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Comparative post-natal growth in five species of the genus Sigmodon. I. External morphological character relationships*

by

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The study of the comparative ontogenesis of rodents at the interspecific level has been largely neglected, although a few works exist on age and growth phenomena in single species. One such work (CHIPMAN, 5) details age determination in the cotton rat (*Sigmodon hispidus*), but this form is not compared with other species in the genus. Thus, the availability of five species of *Sigmodon* as laboratory-raised animals of known ages has provided a unique opportunity to use comparative growth studies as a measure of phylogenetic relationship in rodents.

Rodents of the genus *Sigmodon* are of medium size (225 to 330 mm in total length) and have short tails (less than one-half total length). The animals are robust, with short, rounded ears. The pelage is coarse and grizzled, light brown to dark gray. The tips of the plumbeous-based hairs of the underparts vary from white to fulvous to gray. The skull has a heavy rostrum and prominent supraorbital ridges continuing posterolaterad as temporal ridges. The molar teeth are high-crowned with long, narrow S-shaped enamel loops on the occlusal surfaces. Cotton rats are the dominant grass-eating and runway-making rodents. They are found from sea level to more than 3,200 meters in south temperate and tropical North America, through Central America and reach the southernmost limit of their distribution in Peru.

The species of *Sigmodon* have been recognized as falling into two natural groups, the *S. hispidus* group (one species) and the *S. fulviventer* group (four species).

Cotton rats of the *hispidus* group have a semi-naked tail, with coarse

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annulations only partly obscured by short scattered hairs. They inhabit south temperate and tropical zones where they are widely distributed in an almost continuous range. This species (*S. hispidus*) is the only one of this group, although several subspecies are recognized. On the other hand, the *fulviventer* group have a tail with dense hair that conceals the annulations. They inhabit the tropical, temperate and boreal regions in southwestern United States and western Mexico (BAKER, 3). The group includes four species: *S. alleni, S. fulviventer, S. leucotis* and *S. ochrognathus.*

Most previous knowledge of development, growth and life history was limited to *S. hispidus* and little is known concerning the other four species. The wide distribution of *S. hispidus* in the United States has made this species more available for study, but investigations have been limited largely to the basic life history as observed in the laboratory (MEYER, 14; MEYER and MARSH, 16; SVIHLA, 19) and under natural conditions (GOERTZ, 9; ODUM, 17; SEALANDER and WALKER, 18).

Ovulation in *S. hispidus* occurs during the late period of the vaginal estrus. The gestation period is 27 days. Six and one-half to 12 hours after parturition ovulation may again take place, with copulation following within 3 to 6 hours. The reproductive cycle in the hispid cotton rat is approximately one litter every 59 days (18). Feral females in the United States produce offspring from early spring until late autumn. The number of young per litter varies from one to twelve, depending on the species and whether the litter is born in nature or in captivity (4, 11, 15, 17, 18, 19).

At birth, all *Sigmodon* weigh from 4.5 to 8 g (11, 19) and are completely covered with a fine coat of light-colored and adpressed hair, thickest around the head region. By the second day hairs begin to stand up. The dorsal regions of the head, body and tail are generally slate-gray, while the skin of the undersurfaces is pink. Growth is rapid, the young gain as much as 2 g/day (14) and sexual maturity is reached at various ages. Size is not a good criterion, since most species may breed at about 40 days, even though they are still undergoing rapid growth (ASDELL, 1). HAINES (10) believes that cotton rats are sexually mature when their tail is at least 100 mm long and the hind foot at least 32 mm. BAKER (3) concludes that a cotton rat of less than 75 days is a juvenile; between 75 and 200 days, a young adult; between 200 and 300 days, an adult; and more than 300 days old, a mature adult.

MATERIAL AND METHODS

SPECIMENS: The cotton rats used in this study were bred at the Michigan State University Museum and are descendants of wild individuals caught in Mexico. The rats were killed at different ages and prepared as study specimens, segregated by sex, and then each sex group divided into eight age groups. The details of species, source locality, age groups and sample size are shown in Table 1. The prepared specimens have been deposited at the Michigan State University Museum.

TABLE 1

Number and source of laboratory-raised cotton rats used in study

Species	Locality	Specimens in each age-class								
		1 d.	10 d.	20 d.	30 d.	40 d.	50 d.	100 d.	adult	total
S. hispidus	Nayarit: 27 km SE Tuxpán	7	6	6	4	8	6	6	27	70
S. alleni	Oaxaca: 13 km SSW Juchatengo	6	9	6	4	5	9	6	33	78
S. fulviventer	Chihuahua: Gallego	3	3	2	—	4	6	5	30	53
	Durango: 11 km NNE Boquilla	10	3	1	5	2	5	1	30	57
	Durango: 9 km NNW Canatlán	—	—	4	3	2	—	—	32	41
	Durango: Hda. Coyotes	6	6	3	3	2	5	6	29	60
	Guanajuato: 8 km SW Ibarra	6	9	8	8	9	5	6	20	71
	Jalisco: 2 km NW La Barca	6	6	6	7	7	6	5	25	68
S. leucotis	Durango: Hda. Coyotes	4	5	2	—	2	—	3	31	47
S. ochrognathus	Durango: 3 km NE Boquilla	6	5	6	—	5	6	6	31	65

MEASUREMENTS: External measurements for this study (length of the body, tail, and hind foot) were recorded from the specimen labels. All other measurements were taken with a vernier caliper to an accurancy of 0.1 mm. A total of 610 specimens were studied and grouped as shown in Table 1.

Brief descriptions of the measurements taken are as follows: Length of the body, the total length of the rat from tip of nose to end of tail (not including the hairs), minus the length of the tail; length of the tail, distance from upper base of tail to tip, not including the hairs; length of hind foot, left hind foot from heel to end of middle claw. These external measurements were then used to: a) determine the similarities and differences in measurements between males and females of five species of *Sigmodon* by the Wilcoxon Matched-Pairs Signed-Ranks Test, at the 0.05 level; b) comparatively analyze the graphed growth-curves of body length, length of tail and hind foot in all species of *Sigmodon* to determine the actual total and daily increase (and percent increase) in body dimensions during the first 200 days of life.

The mean for the various measurements in each age-group was used in all statistical calculations.

OBSERVATIONS

SEXUAL DIMORPHISM: To determine whether secondary sexual dimorphism occurs (at least in the population samples used here) the Wilcoxon Matched-Pairs Signed-Ranks Test was applied (Table 2). This method was used to determine significant differences between the sex-groups, even though sample sizes were small in some groups. *Sigmodon hispidus* showed significant sexual difference at the 0.05 level in body length (CHIPMAN, 5; MCINTIRE, 13) and in length of the hind foot. Because the sample size was small, all measurements for the following graphs and tables are based on the combined sexes.

TABLE 2

External dimensions showing significant differences between males and females in the five species of Sigmodon.

	S. hispidus	*S. alleni*	*S. fulviventer*	*S. leucotis*	*S. ochrognathus*
length of body	*	—	—	—	—
length of tail	—	—	—	—	—
length of hindfoot	*	—	—	—	—

* significant difference.

COMPARATIVE GROWTH OF EXTERNAL DIMENSIONS: In the ontogeny of the cotton rat it was found that the rate of growth may be divided in all species into three distinct age periods: 1-40 days; 41-100 days; 100 days to adulthood. In the first period, growth is rapid; in the second it is reduced, and in the third growth almost ceases.

Average and extreme measurements for each age-group of each species are listed in Table 3. Some irregularities in these measurements reflect actual

differences in size between animals of the same age (especially in *S. leucotis*) due probably to the small number of specimens in some age-groups, the possible shrinkage after death of some individuals, and human error in taking the measurements. However, in Figs. 2 to 4 these irregularities are "smoothed-out" in an effort to present what is suspected to be normal growth patterns.

BODY LENGTH: These curves (Fig. 2) rise steeply from the first day to nearly 100 days of age. There is rapid growth to about 40 days, but between 40 and 100 days, the rate for most species is slower. From 100 days to the adult stage, the increase in body length is practically insignificant in all species, with the exception of *S. hispidus,* whose rate of growth apparently continues steadily throughout life. *Sigmodon hispidus* has the greatest body length of all the cotton rats studied, although *S. fulviventer* equals it in growth during the first 40 days. Body growth in *S. alleni* is similar in the first 10 days to that of *S. leucotis* and *S. ochrognathus,* but after ten days, the rate of growth of *S. alleni* increases and equals that of *S. fulviventer.* Growth in *S. leucotis* and the smaller *S. ochrognathus* is similar.

Sigmodon hispidus (Table 4) at 40 days of age has reached 70.6 percent and at 100 days 86.8 percent of the adult body size. *Sigmodon alleni* and *S. fulviventer* at 40 days reach respectively 41.5 and 50.6 percent of their full growth; at 100 days they reach 95.1 and 95.6 percent, respectively. This indicates that *S. fulviventer* grows more rapidly than *S. alleni* up to 40 days, but from 40 to 100 days the reverse is true, with *S. alleni* surpassing *S. fulviventer* in growth rate (19.5 and 13.0 percent respectively). A similar reversal is noted between the smaller *S. leucotis* and *S. ochrognathus.* The highest daily growth rate was achieved in the first 40 days (1.35 mm per day in *S. leucotis* to 2.2 mm per day in *S. hispidus*); the lowest was in the age period between 100 and 200-400 days.

TAIL LENGTH: The tail (Fig. 3) exhibits the same growth pattern as does the body, in that during the first 40 days it increases rapidly in length, but after this age, the rate of growth decreases abruptly. The longest tail at all ages is found in *S. hispidus* with *S. alleni* second. However, the tail of the latter has a similar growth pattern to that of *S. fulviventer.* Growth in tail length of *S. ochrognathus* is intermediate between *S. fulviventer* and *S. leucotis.* The latter species has the shortest tail.

The tail of the five species of cotton rats reaches, at the age of 100 days, 85.1 percent (*S. leucotis*) to 99.0 percent (*S. hispidus*) of its complete growth. Likewise, the greatest percentage of growth occurs during the first 40 days, as does the greatest daily growth rate (1.98 mm per day in *S. hispidus*).

HIND-FOOT LENGTH: The hind foot (Fig. 4) also grows rapidly during early life. After reaching its maximum at 40 days of age, there is no significant growth. *Sigmodon leucotis* has the smallest hind foot at all ages, except in the one day group, and *S. hispidus* has the largest. Hind-foot growth in *S. fulviventer* is similar to that in *S. alleni,* while that of *S. ochrognathus* and *S. leucotis* is the smallest. The hind-foot length reaches adult size by the time the cotton rat

TABLE 3

Average and extreme measurements of the five species of Sigmodon *in eight age classes*

	Age-classes (in days)							
	1 d.	10 d.	20 d.	30 d.	40 d.	50 d.	100 d.	Adult
Sigmodon hispidus								
Length of body	55.6 48-61	86.7 83-91	110.0 89-118	129.8 122-135	143.8 132-157	150.3 140-161	176.8 165-207	203.7 173-217
Length of tail	37.3 30-43	66.5 62-75	86.6 73-97	112.8 100-120	116.6 108-128	122.0 110-129	129.0 100-150	130.3 100-139
Length of hind foot	14.6 13-16	23.8 23-25	29.8 27-31	34.3 31-36	36.4 34-39	37.0 36-39	39.2 38-42	40.9 37-43
Sigmodon alleni								
Length of body	55.2 48-63	78.8 65-91	103.7 99-107	117.5 104-132	122.3 116-135	126.4 123-138	153.8 143-160	161.7 143-183
Length of tail	32.0 29-36	61.9 52-70	81.8 78-86	92.8 81-102	96.8 89-109	99.4 98-117	117.5 113-121	119.6 88-122
Length of hind foot	12.5 12-13	22.1 20-25	26.5 23-28	28.5 26-30	30.0 28-32	30.7 30-33	32.3 31-33	32.3 30-35

Sigmodon fulviventer								
Length of body	53.5	88.4	110.9	128.0	137.4	141.4	159.0	165.8
	48-64	78-97	98-122	124-154	117-157	122-156	138-188	140-186
Length of tail	33.6	60.7	77.8	91.6	96.0	99.0	106.3	109.7
	27-40	56-68	66-84	72-105	76-113	79-107	82-126	86-133
Length of hind foot	13.3	22.4	27.1	30.2	31.4	32.3	32.7	33.3
	11-15	20-25	26-30	28-35	29-34	27-34	28-36	27-35
Sigmodon leucotis								
Length of body	57.8	79.0	93.0	—	112.0	—	141.0	153.9
	55-62	76-80	88-98	—	111-113	—	132-149	140-169
Length of tail	32.0	47.5	64.0	—	80.0	—	86.0	101.1
	30-36	47-48	60-68	—	80	—	69-96	87-117
Length of hind foot	14.0	20.0	23.0	—	25.5	—	27.3	30.2
	13-15	19-21	23	—	25-26	—	27-28	28-31
Sigmodon ochrognathus								
Length of body	52.00	75.2	96.3	—	128.4	131.7	138-8	150.0
	49-55	73-80	84-104	—	123-131	116-137	130-149	141-175
Length of tail	32.8	59.2	65.3	—	102.0	102.3	102.5	103.8
	31-34	56-61	45-73	—	99-109	94-105	83-120	64-113
Length of hind foot	12.8	19.6	24.8	—	28.0	28.8	29.0	30.7
	12-13	18-20	23-26	—	27-31	28-29	29-30	26-32

TABLE 4

Analysis of growth rates in cotton rats as shown by measurements of the length of the body, tail, and hind foot of different age classes

Species	Age-Groups	X. body length	% body length	Incr. of %	Incr. in mm/d.	X. tail length	% tail length	Incr. of %	Incr. in mm/d.	X.H-F length	% H-F length	Incr. of %	Incr. in mm/d.
S. hispidus	1 day	55.6	27.3	—	—	37.3	28.6	—	—	14.6	35.7	—	—
	40 d.	143.8	70.6	43.3	2.20	116.6	89.5	60.9	1.98	36.4	89.0	53.3	0.54
	100 d.	176.8	86.8	16.2	0.55	129.0	99.0	9.5	0.22	39.2	95.9	6.9	0.04
	adult	203.7	100.0	13.2	0.27	130.3	100.0	1.0	0.01	40.9	100.0	4.1	0.02
S. alleni	1 day	55.2	34.1	—	—	32.0	26.8	—	—	12.5	38.7	—	—
	40 d.	122.3	75.6	41.5	1.67	98.8	82.6	55.8	1.67	30.0	92.9	54.2	0.43
	100 d.	153.8	95.1	19.5	0.52	117.5	9 8.2	15.6	0.31	32.3	100.0	7.1	0.04
	adult	161.7	100.0	4.9	0.08	119.6	100.0	1.8	0.02	32.3	00.0	0.0	0.00
S. fulviventer	1 day	53.5	32.3	—	—	33.6	30.6	—	—	13.3	39.9	—	—
	40 d.	137.4	82.9	50.6	2.09	96.0	87.5	56.9	1.56	31.4	94.3	54.4	0.45
	100 d.	159.0	95.9	13.0	0.21	106.3	96.9	9.4	0.17	32.7	98.2	3.9	0.02
	adult	165.8	100.0	4.1	0.16	109.7	100.0	3.1	0.03	33.3	100.0	1.8	0.01
S. leucotis	1 day	57.8	37.6	—	—	32.0	31.7	—	—	14.0	46.4	—	—
	40 d.	112.0	72.8	35.2	1.35	80.0	79.1	47.4	1.20	25.5	84.4	38.0	0.28
	100 d.	141.0	91.6	18.8	0.48	86.0	85.1	6.0	0.10	27.3	90.4	6.0	0.03
	adult	153.9	100.0	8.4	0.13	101.0	100.0	14.9	0.15	30.2	100.0	9.6	0.03
S. ochrognathus	1 day	52.0	34.7	—	—	32.8	31.6	—	—	12.8	41.7	—	—
	40 d.	128.4	85.6	50.9	1.91	102.0	98.3	66.7	1.73	28.0	91.2	49.5	0.38
	100 d.	138.8	92.5	6.9	0.17	102.5	98.7	0.4	0.01	29.0	94.5	3.3	0.02
	adult	150.0	100.0	7.5	0.11	103.8	100.0	1.3	0.01	30.7	100.0	5.5	0.03

is 100 days old (94.5 percent in *S. ochrognathus* and 100 percent in *S. alleni*). The daily growth-rate in this age period varied between species from 0.28 to 0.54 mm per day and was practically nil in older animals.

DISCUSSION

Cotton rats exhibit two phases of growth. From 1 to 40 days most species of *Sigmodon* present rapid growth in all body dimensions. During this generalized phase of growth the increase in body dimensions is almost doubled (more than 80 percent). The second phase of growth takes place from 40 days to the adult stage, and may be divided into two different growth types. The first, from 40 to 100 days, results in a more uniform increase in all the dimensions studied, and in most species of cotton rats adulthood is reached during this time. The second growth type is from 100 days on, characterized by a gradual cessation of growth. HOFFMEISTER (11) demonstrated that there is little or no further increase in the total body and tail length in *S. ochrognathus* after 100 days. LAYNE (12) showed that *Peromyscus floridanus* reaches 92 percent of the adult size by the eighth week. The same is true for *S. hispidus* (15) as the growth of the individual cotton rats is fairly constant through the first 50 days of life, decreasing somewhat between 50 and 100 days and tapering off after 100 days of age. DICE and BRADLEY (7) studied *Peromyscus maniculatus* and determined that these deer-mice grow rapidly in all body dimensions until they are 6 weeks old. They also noted that the slowing down of the growth rate after 4 to 6 weeks is correlated with approaching sexual maturity. MEYER (14) has demonstrated that female cotton rats have their first estrum between 20 and 30 days and that in males, testes descend to the scrotum at the same time. These ages of attaining sexual maturity correspond with the age at which the young change from a higher (1-40 days) to a much lower rate of growth (40-100 days). The slopes of the growth curves demonstrated that not all species of *Sigmodon* grow equally rapidly. The growth curves of the two smaller species, *S. ochrognathus* and *S. leucotis* begin to flatten out at an earlier age (20 days) than those of the largest species, *S. hispidus* (40-50 days). Those species that are intermediate in size, *S. alleni* and *S. fulviventer,* begin to reduce their rate of growth at an age which is somewhat intermediate, between 30 and 40 days of life (Figs. 2, 3, 4).

Whereas, according to DICE and BRADLEY (7), "...races of deer-mice that are relatively larger or relatively smaller in any dimensions at birth tend to retain these size relationships as they grow to adult size", cotton rats show a different pattern of growth. The smaller *S. leucotis* and *S. ochrognathus,* are the largest at birth but are soon exceded in size by the other three species (Figs. 2, 3, 4).

CLARK (6) mentions that ratios between body measurements indicate that the species of *Peromyscus* differ greatly in body proportions. Likewise, the five *Sigmodon* species also show marked differences in the comparative growth of their different body dimensions. The sample of *S. hispidus* used in this study (*S. hispidus major* from near Tuxpan, Nayarit) represents one of the largest

species (BAILEY, 2). *Sigmodon fulviventer* populations present interesting patterns of growth in that there is a decline in over-all size from north to south (Chihuahua to Jalisco). The average for the various measurements and the growth rates of *S. fulviventer* are closely comparable to those of *S. alleni.* The patterns of growth of the smaller *S. leucotis* and *S. ochrognathus* are different from the above mentioned, but again, similar to each other. These relationships between *S. alleni* and *S. fulviventer* on the one hand, and *S. leucotis* and *S. ochrognathus* on the other, are related in a general sense to environmental conditions. *Sigmodon alleni* and *S. fulviventer* live on deep soils covered with grass and brush. *Sigmodon leucotis* and *S. ochrognathus* live on shallow soils, on rocky slopes covered with bunch grass and some shrubs.

FOX (8), in studies with subspecies of *Peromyscus maniculatus* has demonstrated a direct relationship between tail length and environmental conditions: animals with longer tails live in forested areas, while those with shorter tails live in open areas. The hind feet do not vary. *Sigmodon hispidus, S. alleni* and *S. fulviventer* have the longest tails and hind feet of all the species studied and live on deep soils with grass-shrub cover. *Sigmodon leucotis* and *S. ochrognathus,* with the shortest tails and hind feet, inhabit shallow soils, often covered with sparse bunch grass. Possibly, the short tail, as well as the small size are of survival value to cotton rats living in sparse overhead cover, especially for avoiding avian predators (hawks and owls) which locate their prey from above by keen eye-sight.

Comparison of the growth data of *S. hispidus* from Tuxpan (Nayarit) with that given by other authors for the same species, but from different localities, shows that the Tuxpan specimens are the largest. They are also much larger than any of the other species of cotton rats represented in the present study.

The growth data of the *fulviventer* group suggest the separation of the four species into two categories: *S. alleni* and *S. fulviventer,* showing the larger dimensions as adults; and *S. leucotis* and *S. ochrognathus* showing the smaller. As BAKER (3) has pointed out, *S. leucotis* and *S. ochrognathus* may have separated earlier from the ancestral stock of *S. hispidus* than *S. alleni* and *S. fulviventer.* This earlier separation may account for the great amount of distinctive variation in body features found in both species. The size and proportions shown by *S. alleni* and *S. fulviventer,* however, indicate a closer relationship to *S. hispidus.*

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SUMMARY

A comparative study of five species of cotton rats (*Sigmodon*) was carried out to diagnose similarities and differences in external morphology. These animals (a total of 610 individuals) were descendants of wild cotton rats from various localities in Mexico.

The growth rate of body dimensions can be divided into three categories: from 1 to 40 days there is a rapid increase in length in all body dimensions; from 41 to 100 days the increase is moderate and from 101 days to adulthood (200-400 days) there is practically no growth.

Regarding size, the five species can be divided into three groups: *S. hispidus* was represented by a population sample having large measurements and was the largest cotton rat studied. *Sigmodon alleni* and *S. fulviventer* were smaller and showed parallel growth rates. *Sigmodon leucotis* and *S. ochrognathus* were the smallest and showed similar patterns of growth. The differences found indicate that *S. leucotis* and *S. ochrognathus* are perhaps more remote from the supposed parent stock (presumably resembling *S. hispidus*). *Sigmodon alleni* and *S. fulviventer,* on the other hand, appear similar to *S. hispidus* in morphological development and thereby more closely related.

When comparing morphological characteristics with the preferred habitats of the species, it was found that, whereas the three larger species prefer deep soils and abundant grass or shrub cover, the smaller and shorter-tailed species (*S. leucotis* and *S. ochrognathus*) live usually on shallow rocky soils on sparsely-vegetated slopes, suggesting survival patterns.

RESUMEN

En un estudio comparativo de la morfología externa de las cinco especies reconocidas del género *Sigmodon* se utilizaron 610 ratas algodoneras, nacidas en el laboratorio del Museo de la Universidad del Estado de Michigan. Estos roedores, descendientes de individuos capturados en varias localidades de México, fueron matados a intervalos predeterminados (1, 10, 20, 30, 40, 50, 100, y 200 a 400 días de nacidos). El crecimiento post-natal fue determinado haciendo relaciones entre las medidas externas (longitud del cuerpo, longitud de la cola y longitud de la pata trasera). Se encontró dimorfismo sexual secundario en *Sigmodon hispidus,* pero sin que fuera estadísticamente representativo debido al tamaño reducido de algunas muestras.

La longitud del cuerpo aumenta rápidamente durante los primeros 40 días de vida. De los 41 a los 100 días, este crecimiento se torna más lento, y prácticamente se detiene entre los 100 días y el estado adulto (200+ días). *Sigmodon hispidus* resultó ser la especie con individuos de mayor tamaño, y *S. leucotis* y *S. ochrognathus* los más pequeños. En todas las especies la longitud de la cola y de la pata trasera alcanzó su máximo desarrollo durante los primeros 40 días, correspondiendo el mayor tamaño a *S. hispidus* y el menor a *S. leucotis.*

Al nacer, *S. leucotis* y *S. ochrognathus* son de mayor tamaño que las otras tres especies. Sin embargo, éstas tienen una tasa de crecimiento más rápida, y a los pocos días los alcanzan y los sobrepasan en tamaño.

Ecológicamente, las tres especies de ratas algodoneras de mayor tamaño, *S. hispidus, S. alleni* y *S. fulviventer,* están asociadas con suelos profundos cubiertos por hierbas abundantes y matorrales. Las otras dos (*S. leucotis* y *S. ochrognathus*) prefieren suelos poco profundos en laderas rocosas de escasa vegetación. Su cola corta y el tamaño pequeño parecen tener un valor de sobrevivencia muy alto debido a la poca protección que tienen en su habitat natural.

Sigmodon leucotis y *S. ochrognathus* muestran patrones de crecimiento tan diferentes de los de las otras tres especies que se les podría considerar como un grupo separado. Suponiendo que las cinco especies de ratas algodoneras tuvieran un ancestro común, tipo *hispidus,* las características morfológicas encontradas en las primeras dos parecen indicar que éstas se separaron del vástago ancestral en un tiempo quizás más remoto, pues *S. alleni* y *S. fulviventer* poseen características de desarrollo más cercanas a las de *S. hispidus.*

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Fig. 1. Map showing the approximate sites of collection of the species of *Sigmodon.* 1. Tuxpan, Nayarit; 2. Juchatengo, Oaxaca; 3. La Barca, Jalisco; 4. Canatlán, Durango; 5. Coyotes, Durango; 6. Boquilla, Durango; 7. Gallego, Chihuahua; 8. Ibarra, Guanajuato.

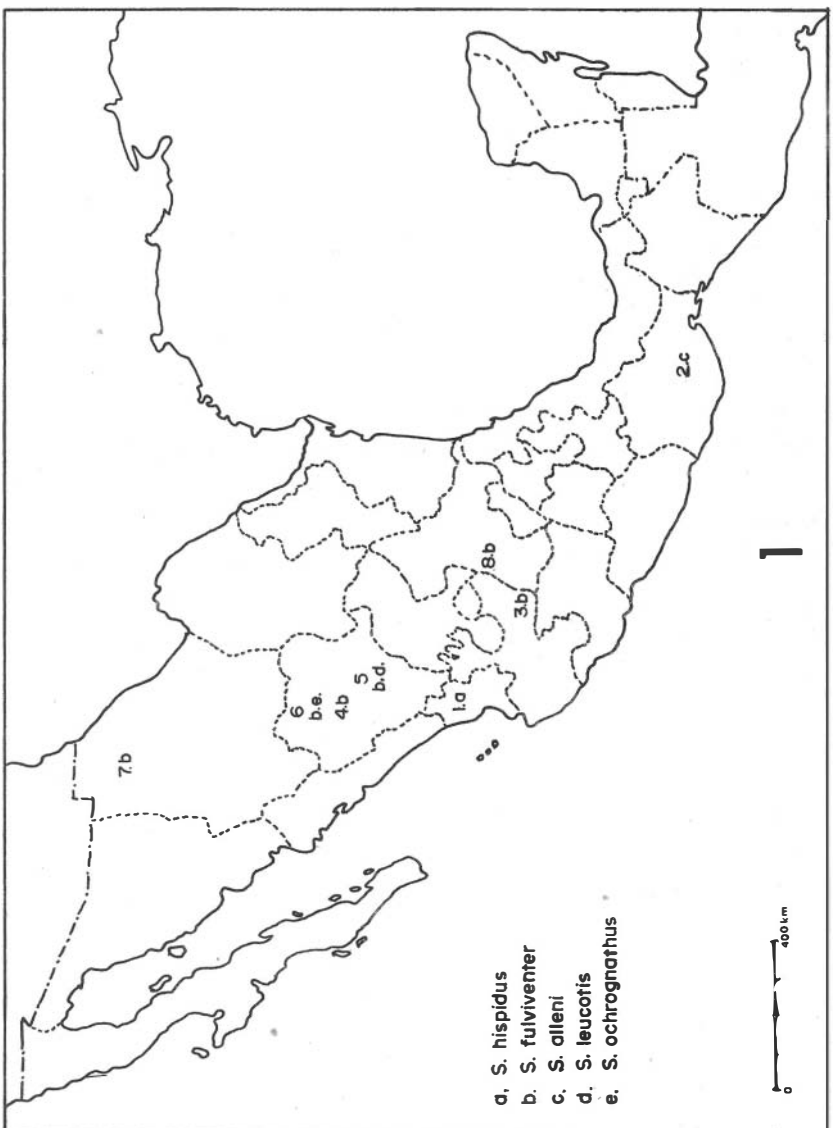
a. S. hispidus
b. S. fulviventer
c. S. alleni
d. S. leucotis
e. S. ochrognathus
0
400 km
7.b
6
b.e.
4.b
5
b.d.
1.a
8.b
3.b
2.c

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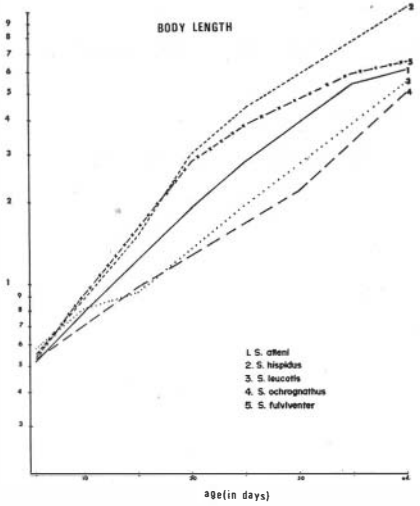
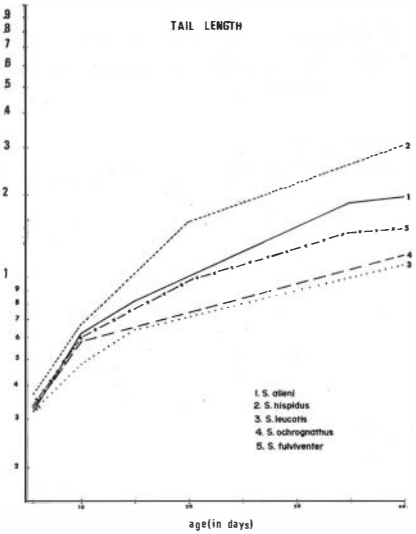
Fig. 2. Body length curves for all the five *Sigmodon* species studied.

Fig. 3. Tail length curves for all the five *Sigmodon* species studied.

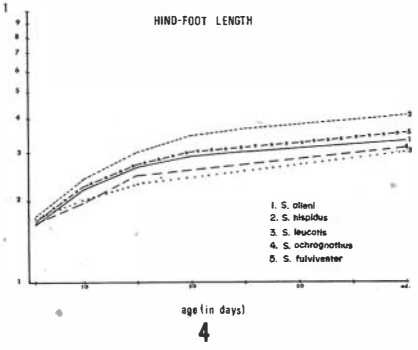
Fig. 4. Hind-foot length curves for all the five *Sigmodon* species studied.


BODY LENGTH
1. S. alleni
2. S. hispidus
3. S. leucotis
4. S. ochrognathus
5. S. fulviventer
age(in days)

2


TAIL LENGTH
1. S. alleni
2. S. hispidus
3. S. leucotis
4. S. ochrognathus
5. S. fulviventer
age(in days)

3


HIND-FOOT LENGTH
1. S. alleni
2. S. hispidus
3. S. leucotis
4. S. ochrognathus
5. S. fulviventer
age (in days)

4

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