male opossum was with a male armadillo in a den characteristic of armadillo workmanship. A bushel or more of old nest material and fresh soil was piled immediately before the entrance to the den. Two side burrows led away from the nest material in the central chamber. Both of these features are commonly found in armadillo dens. Another opossum, a female with 8 young, was found in a minor part of a network of armadillo excavations. The other five opossum dens showed little if any indication of armadillo use. The typical opossum den on the prairie is a simple burrow about 6 feet long, without branches and without the pile of soil at the entrance that characterizes the typical armadillo burrow.

The importance of armadillo burrows for fur animal dens is problematical. It is true that opossums use armadillo burrows and it is likely that they dig few dens. But opossums were common before the armadillo migrated into the region and there is an abundance of unoccupied dens on the prairie that were made by skunks or other agents. This surplus of available den sites on the prairie as well as in woodland makes it unlikely that den sites are limiting factors for opossums.

A series of 30 artificial den boxes made of 8-inch boards was planted in 1938 in prairie at a distance from woody cover and in woodland. Two of the ten boxes in prairie were used, one by a common skunk and one by an opossum. The 28 boxes not used further indicate that den sites are not a serious limiting factor.

OPOSSUM AS FUR RESOURCE

The available records in Texas on the number of fur pelts handled are incomplete. Lay (1938 and 1939) has discussed these records. The state-wide crop in all probability exceeds one million opossums a year. When the pelt value is 25 or 30 cents each, the trappers in more favorable habitat make a satisfactory income because of the large number of opossums and the relative ease of skinning and stretching their pelts. The opossum is doubtless the most numerous fur animal in Texas, but the value of the annual catch probably is exceeded by the catch of muskrats.

DISCUSSION

Neither food supplies nor den supplies appear to limit opossum populations as much as man's fur trapping, predatory animal control, and meat hunting. There is a tremendous waste of opossums when the meat or fur is either of poor quality or is not desired. The fur is generally prime only between December 15 and January 15 in Texas. Concentration of predatory animal trapping in winter would prevent loss of fur value and (with the larger traps) springs under the pans would reduce captures of unwanted opossums.

SUMMARY

1. Live-trapping in 86 acres of flat coastal pine-hardwood with 26 traps for 24 months revealed 117 opossums, which were taken 378 times.

2. Fifty-eight or 49 percent of them were taken only once and 29 individuals visited three or more stations. The average minimum area between the stations in these 29 home ranges was 11.5 acres. The mean of the greatest distances traveled between stations was 1,460 feet, which would form a theoretical circle of 38.4 acres.

3. Separate individual territories are not important to opossums as home ranges overlapped in every instance.

4. The sex ratio among 117 opossums trapped was 57 males to 43 females.

5. A population density of one to four acres was estimated for the 86-acre study plot on the basis of quarterly tabulations of catches.

6. An annual county-wide harvest of Walker County of one to 52 acres was revealed.

7. A trapping-life-span of 83 days and the rapid disappearance of young after weaning suggests a relatively short life cycle for opossums.

8. Two litters a year are normal during the January to July breeding season. Three case records of two litters per female were revealed by live trapping. Peaks of breeding are reached in February and June with a low in April. None of the 92 adult females examined July 31 to December 31 carried young in the pouch. The mean of 65 litters was 6.8 young.

9. Food supplies rarely could limit opossum populations because almost any vegetable or animal food is acceptable, as indicated by inspection of 16 stomachs and other observations.

10. Dens are not limiting factors; and armadillos, although useful, probably do not cause increases in opossum numbers.

11. The Texas opossum crop exceeds one million pelts a year, but in value the opossum is probably second to the muskrat.

12. No intensive habitat improvement for the opossum can be justified economically, but various measures for preventing waste of opossums should cause some increase in the total population.

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ON THE CAUSE AND NATURE OF A POISONOUS ACTION PRODUCED BY THE BITE OF A SHREW (*BLARINA BREVICAUDA*)

BY OLIVER P. PEARSON

A number of years ago it was common knowledge that the bite of a shrew was poisonous and, in England and on the Continent, these little mammals of the insectivore group were feared as much as the viper. The attitude of 17th century naturalists toward the shrew is illustrated by the following quotation from a book entitled "History of the Four-footed Beasts and Serpents" by the Reverend Topsell published in London in 1658: "It is a ravening beast, feigning itself gentle and tame, but, being touched, it biteth deep, and poysoneth deadly."

With the passage of time, confidence in the poisonous powers of the shrew seems to have waned, especially among those educated in science, until today this strange power is relegated to the category of quaint folklore. It is possible that this change in outlook has been brought about by the discovery of bacteria and their power to cause serious infection of small wounds. When learned people of our day encounter the statement that the bite of a shrew is poisonous, they pass off the matter by stating that our unfortunate ancestors knew nothing of asepsis and did not suspect that the teeth of animals were teeming with bacteria capable of causing an infection that might result in death.

In 1889 Maynard reported the effects produced by a short-tailed shrew that bit him when he was trying to capture it. The skin of his hand was barely punctured in a number of places, yet within 30 seconds a burning sensation was felt, which soon became intensified by shooting pains in the arm. The pain and swelling reached a maximum in about one hour, but considerable discomfort was felt for more than a week afterward.

The rapidity with which the effects of this bite were felt makes it certain that something other than bacterial infection was involved. Maynard passed off the incident by stating that an enraged animal, even a man, is capable of inflicting a poisonous wound.

Some time after I had read Maynard's paper, Dr. George Wislocki called my attention to the fact that the submaxillary salivary glands of *Blarina*, the short-tailed shrew, contain an unusual segment of coarsely granular cells in the secretory tubules, a type of segment that to my knowledge has been found in no other mammal except *Crossopus fodiens*, an European water shrew (Schaffer, 1908).

The discovery of this peculiar characteristic of the submaxillary gland suggested at once that it might be the seat of production of some poisonous sub-