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Peromyscus gossypinus.

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Peromyscus gossypinus (Le Conte, 1853)

Cotton Mouse

Hesperomys gossypinus Le Conte, 1853:411. Type locality near Riceboro, Liberty Co., Georgia (Bangs, 1896:123).

Peromyscus gossypinus Rhoads, 1896:189.

CONTEXT AND CONTENT. Order Rodentia, Family Muridae, Subfamily Cricetinae, Subgenus *Peromyscus*, Species-group *leucopus* (Osgood, 1909; Hooper and Musser, 1964; Hooper, 1968). Seven subspecies were recognized by Hall and Kelson (1959), as follows:

P. g. gossypinus (Le Conte, 1853), see above.

P. g. megacephalus (Rhoads, 1894:254). Type locality Woodville, Jackson Co., Alabama.

P. g. palmarius Bangs, 1896:124. Type locality Oak Lodge, East Peninsula, Brevard Co., Florida.

P. g. anastasae (Bangs, 1898:195). Type locality Anastasia Island, St. Johns Co., Florida.

P. g. restrictus Howell, 1939:364. Type locality Chadwick Beach, Englewood, Sarasota Co., Florida.

P. g. allipaticola Schwartz, 1952:383. Type locality Key Largo, Monroe Co., Florida.

P. g. telmaphilus Schwartz, 1952:384. Type locality Royal Palm Hammock, Collier Co., Florida.

DIAGNOSIS. The diagnostic characteristics of the subgenus *Peromyscus* will serve to distinguish *P. gossypinus* from some other members of the genus. These characteristics include six plantar tubercles, six mammae, total length generally less than 250 mm, outer accessory tubercles or loops of m1 and m2 only slightly developed, and a male reproductive tract that lacks developed preputial glands. Within the subgenus *Peromyscus* a precise diagnosis is difficult because the uniqueness of this species is based mostly on a combination of quantitative, rather than qualitative differences.

Other species of *Peromyscus* occurring within or adjacent to the range of *P. gossypinus* are *P. floridanus*, *P. polionotus*, *P. maniculatus*, and *P. leucopus*. *P. gossypinus* can be distinguished from *P. floridanus* by the six plantar tubercles on each hind foot. *P. floridanus* (subgenus *Podomys*) has five plantar tubercles. Adult *P. polionotus* can readily be differentiated by their smaller size. Sympatric races of *P. maniculatus* (*nubiterrae* and *bairdi*) also have decidedly smaller body sizes and, unlike *P. gossypinus*, they normally have sharply bicolor tails.

The greatest difficulties have arisen in distinguishing *P. leucopus* and *P. gossypinus*. These two species are not well differentiated and are interfertile under laboratory conditions. Hybrids between the two species have been obtained through captive breeding (Dice, 1937), and naturally occurring hybrids have been reported in Virginia (Dice, 1940), Alabama (Howell, 1921) and Texas (McCarley, 1954*a*). The authors are of the opinion that natural hybridization between *P. leucopus* and *P. gossypinus* rarely occurs. Keys in general use distinguish *P. gossypinus* on the basis of hind foot length greater than 22 mm and skull length greater than 28 mm. Studies in Alabama have shown that specimens showing intermediate (or "hybrid") skull or hind foot lengths can be distinguished by other, perhaps more critical criteria such as length and width of the anterior palatine foramina (Linzey *et al.*, 1976). It is generally stated that ecological displacement between the two species occurs (McCarley, 1954*b*, 1963), although both taxa may be taken side by side in some habitats (Linzey and Linzey, 1968). The possibility of ethological isolation is a promising area of study (McCarley, 1964).

GENERAL CHARACTERISTICS. This medium-sized rodent is dark golden-brown above. A dusky middorsal area extends from the shoulders to the base of the tail. The underparts are white, as are the feet. The sparsely-haired tail is shorter than the head and body, dark above, and fading to white or off-white below. Adult measurements (in mm) from the literature are: total length, 142 to 206; body length, 71 to 116; tail length, 55 to 97; hind foot length, 16 to 26; ear length, 10 to 21. Weight is 17 to 46 g.

The skull has been described by Osgood (1909). It does not differ greatly from the skulls of other species of *Peromyscus*, although it is larger and heavier than those of other species in the eastern United States. The overall length of skull generally exceeds 27 mm.

Three of the seven subspecies currently recognized (*allapaticola*, *anastasae*, and *restrictus*) are known only from the type localities in Georgia and Florida, and *telmaphilus* is restricted to extreme southern Florida. The remaining three subspecies (*palmarius*, *gossypinus*, and *megacephalus*) occupy most of the range of the species. There is marked variation in size between specimens from northern (*megacephalus*) and southern (*palmarius*) portions of the range. Any re-evaluation of this species should consider the possibility that these size differences are clinal in nature.

PALEONTOLOGY. Pleistocene fossils of cotton mice have been reported from Marion and Brevard counties in Florida (Ray, 1958; Gut and Ray, 1963) and Denton County, Texas (Crook and Harris, 1958).

DISTRIBUTION. The geographic range of the species extends northward from the Gulf of Mexico to southeastern Virginia and southern Illinois, and westward from the Atlantic Ocean to eastern Texas and southeastern Oklahoma. There seems to be a hiatus in the southern Appalachians (figure 1).

FORM. Information on the gross anatomy of *Peromyscus* has been summarized by Klingener (1968).

The pelage of adult *P. gossypinus* from Alabama has been described by Batson (1958). It is composed of two types of hair, a heavy growth of short hair that covers most of the body surface, and a lesser growth of long black hair concentrated on the middorsum. Individual hairs of the dorsal surface are gray at the base and have brown tips. Ventral hairs are also gray basally, but have a broad white distal band. According to Batson (1958), the pelage tends to be paler in spring and summer than in autumn and winter.

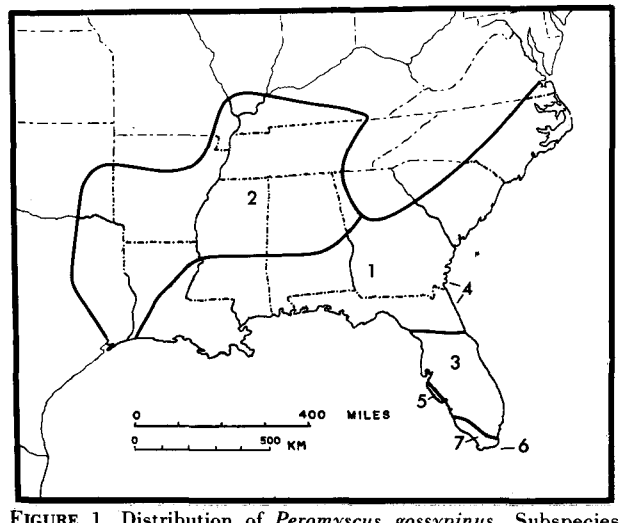

FIGURE 1. Distribution of *Peromyscus gossypinus*. Subspecies (after Hall and Kelson, 1959) are: (1) *P. g. gossypinus*, (2) *P. g. megacephalus*, (3) *P. g. palmarius*, (4) *P. g. anastasae*, (5) *P. g. restrictus*, (6) *P. g. allipaticola*, and (7) *P. g. telmaphilus*.

FIGURE 2. *Peromyscus gossypinus* from Monroe County, Mississippi.

Dentition of *P. gossypinus* is i 1/1, c 0/0, 0/0, 3/3, total 16. Bader (1959) examined accessory dental structures (lophs and styles) of *P. gossypinus* from Florida and found that the mesostyle, mesostylid, and mesoloph were present in all, or nearly all, the specimens he examined. He observed that the mesoloph arises from the mure, whereas the mesolophid and ectolophid originate from the entoconid and hypoconid, respectively (figure 4). Accessory structures of the lower molars were more common on the lingual side than on the labial side.

In comparing the climbing ability of *P. gossypinus* and *P. floridanus*, Layne (1970) attributed the greater climbing ability of *P. gossypinus* to a greater development of the plantar tubercles. Plantar tubercles on the hind foot represented 47% of the hind foot length in *P. gossypinus* as compared to 26.5% in *P. floridanus*. Siegal and Van Meter (1973) studied the skeletal structure of the hind foot in the two species and considered features of the *P. gossypinus* hind foot to be arboreal adaptations related to a greater prehensile use of the foot.

The only system of the internal anatomy of *P. gossypinus* that has been studied extensively has been the male reproductive tract. The baculum (os penis) of this species was described by Blair (1942) and Burt (1960). It is a rodlike structure with a laterally expanded basal portion that tapers abruptly to a slender shaft. Blair (1942) found that the greatest basal width averaged 1.4 mm, and that overall mean length was 10.8 mm. The shaft of the baculum in *P. gossypinus* is "nearly straight or slightly curved," and the base is slightly concave above and convex below (Burt, 1960). It is, on the average, longer and broader than that of *P. leucopus*.

Hooper (1958) compared the glans penis in a number of species of *Peromyscus*, including *P. gossypinus*. The remaining structures of the male reproductive tract in *P. gossypinus* have been studied by Linzey and Layne (1969). The accessory gland complement includes a single pair each of ampullary, vesicular, anterior and dorsal prostates, bulbo-urethral, and two pairs of ventral prostates. Although not grossly discernible, vestigial preputial glands are also present.

Hirth (1960) and Linzey and Layne (1974) described the spermatozoa of *P. gossypinus*. The sperm head is oblong and bears a recurved "hook." Its average width is 2.9 microns and its length is 5.4 microns. The midpiece attaches to one side of the head and is about 17.3 microns long, whereas the tail piece averages 63.4 microns in length.

FUNCTION. The scant literature on endocrinology of *Peromyscus* has been reviewed by Eleftheriou (1968).

The hematology of *Peromyscus gossypinus* from Louisiana has been studied by Gough and Kilgore (1964). Data obtained included red blood cell count, hemoglobin concentration, white blood cell count, hematocrit, mean corpuscular hemoglobins, and mean corpuscular hemoglobin concentrations.

Foreman (1968) studied the ionographic properties of hemoglobins from ten species of *Peromyscus*, including *P. gossypinus*. Three different true-breeding phenotypes were found to be present in *P. gossypinus* studied, although additional phenotypes had been reported in an earlier paper (Foreman, 1966). Normally, only two hemoglobin phenotypes are present in *P. leucopus*.

Glenn (1970) compared water relations in two xeric-adapted species of *Peromyscus* (*floridanus* and *polionotus*) and mesic-adapted *P. gossypinus*. The latter shows the greatest

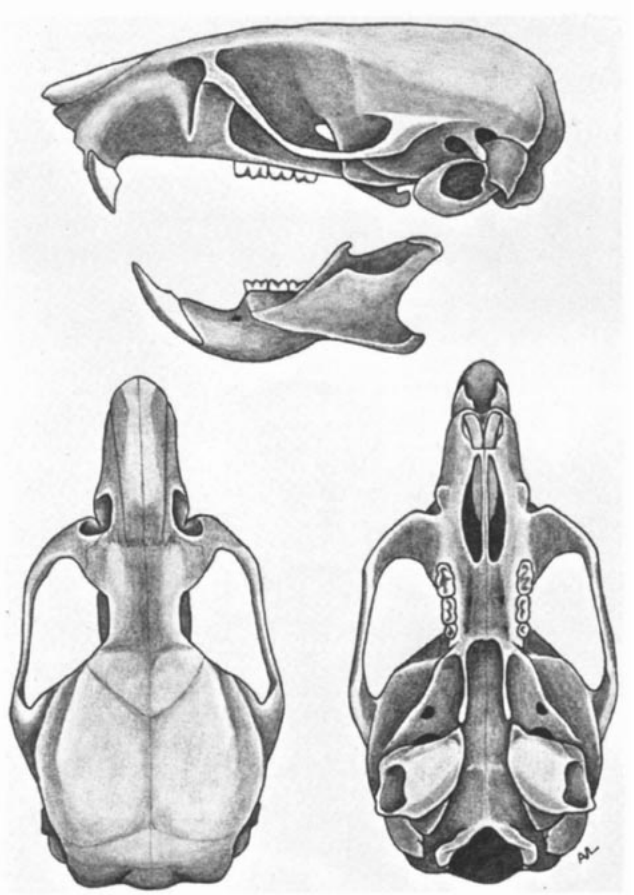

FIGURE 3. Skull of *Peromyscus gossypinus*, Univ. South Alabama no. 315, male, Mobile County, Alabama. Skull length, 27 mm.

variability in regulating water turnover and poorest tolerance of water deprivation in terms of mean survival time. The basal metabolic rate of nine individuals with an average weight (grams) of 21.5 ± 1.58 was 1.72 ± 0.13 cm^3 O_2/g per hour.

McCarley (1959) described the effects of irradiation on the population dynamics of *P. gossypinus* and *Ochrotomys nuttalli* in Texas. Male mice were treated with 500 r of x-irradiation administered to the testes, and released back to the population. Evidence obtained from subsequent study of the treated population indicated that the reproductive rate was decreased through a decline in the number or size of litters, life spans of presumed offspring of irradiated males were significantly shorter than life spans of presumed offspring of normal males, and the irradiated population exhibited a larger incidence of pelage color mutation.

ONTOGENY AND REPRODUCTION. Except as noted, the information that follows is taken from a study of reproduction and post-natal development of *P. gossypinus* in northern Florida by Pournelle (1952).

In Florida, this species breeds throughout the year although there is a decline in reproductive activities during the summer months. Pournelle found that male cotton mice kept at temperatures between 31.7°C and 38.3°C were not in breeding condition, but that individuals kept at 20.6°C to 28.9°C were able to breed. Females apparently produce litters in succession during the breeding season, with a peak in breeding activity in late autumn and early winter in Florida.

The average length of the estrous cycle is 5.26 days. The gestation period of nonnursing females is approximately 23 days. A postpartum estrous occurs, and the gestation period of one nursing female was lengthened to 30 days. Litter size ranges from one to seven; 72 litters averaged 3.7 young.

Information on reproduction in other parts of the range is scarce. In Texas, as in Florida, breeding extends throughout the year and activity declines during the months of July, August, and September (McCarley, 1954c). In the Great Smoky Mountains of Tennessee and North Carolina, two females

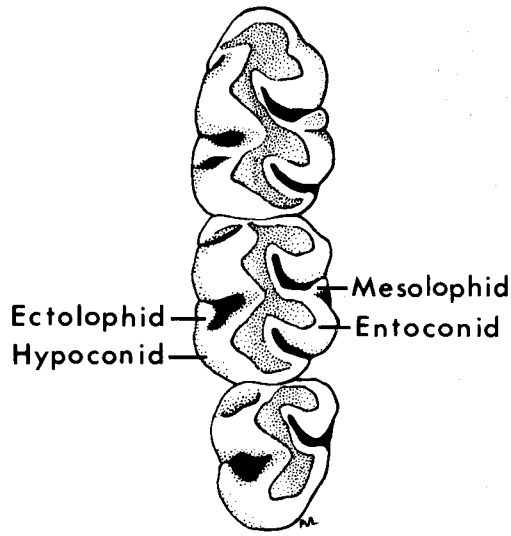

FIGURE 4. Left lower molars of *Peromyscus gossypinus*, Univ. South Alabama no. 396, female, Mobile County, Alabama. Toothrow length, 4.5 mm.

taken on 4 March each contained three embryos (Linzey and Linzey, 1968). In the same study, a nursing female (placental scars 1R, 2L) was recorded on 26 August and males in breeding condition were examined in August, September, and October. In a study by Linzey (1970) in southern Alabama, females with embryos or placental scars were taken in February, March, May, July, September, and December. An unusually small female (118-39-17. 10.1 g), taken on 2 July, contained three embryos (0R, 3L). Juveniles were recorded in January, February, March, May, and December, and males in breeding condition were taken in February, March, June, August, September, and December.

In Pournelle's study, most litters were born during the morning hours. Newborn cotton mice are hairless except for vibrissae on the upper lip. The eyes are closed, the pinnae folded over and sealed, and the incisors have not erupted. By day 5, fine hairs cover the dorsum, although the abdomen is still hairless. The pinnae become erect at about day 4, and by day 7 the incisors have erupted. By day 10, animals are fully haired, appear alert, and react to noises. Most individuals open their eyes between days 12 and 14. Weaning of most litters occurs by the third or fourth week. Most individuals begin the first developmental molt between day 34 and 40. Adult pelage appears first along each side of the body, and then extends anteriorly over the shoulders and side of the face, dorsally over the back and posteriorly over the flanks. The last remnant of juvenal pelage is found above the base of the tail. Young male *P. gossypinus* have sperm in the epididymides at about 45 days of age. The earliest fertile mating of a female occurred when she was 73 days old.

Average measurements (in mm) and weight of 45 individuals at birth (percentage of adult size in parentheses) were: total length, 47.16 (26.3); tail, 10.98 (14.7); hind foot, 6.53 (28); and weight, 2.19 g (7.6). The total length doubles by day 13 and attains 83% and 93% of adult size by day 30 and day 60, respectively. Tail length doubles by day 7 and attains 83% of adult size by day 30. At day 60, the tail is 94.5% of adult size. Hind foot length doubles by day 8 and approximates adult size by day 30. A constant weight gain of .53 g per day occurs until day 30, while between days 30 and 60 weight gain averages .25 g per day.

ECOLOGY. The preferred habitat of the cotton mouse is bottomland hardwood forests, mesic and hydric hammocks, and swamps (Rhoads, 1896; Howell, 1921; Dice, 1940; Hamilton, 1943; Ivey, 1949; Pournelle, 1950; Pearson, 1953, 1960; McCarley, 1954*b*, 1963). It has also been reported in varying numbers in the margins of cleared fields, edges of salt savannah, palmetto thickets bordering beaches (Bangs, 1896), dry hammocks, beach dunes, and pine flatwoods (Ivey, 1949; Pournelle, 1950; Layne, 1974), upland timber (Howell, 1921), mixed pine-hardwood forests (Shadowen, 1963; Stephenson, *et al.* 1963), pine-turkey oak, and sand pine scrub (Layne, 1970). Gentry *et al.* (1968) found no significant differences in numbers in lowland hardwood swamps, upland forests, and old fields. Calhoun (1941) found the species to be most common in areas subject to annual inundation, and several authors (Pearson, 1953; McCarley, 1959) have reported on its responses to periodic flooding. Howell (1921) and Kellogg (1939) noted that cotton mice frequently are found along rocky bluffs or ledges and in caves. Cotton mice also frequent abandoned or intermittently-used buildings (Hamilton, 1943; Pearson, 1960).

Density estimates reported are as follows: .25 to 7.17 per hectare in Florida pine flatwoods (Layne, 1974), up to 3.01 per ha in Louisiana mixed pine-hardwood forests (Shadowen, 1963), 2.5 to 4.9 per ha in mixed habitats in South Carolina (Gentry *et al.*, 1968), and a high of 96.6 per ha in wet lowland forests bordering Reelfoot Lake, Tennessee (Calhoun, 1941). Populations typically reach a peak in mid- or late winter and are at their lowest in late summer. Peak densities have been reported from October to December (Pearson, 1953) in a Florida mesic hammock and December to March in Florida flatwoods (Layne, 1974). In Louisiana, Shadowen (1963) found the highest densities in January and February. Texas populations were found to peak in February and March (McCarley, 1954*c*). The highest proportions of juveniles in the population generally coincide with the times of highest density. Sex ratios from trapping studies tend to indicate a preponderance of males (Terman, 1968; Pournelle, 1950; Layne, 1974).

Longevity of individuals in the field is generally short. In flatwoods habitat, Layne (1974) reported an average of 1.7 months and a maximum of five months. McCarley, working in lowland forests in eastern Texas, found in one study (1954*c*) rapid turnover with no adults living through a year, and in another (1959) reported an average longevity of four to five months and a maximum of 15 months. Pearson (1953) found that 28% of a population studied in a Florida mesic hammock lived longer than 100 days, and one individual was recaptured after nearly two years.

Population regulation was attributed to climate and environmental conditions by McCarley (1954*c*), who suggested along with Pournelle (1952) that hot, dry summers severely curtail reproduction. Pearson (1953) suggested a correlation between acorn production and population levels.

Pournelle (1950) reported movements of individuals ranging up to 853 m (average for 21 males was 145 m, five females averaged 115 m). By using a line connecting the extreme capture points as the home range diameter, Shadowen (1963) reported an average area of .45 hectares and found the home range of males to be larger than that of females. McCarley (1959) examined the relationship between number of captures and home range area in the species. He found a direct relationship, with no leveling off, at his maximum of 15 captures and an area of .81 hectares. He found no significant differences between males and females. Stephenson *et al.* (1963) reported an average home range of .49 ha (inclusive boundary strip). Layne (1974), using the minimum area method, found an average home range of .18 ha in Florida flatwoods. Pearson (1953) found that home range area decreased with increasing population density. In his study, male home ranges were larger than those of females and overlapped extensively, whereas those of females were essentially exclusive. He pointed out that this was possibly related to the fact that males greatly outnumbered females in the area of study.

There is some evidence of competition with other species. The trapping data of Gentry *et al.* (1968) and Pearson (1953) suggest that *P. gossypinus* may inhibit terrestrial movements of *Ochrotomys nuttalli*. According to McCarley (1963), *P. gossypinus* may exclude *P. leucopus* from areas of favorable habitat in areas of sympatry.

P. gossypinus is an omnivore, and appears to be an opportunistic feeder (Bangs, 1896; Calhoun, 1941; Pournelle, 1950). Calhoun (1941) reported a diet of 68% animal matter and suggested that availability of items was the key factor in determining dietary composition.

Although a number of parasites have been recorded from the cotton mouse, little is known of their ecological effects on the species. Listed (with references) by Whittaker (1968) are: unidentified pentastomid larvae; two trematodes; two cestodes; one nematode; eight mites, including two trombiculid larvae; two adult ticks and unidentified *Ixodes* larvae; and eight fleas. An additional pentastomid and another nematode have been reported by Layne (1967, 1968).

BEHAVIOR. Bangs (1896) expanded a statement by Le Conte (1853) to suggest that *P. gossypinus*, has proportionally

longer front legs than *P. leucopus*, which results in a different gait. *P. gossypinus* reportedly progresses on the ground via an "even run," whereas *P. leucopus* utilizes a series of little leaps. In the absence of systematic observations, it seems likely that the terrestrial locomotion is similar to that of other members of the genus (see Eisenberg, 1968). That the species is able and predisposed to climb has been demonstrated in a number of studies. Taylor and McCarley (1963) demonstrated a clear preference for elevated nests (810 mm above ground). Layne (1970) reported that about 20% of individuals released from live traps sought refuge in trees or bushes, and demonstrated well-developed climbing ability (and tendency) in laboratory tests. Pournelle (1950) noted that the method of ascending a tree trunk was similar to that of gray squirrels. Ivey (1949) observed that cotton mice ran "about trunks and limbs with great freedom and agility." One of us (Wolfe) has live-trapped individuals 4.6 m above the ground in hardwood trees, and once found several in an abandoned gray squirrel nest 6.1 m high in a live oak.

Calhoun (1941) and Pournelle (1950) documented swimming and diving by the species, and several other studies (McCarley, 1959; Rhoads, 1896) indicate a preference for flooded or wet areas. Pournelle (1950) correctly pointed out that climbing and swimming are highly adaptive in the preferred habitat of cotton mice.

Layne and Ehrhart (1970) in a laboratory study found digging activity greater than that of *P. floridanus*, less than that of *P. polionotus*, and about equal to that of *P. leucopus*.

Behavior of females during and immediately following parturition was described by Pournelle (1952). The average time required for the birth of a litter is 55 minutes. Females lick newborn individuals clean and consume the afterbirth. Maternal care seems to be elicited in part by squeaking vocalizations of the young.

Nesting sites are in and under logs, in stumps, under brush piles and palmettos, and in moss on floating logs (Ivey, 1949; King, 1963). Various nesting materials have been noted, including palm and palmetto fibers (Ivey, 1949) and up to a pound of cotton (Le Conte, 1853). Laboratory studies on nest-building by Layne (1969) and Wolfe (1970) found nest-building tendency and nest size to be similar to these features in *P. leucopus* and greater than these in *P. polionotus* and *P. floridanus*.

In a study of homing of cotton mice, Griffo (1961) concluded that: 1) individuals tend to "home" better from natural than unnatural habitat; 2) initial orientation in unfamiliar areas is not correlated with the direct route home; 3) males do better than females in long-distance homing; 4) mice held captive for 12 weeks show no decrease in homing ability; and 5) mice upon repeated liberations can learn homing pathways. In this paper he proposed the Life Range concept and suggested that homing consists of random wandering outside the Life Range and a directed search once a familiar area is encountered.

In laboratory experiments cotton mice are strongly nocturnal. However, they exhibit more daytime activity and a higher level of general activity than does *P. floridanus* (Layne, 1971).

Details of the social behavior of cotton mice are scarce. Wright (1973) found that there was a higher agonistic interaction rate in *P. gossypinus* than in *P. leucopus*, and that the former was usually dominant in interspecific encounters. This lends weight to the contention of McCarley (1963) that *P. gossypinus* actively excludes *P. leucopus* from areas of optimum habitat. In another study of interspecific interactions with *P. leucopus*, McCarley (1964) observed species discrimination by males, suggesting behaviorial reproductive isolation.

GENETICS. Data on genetics of the cotton mouse are virtually non-existent. Cross (1938) and Hsu and Benirschke (1968) reported a diploid chromosome number of 48 and described karyotypes of *P. g. palmarius*, *P. g. gossypinus*, and *P. g. megacephalus*. The karyotypes of the latter two were reported as identical. See the section on Function for information on the inheritance of hemoglobin patterns.

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