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Galemys pyrenaicus.

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Galemys Kaup, 1829

Galemys Kaup, 1829:118. Type species *Mygale pyrenaica* Geoffroy Saint-Hilaire.

Mygalina I. Geoffroy Saint-Hilaire, *in* Gervais, 1835:45. Type species *Mygale pyrenaica* Geoffroy Saint-Hilaire.

Galomys Agassiz, 1846:159. Emendation of *Galemys*.

CONTEXT AND CONTENT. Order Insectivora, Family Talpidae, Subfamily Desmaninae. This subfamily contains only two living species belonging to monotypic genera, *Desmana* and *Galemys*.

Galemys pyrenaicus (E. Geoffroy Saint-Hilaire, 1811)

Iberian Desman

Mygale pyrenaica E. Geoffroy Saint-Hilaire, 1811:193. Type locality near Tarbes, Hautes-Pyrénées, France.

Myogalea rufula Graells, 1897:460. Type locality, river Balsain, above Venta de los Mosquitos, Sierra de Guadarrama, Segovia, Spain.

CONTEXT AND CONTENT. For context see generic summary above. Two subspecies have been recognized (Ellerman and Morrison-Scott, 1951), although some authors believe the species to be monotypic (e.g., Corbet, 1978).

G. p. pyrenaicus (E. Geoffroy Saint-Hilaire, 1811:193), see above.
G. p. rufulus (Graells, 1897:460), see above.

DIAGNOSIS. A long tail, that may reach or even exceed the length of head and body, distinguishes the Desmaninae from all other Talpidae (Fig. 1). They also possess hindfeet that are wider than the forefeet; in the Talpinae these proportions are reversed. The geographical ranges of the only two Recent species of Desmaninae are disjunct. They are easily distinguishable; *Desmana moschata* is much larger than *Galemys pyrenaicus*. The tail of the former is compressed laterally throughout its length, whereas the tail of the latter is mostly cylindrical, and only the distal part is flattened. The snout of the Iberian desman is proportionally longer than that of *Desmana*. The unicuspid teeth are relatively much lower and wider in *Desmana* than in *Galemys*.

GENERAL CHARACTERS. The conical head and short neck of *Galemys* give it the general appearance of a mole, although the body is less elongate and more fusiform than in *Talpa*. The fur is thick and appears shiny when the animal is underwater. The dorsal pelage is dark grayish brown, becoming lighter and more reddish when worn (Niethammer, 1970). The ventral pelage is light and silvery; laterally the transition in color is gradual. The long muzzle is black and almost devoid of fur, covered instead by a mass of vibrissae that decrease in length distally. The muzzle is compressed dorso-ventrally and has a longitudinal median groove on both upper and lower surfaces. The snout is widened at the tip where two partially divided lobes are evident, each with an elongated nostril opening on the upper side (Fig. 2). The eyes are small and surrounded by shorter, slightly lighter hair. There is no pinna and the auditory meatus is hidden by fur. The forelimbs are smaller than the hindlimbs, and the hindfeet are huge. Both forefeet and hindfeet are webbed, have sharp claws, and the lateral edges are bordered with fringes of rigid hairs (Fig. 2). The tail is cylindrical along its entire length except at the tip, which is compressed laterally; it is scaly and covered by sparse, short hairs. The elongated rostrum supports conspicuous anterior upper incisors (Fig. 3). The dental formula is i 3/3, c 1/1, p 4/4, m 3/3, total 44 (Fig. 4); Ziegler (1971) suggested that the first premolar may be an unreplaced milk tooth. Puisségur (1935) and Trutat (1891) also described external and internal morphology.

There is no size dimorphism between sexes in *Galemys* (Niethammer, 1970). However, Puisségur (1935) noted the existence of a difference in the pelvic girdle that allows easy separation of the sexes in living adult specimens (Peyre, 1957*a*, 1961); in adult males an ossified arch connects the two ischio-pubic extremities, in contrast to adult females in which the arch is soft. The difference can be detected simply by touching this region (Peyre, 1957*a*, 1961).

Means and ranges of some external measurements (in mm) of 19 specimens are (Niethammer, 1970): length of head and body, 120.5 (108 to 135); length of tail, 146.9 (123 to 156); length of hindfoot, 34.3 (31 to 36). Miller (1912) gives the following skull measurements (in mm): condylobasal length, 34.1 (32.8 to 35.4, n = 11); zygomatic breadth, 13.3 (12.4 to 14.0, n = 12); breadth of brain case, 16.5 (15.6 to 17.4, n = 11); interorbital constriction, 6.5 (6.0 to 6.8, n = 14); maxillary toothrow, 17.1 (16.2 to 17.6, n = 15); length of mandible, 22.4 (21.8 to 23.0, n = 15); mandibular toothrow, 14.0 (13.6 to 14.4, n = 15). Body mass apparently ranges between 35.5 g (Saint Girons, 1973) and 80 g (Niethammer, 1970).

DISTRIBUTION. Although the fossil record indicates that the subfamily Desmaninae formerly was distributed widely in Europe, it now is restricted to two disjunct areas. *Desmana moschata* exists in an area north of the Black and Caspian seas in the USSR, whereas *Galemys pyrenaicus* is found in the Pyrenees and in the northern half of the Iberian Peninsula (Fig. 5); both probably are relict distributions.

On the north (French) slope of the Pyrenees, *Galemys* seems to be present wherever there is suitable habitat, but Richard (1972, 1976*a*) referred to a recent decline in numbers of unknown extent. Few records of the species on the Spanish slope of the Pyrenees are available, possibly because biological exploration of the area is less thorough. In the Iberian Peninsula, the species occurs throughout the Cantabrian Mountains, the mountains of northern Portugal, and in the line of high mountains that cross the Iberian Peninsula from near the Portuguese coast to the Ebro Valley. At least the southwestern-most locality on the range map provided by Niethammer (1970) appears to be a misinterpretation of Puisségur's (1935) map.

Whether populations in the Pyrenees are isolated from the rest of the range by the Ebro Valley is not clear. The two geographical populations are considered distinct subspecies, although mor-

FIGURE 1. Photograph of captive Iberian desman (*Galemys pyrenaicus*), courtesy of J. Niethammer.

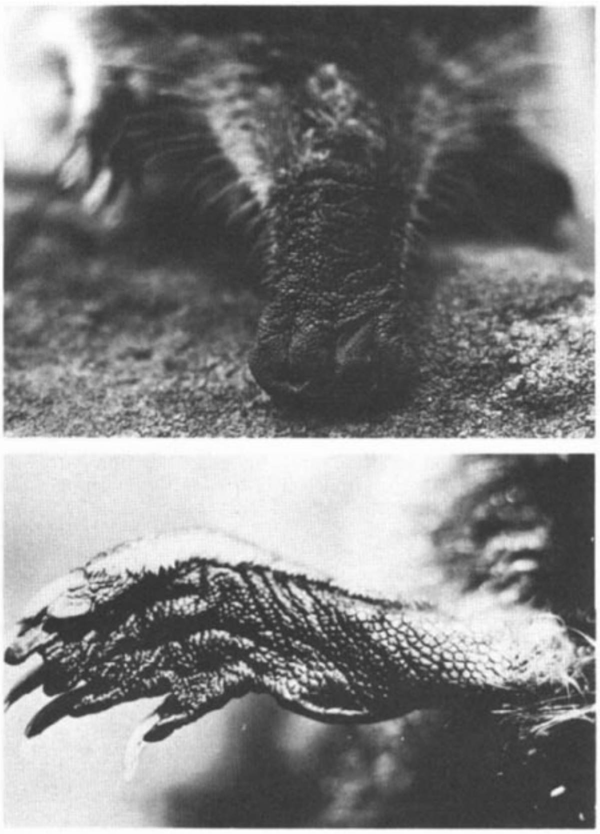

FIGURE 2. Snout and muzzle (above) and ventral surface of left hindfoot (below). (Photos courtesy J. Niethammer.)

phological differences between them are not great. The typical form, *Galemys pyrenaicus pyrenaicus*, occupies the Pyrenees, whereas the larger *Galemys pyrenaicus rufulus* occurs west of the Ebro Valley.

FOSSIL RECORD. Although the generic name *Galemys* was applied to certain fossil forms, this assignment seems to be incorrect (Rzebik-Kowalska, 1971; Schreuder, 1940). Thus, the history of this genus remains unknown. Saint Girons (1973) implied that *G. pyrenaicus* was found in Pliocene deposits at Sansan (France) and Norfolk (England), but those records refer to other fossil Desmaninae (Hutchison, 1974). Some authors (e.g., Hutchison, 1976; Schreuder, 1940; Ziegler, 1971) believe that *Mygalea*, from the late Miocene, is ancestral both to *Desmana* and to *Galemys*.

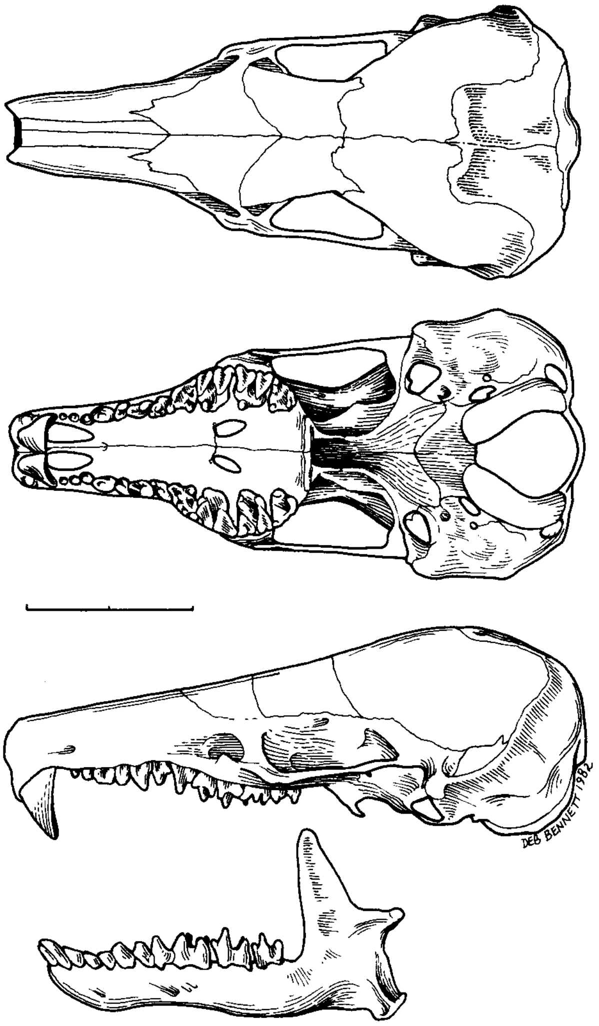

FIGURE 3. (A) Skull of *Galemys pyrenaicus* (KU 35421), from Castillon, Ariège, France, shown, from top to bottom, in dorsal, ventral, and lateral views, the last including mandible. Scale is 10 mm.

FORM AND FUNCTION. The limbs clearly are adapted for swimming. Niethammer (1970) noted the similarity of the general body shape and position of the hindfeet of *Galemys* to certain diving birds such as loons (Gaviidae) and grebes (Podicipedidae) as an evolutionary convergence in response to diving activities. The hindfeet are proportionally enormous and, as in many other semiaquatic mammals, all four feet are webbed and fringed with rigid hairs, which enlarges their surface (Howell, 1930). The end of the long tail is compressed laterally and has a midventral ridge of stiff hairs, possibly to improve the effectiveness of the tail as a rudder and to damp oscillations caused by alternate strokes of the hindfeet. Trutat (1891) described anatomical structures that permit *Galemys* to close the nostrils and ears; whether they are closed throughout submergence is unclear. Richard and Micheau (1975) suggested that at least the external apertures are not sealed, and described a laryngeal "stopper" originating from the velum which, they concluded, prevents water from entering the respiratory tract but still allows water to enter into the nasal passageways for "olfactive analysis." Bauchot et al. (1973) reported that *Galemys* even may inspire water through the nostrils. A tracheal "cross-road," also present in *Talpa* and other insectivores, allows complete separation between the digestive and respiratory tracts, and makes possible the swallowing of prey underwater (Richard and Micheau, 1975). *Galemys pyrenaicus* usually stays underwater about 1 min, but may extend dives to 4 min, a long period for an animal of its size (Richard and Micheau, 1975). The guard hairs, roughly twice as long as the underhairs, are greatly enlarged distally, a characteristic shared with some other aquatic mammals. The pelage, when in good condition, effectively insulates the animal from the water (Puisségur, 1935).

Bauchot (1963) described the brain of *Galemys*; Bauchot and Stephan (1968) and Stephan and Bauchot (1959) compared the brain with that of *Talpa*, emphasizing modifications induced by aquatic life. These adaptations parallel those observed in other semiaquatic insectivores such as *Desmana*, *Neomys*, *Limnogale*, and *Potamogale*: "regression of the olfactory centers, enlargement of the auditory centers and of those of the tactile trigeminal system, enlargement of such centers that are related with motricity and correlation of motricity, enlargement of neocortical regions, especially of the centers of association; on the whole, there is an increase in brain weight and of the index of encephalization" (Bauchot and Stephan, 1968:270).

The long snout of *Galemys pyrenaicus* possesses several bundles of striated muscle fibers that confer great mobility. While foraging, *Galemys* presses the snout continually against the substrate; likely the snout is an important location of sensory receptors (Argaud, 1944; Puisségur, 1935; Trutat, 1891). Bauchot et al. (1973) studied the sensory histology of the snout with both conventional methods and scanning electron microscopy, and Buisseret et al. (1976) with transmission electron microscopy. Chemical receptors were not found in the muzzle but mechanical sensory receptors are well developed. The zone around the nostrils is rich in Eimer's organs similar to those in *Talpa*. Eimer's organs are dispersed among short vibrissae, intraepidermal fibers, and Merkel cells, and seem to be sensitive tactile receptors. Proximally, the snout is covered by numerous vibrissae, innervated by three fascicles of trigem-

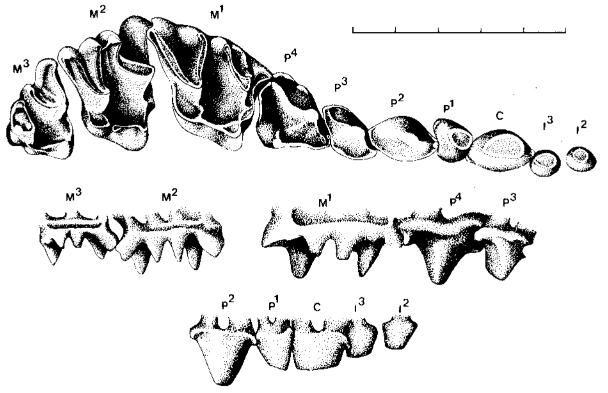

FIGURE 4. Details of right upper dentition of *Galemys pyrenaicus* (KU 35421) shown, from top to bottom in occlusal, posterior lateral, and anterior lateral views. Scale is 5 mm.

inus fibers. They have "fingered" and non-myelinated terminations, and also Merkel cells and laminar formations. Presumably sensitive to vibrations, the vibrissae may have a important role in orientation and detection of prey.

Niethammer (1970) observed the molt of one captive specimen between mid-August and mid-September. Approximately 2 weeks after molt commenced the upper part of the head and dorsum had new hair. Nineteen days later only the base of the tail and midline of the head still had old pelage. This pattern was confirmed in wild-caught specimens.

Richard (1976*b*) proposed a method for age determination based on tooth wear and eruption. He divided his sample into four age groups, the fourth one including both 3- and 4-year-old animals. Wear on the incisors and canines was more rapid than on the post-canine teeth, and in a 2-year-old animal the crowns of these teeth often were abraded entirely. However, he concluded that such wear did not affect seriously the foraging capabilities of the animals. A marked male survived at least 2.5 years under natural conditions (Richard, 1976*b*).

Galemys has scent glands at the base of the tail that release a strong odor but are less conspicuous than those of *Desmana* (Trutat, 1891).

ONTOGENY AND REPRODUCTION. The genital tract of some males is functional before the end of December; regression begins in late June. Spermatogenesis begins in November and continues until May (Peyre, 1954, 1961). Estrus in the female commences in January, and pregnant animals were found from the beginning of February through the end of June (Peyre, 1961). Lactation continues until late August (Peyre, 1961). The existence of three annual peaks in the number of pregnant females suggests they are polyestrous; one peak occurs in February, another in March, and the last in May (Peyre, 1961). Post-partum estrus is indicated by the capture of lactating females that also are pregnant (Peyre, 1961). The gestation period is about 30 days (Peyre, 1961).

No nests with young have been reported. Among 53 pregnant females, the number of embryos per female ranged from 1 to 5 ($\bar{X}$ = 3.6). The most developed measured 30 to 32 mm in length, probably close to that of newborn desmans. The first weaned juveniles born each year were trapped in late March (Peyre, 1961). Peyre also believed that individuals reached maturity during their second year.

ECOLOGY. *Galemys pyrenaicus* is a semi-aquatic species whose usual habitat is mountain streams. Seemingly, cold, flowing, highly oxygenated water with an abundance of crustaceans and insect larvae is required (Peyre, 1956). Provided that these conditions are met, *G. pyrenaicus* may be found both in small mountain streams and wider rivers in lower valleys. Peyre (1956) claimed that *Galemys* was restricted to the "trout zone," and that it disappeared in the lower rivers where trout were replaced by cyprinids. Richard (1976*a*) found *Galemys* in mountain lakes. Channels of water mills are particularly good environments for this desman (Peyre, 1956; Trutat, 1891). The distribution of *Galemys* reveals that it is a mountain species and most of the stations where it has been caught range from 300 m to 1,200 m above sea level. However, it has been found above 1,700 m in Spain (Niethammer, 1970) and at 2,200 m in the French Pyrenees (Richard, 1976*a*). The altitudinal range includes a great diversity of vegetational types. A major element of its habitat is the existence of suitable shelter, usually crevices or holes among stones and roots along stream banks. Most recent authors agree that *Galemys* is not typically fossorial, but may occasionally dig its own burrows when the substrate is not too rocky (Richard, 1976*a*; Richard and Vallette Viallard, 1969). It also may use *Arvicola* tunnels (Puisségur, 1935; Trutat, 1891). Combes and Salvayre (1964) caught a young male in a cave on the bank of subterranean stream, but considered it accidental there. However, Richard (1976*a*) believed that *Galemys* may use caves as normal shelter.

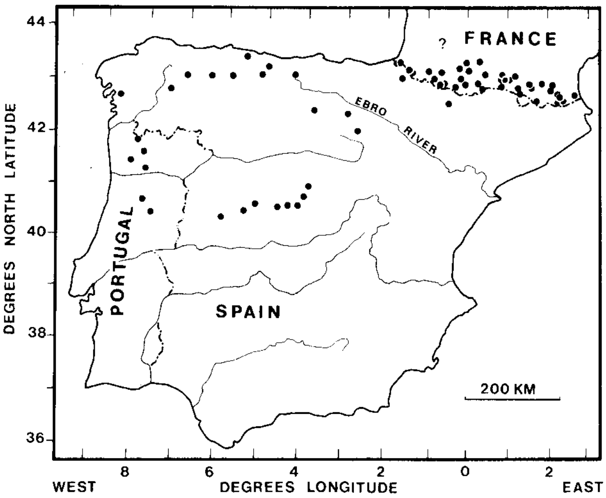

FIGURE 5. Distribution of *Galemys pyrenaicus* in the Iberian peninsula based on Cabrera (1914), Engels (1972), Garzon-Heydt and Castroviejo (1971), Graells (1897), Hinton (1929), Miller (1912), G. Niethammer (1970), J. Niethammer (1956), Richard (1976*a*), Seabra (1900, 1910), Themido (1928), and Vericad (1970).

Analysis of stomach contents by Peyre (1956) and Puisségur (1935) revealed mainly larval Trichoptera and Plecoptera, crustaceans (*Gammarus*), and terrestrial insects. According to Richard (1973*b*, 1976*a*), *Galemys* eats available dead or live animal food. Although it apparently does not usually prey upon fish, some individuals ate trout caught in the same trap (Niethammer, 1970; Richard, 1976*a*) and fish may be caught opportunistically in nature.

Richard and Vallette Viallard (1969) wrote that in captivity this desman eats at least the equivalent of two-thirds of its body mass every day. However, Richard and Micheau (1975) stated that it requires just one-third its body mass, and Niethammer (1970), using newborn mice as food, determined that the daily requirement was only one-fifth of its mass.

Whether *Galemys* is a wholly aquatic forager or, as Trutat (1891) stated, also hunts away from the water, is not clear. No other authority has obtained evidence of terrestrial hunting behavior (Peyre, 1956; Puisségur, 1935; Richard, 1976*a*).

Desmans have been live-trapped in funnel fish traps placed with their openings in the direction of the water flow, half-submerged to prevent captured animals from drowning (Peyre, 1956; Puisségur, 1935). Richard (1973*a*) also gave advice concerning handling, transport, and maintenance of captive desmans. Richard and Vallette Viallard (1969) marked desmans in the French Pyrenees with bird bands, but the study was terminated by extirpation of the species locally (Richard, 1976*a*).

The water shrew *Neomys* and the water vole *Arvicola* are the only other amphibious small mammals that are sympatric with *Galemys*. Peyre (1956) compared the ecological preferences and the ethology of the three genera. The only report of predation on *Galemys* was by a weasel (*Mustela nivalis*) in a funnel fish trap to which it probably was attracted by a captured desman (Richard, 1976*a*).

In the French Pyrenees, numbers of *Galemys* seem to be decreasing, probably because of pollution of streams and other modifications of their habitat (Richard, 1972, 1976*a*). In Portugal and Spain, the status of *Galemys* is not well-known, but is a matter of concern, because of its apparent vulnerability to habitat change and its restricted distribution.

BEHAVIOR. Observation of *Galemys* in the wild is extremely difficult. With the exception of data obtained by trapping and recapturing marked individuals (Richard and Vallette Viallard, 1969), knowledge of its behavior is based on studies of captives.

The Iberian desman appears to have a fixed home range throughout the year; it varies from "some tens" of meters to 200 m (Richard and Vallette Viallard, 1969). Fidelity to this home range was verified by homing experiments that demonstrated that return from distances up to 1,500 m is possible (Richard and Vallette Viallard, 1969). A male and a female may live in the same area. Although individuals of both sexes may make movements in search of mates, females are more sedentary in home range than males. The desman seems to have a "memorized" knowledge of its home range and the displacement of any object appears to confuse the animal (Richard, 1973*b*; Richard and Vallette Viallard, 1969). When a stream is completely blocked with traps, all individuals always are caught in the same trap (Peyre, 1956), which suggests existence of fixed travel routes used by several (up to 10) desmans.

Observations on captive specimens suggest that *Galemys* may defend a small territory within its home range. Several authors reported a high degree of intraspecific aggression, even between the sexes (Niethammer, 1970; Richard, 1973*b*; Richard and Vallette Viallard, 1969). Although Neithammer (1970) observed a desman defecating in the water, they usually defecate repeatedly in the same dry place, such as on top of a conspicuous stone (Niethammer, 1970; Richard and Vallette Viallard, 1969). Musk glands at the base of the tail may be employed in territory-marking behavior.

Although it usually nests in natural cavities, tunneling has been recorded. A captive specimen enlarged and deepened a man-made hole in a clay surface; it used the snout to dig and the forefeet to remove the loose soil (Richard, 1976*a*). Possibly they dig their own burrows where such behavior is not constrained by the stony substratum typical of their usual habitat (Richard, 1976*a*). Niethammer (1970) observed nest building in a captive *Galemys*. Holes in the substrate were covered with grass and leaves that the desman transported with its teeth and snout; the desman slept under these materials.

Galemys clearly is a nocturnal animal, but apparently has short periods of activity during the day (Peyre, 1956), particularly just before noon (Richard and Vallette Viallard, 1969). Periods of activity alternate with resting phases in a 2- to 3-h cycle (Richard and Vallette Viallard, 1969).

Because of morphological adaptations to an aquatic environment, terrestrial locomotion of *Galemys* is slow and difficult (Peyre, 1956; Richard and Vallette Viallard, 1969). However, its sharp claws confer excellent climbing ability (Niethammer, 1970; Peyre, 1956; Richard and Vallette Viallard, 1969), an essential attribute on the usually steep banks of streams where it lives. Sometimes it stands vertically, supported by the hindfeet and tail, apparently in an exploratory attitude (Richard and Micheau, 1975). According to Niethammer (1970), who filmed swimming desmans, they push forward by strong alternate strokes of the webbed hindfeet at a rate of around 2.5 strokes/s, while the forelimbs remain inactive and extended forward. However, the high mobility of *Galemys* in the water implies a great variety of movements (Niethammer, 1970; Richard and Vallette Viallard, 1969).

While foraging, the Iberian desman actively explores the bottom of the stream, moving sediment with the snout, head, and forefeet (Niethammer, 1970; Peyre, 1956; Richard, 1973*b*). Apparently, it eats small prey and food particles underwater (Richard and Micheau, 1975) but large prey items are carried to the bank before being consumed (Puisségur, 1935; Richard and Micheau, 1975; Richard and Vallette Viallard, 1969). Niethammer (1970) observed that a captive individual repeatedly ate in the same sheltered place. On land they often eat, aided by their forefeet and mobile snout, while standing erect and supported by hindfeet and tail (Niethammer, 1970; Richard and Vallette Viallard, 1969). When offered fish and young mice a captive *Galemys* always began to eat them head first (Niethammer, 1970). When prey items were too large for a single meal, the desman buried uneaten portions and ate them later. Niethammer (1970) found that his captive drank much water, particularly after eating.

Meals usually are followed by a cleaning session in which the mouth and snout are washed carefully with the help of the forefeet (Richard and Vallette Viallard, 1969). After leaving the water they vigorously shake the body, then thoroughly brush the fur with quick strokes of the hindfeet. These grooming strokes reach most of the body of the animal (Niethammer, 1970; Richard and Vallette Viallard, 1969). The long rear claws, with longitudinal grooves and sharp edges (especially on the second and third toes), are particularly suitable for grooming the fur (Dubost, 1970; Niethammer, 1970).

The Iberian desman is essentially a silent animal, but Niethammer (1970) and Richard (1973*b*) reported various sounds produced on several occasions by captive specimens. The meaning of these sounds is unknown, but some of them were emitted at the time of intraspecific encounters. Richard (1973*b*) speculated that desmans likely employ sounds produced by slapping the forefeet against the water surface for echolocation.

GENETICS. Peyre (1957*b*) reported a diploid number of 42 chromosomes and a fundamental number of about 65–67; he noted its karyological similarity to *Talpa*.

REMARK. *Galemys pyrenaicus* also is known in the vernacular as the Pyrenean desman.

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