

Swimming ability in six West-African rodent species under laboratory conditions

Evaluation of their potentialities
to colonize islands

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■ Introduction

Swimming ability has already been tested in different groups of rodents to examine the role that water bodies (rivers or sea-arms) may play as barriers to dispersal, mainly as an attempt to explain the observed distributions of various continental populations or species (HAFNER and HAFNER, 1975; SAVIDGE, 1973; GIANNONI *et al.*, 1994), less frequently to assess different species' potential to invade islands (CARTER and MERRITT, 1981). Similarly, a large number of studies on this topic have concerned European and North American rodents and strangely enough mainly subterranean rodents (see HICKMAN, 1988, for a review), yet only one study has been devoted to above-ground African species (HICKMAN and MACHINÉ, 1986).

Several field studies in Senegal allowed us to study island populations in two very different contexts: the rocky Madeleine Island off the coast of Dakar on the one hand, and the sandy islands of the Saloum Delta (DUPLANTIER, 1988; GRANJON, 1987; GRANJON and DUPLANTIER, 1989) on the other hand. The rodent community on an

island can be either the remnant of an original mainland community, subsequently isolated, or the result of immigrations, or the resultant of the two processes. It is generally accepted that islands are colonized by the most abundant species from the nearest mainland and/or by species commensal with humans (MAC ARTHUR and WILSON, 1967). This general pattern corresponds to the situation we observed on Madeleine Island: the only species occurring on the island, *Mastomys erythroleucus*, is the most abundant species on the mainland, indoors as well as outdoors. Conversely, three other rodent species were encountered on the Saloum islands. The black rat, *Rattus rattus*, is indeed a commensal species, yet the other two, *Mastomys huberti* and *Tatera gambiana* are not, nor are they the most abundant species on the nearby mainland. Therefore, they must have arrived on these islands by their own means. It thus appeared interesting to compare swimming ability of the main species on the mainland in an effort to understand the present community on these islands.

■ Material and methods

Five species of Muridae (*Arvicanthis niloticus*, *Mastomys huberti*, *Mastomys erythroleucus*, *Myomys daltoni* and *Dasymys rufulus*) and one Gerbillidae (*Tatera gambiana*) were used in this study. Ten individuals of each species (5 males and 5 females) were tested under identical conditions, except for *Myomys daltoni* for which only 3 males and 3 females were studied. All individuals were adults captured in nature and maintained in captivity for several weeks prior to the tests. Only individuals showing no wounds (in particular with a complete and intact tail) were used.

Tests were carried out in a plastic aquarium 100 cm long, 50 cm wide and 40 cm high, filled with fresh water up to 22 cm high. Water temperature was 22 °C. Animals were tested individually and each test lasted 10 minutes. Each individual was weighed before and after the test, and also after one, three and five minutes in the water, to assess water uptake by the fur relative to time spent in the water.

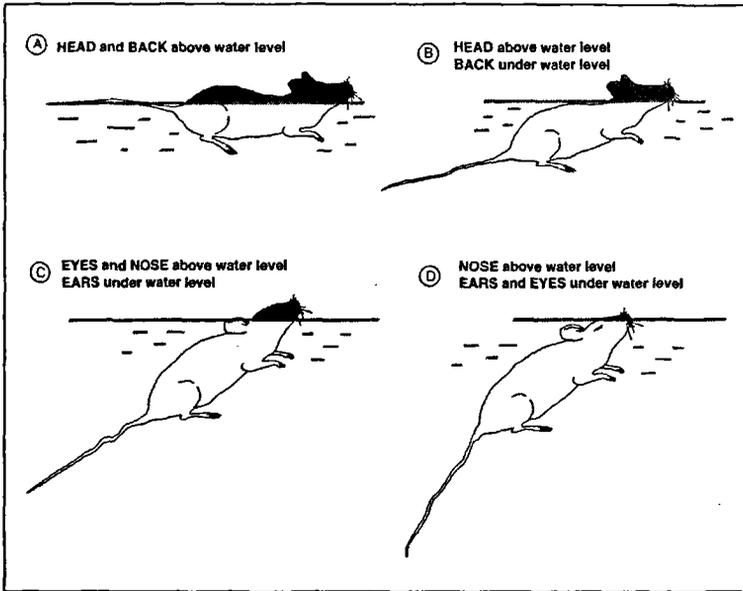
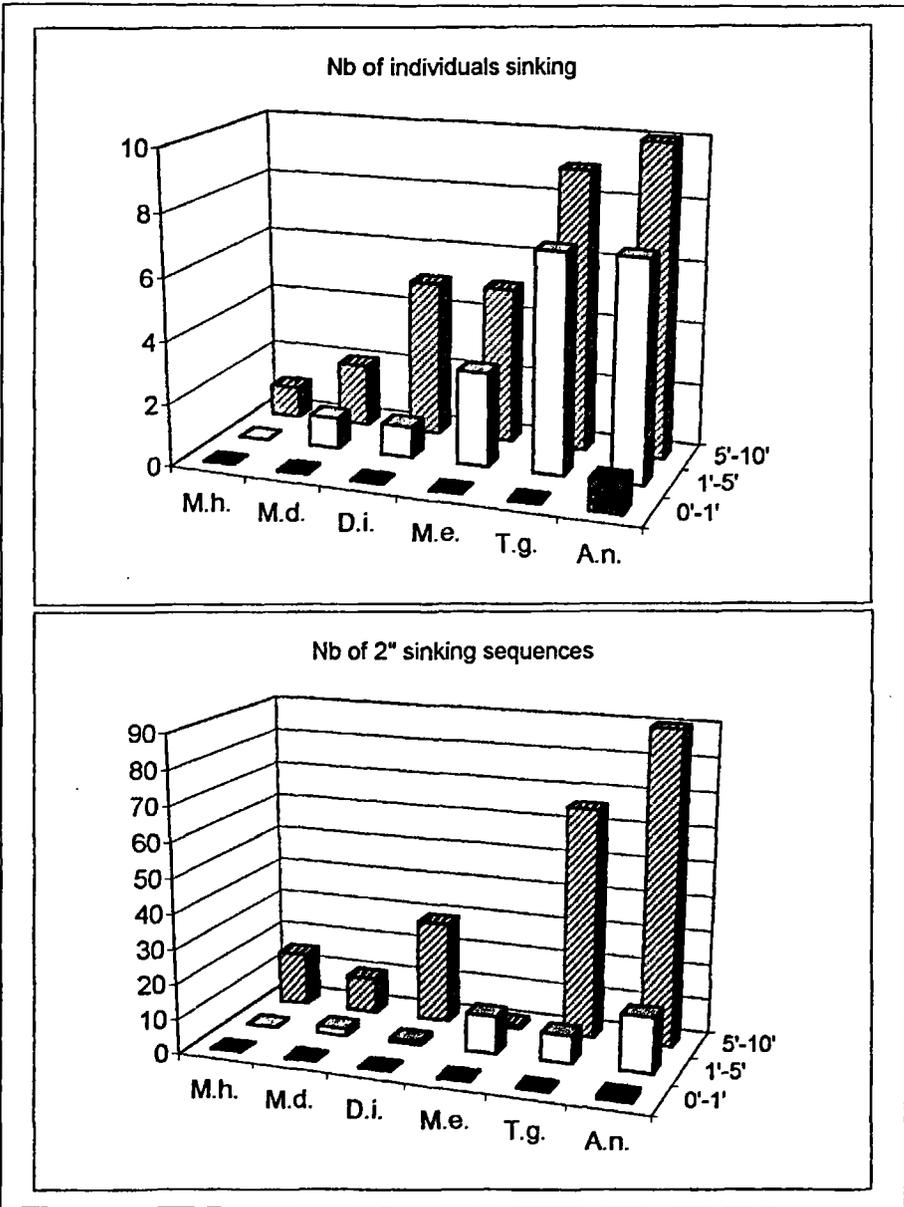


Figure 1
Different body positions in water,
recorded during the tests.

During the tests, we recorded the following activities, swimming, floating, sinking, and diving by two-second sequences: that is to say that activities lasting less than 2" were not taken into account and those lasting more were divided in 2" units. Swimming refers to the animal moving by means of the limbs and / or the tail. Floating refers to the animal keeping its limbs immobile while maintaining its body stable in the water. Sinking refers to the body going under water by the rear with or without tail or limb movements and with the nose under water level. When more than ten sinking sequences occurred within one minute, or when a rodent displayed difficulty in surfacing again after sinking with signs of drowning, it was immediately retrieved from the water and the test was stopped for that individual. Diving refers to the animal swimming under the water, head first, towards the bottom of the aquarium. At the end of each minute, the position of the body in the water was recorded (fig. 1).



■ Figure 2

Importance of sinking according to time spent in water, for the six species tested (A.n. = *Arvicanthis niloticus*, D.i. = *Dasymys rufulus*, M.d. = *Myomys daltoni*, M.e. = *Mastomys erythroleucus*, M.h. = *Mastomys huberti*, T.g. = *Tatera gambiana*).

Results

Overall results and sinking

In three species, *D. rufulus*, *M. huberti* and *M. daltoni*, all individuals passed the 10-minute test. In contrast, only 7 out of 10 individuals in *A. niloticus* and *T. gambiana*, and 6 out of 10 in *M. erythroleucus* succeeded. In *T. gambiana*, the individuals that failed were the lightest (1 male and 2 females). Three *A. niloticus* females were eliminated with no apparent relation to their weight (they ranked 3rd, 7th and 10th by decreasing weight).

Three *M. erythroleucus* females and one male were eliminated with no relation to weight either (1st, 4th, 7th and 10th by decreasing weight). But the 6 remaining individuals presented the lowest number of sinking sequences (fig 2). All *A. niloticus* individuals and 9/10 *T. gambiana* individuals sank at least once during the experiment, against only one *M. huberti*.

Water uptake by the fur

With the exception of *M. daltoni*, there was extensive individual variability for this parameter in all species, as denoted by important standard deviations (fig 3). Increase in body weight peaked after one minute in the water, except for *M. huberti*. This species always displayed the lowest average values regardless of time spent in the water. Conversely, *D. rufulus* always displayed the highest averages. After 10 minutes the average increase in body weight was significantly larger in *D. rufulus* than in *M. huberti* (Mann-Whitney U test, $p < 0.05$). For five species we did not detect any correlation between initial (dry) weight of individuals and the magnitude of water uptake at the end of the test. In *D. rufulus*, however, this correlation was negative: the heaviest individuals displayed the lowest relative water uptake (% of initial weight, $r = -0.8526$, $p > 0.01$). We did not observe any significant difference between males and females within a given species. Finally, the individuals that had to be removed from the water before the end of the experiment did not display the highest water uptake: the 3 *T. gambiana* that were eliminated ranked 3rd, 4th and

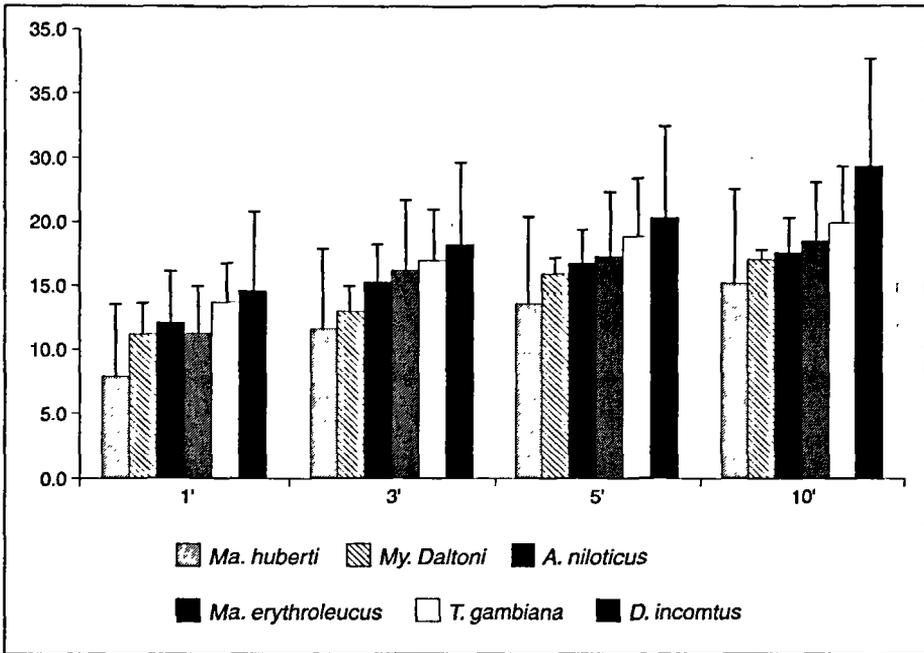


Figure 3

Water uptake by the fur according to time spent in water (mean and standard deviation, expressed as percentage of the initial weight).

10th by decreasing water uptake. The 4 eliminated *M. erythroleucus* similarly ranked 1st, 4th, 6th and 8th; and the 3 eliminated *A. niloticus* ranked 4th, 6th and 8th.

Position in the water

M. huberti and *D. rufulus* were the only species which individuals were still horizontal after ten minutes of test. In these two species as in *M. erythroleucus*, there was great individual variations however. In *D. rufulus* the three individuals that were in position A after 10 minutes were all males, whereas of the 5 individuals in position D there were 4 females and 1 male. In *M. huberti* the two individuals that were in position A at the end of the test were males, two other males were in position B and the fifth was in position D. In *M. erythroleucus*, 3 females were eliminated, 1 was in position C and 1 in position D.

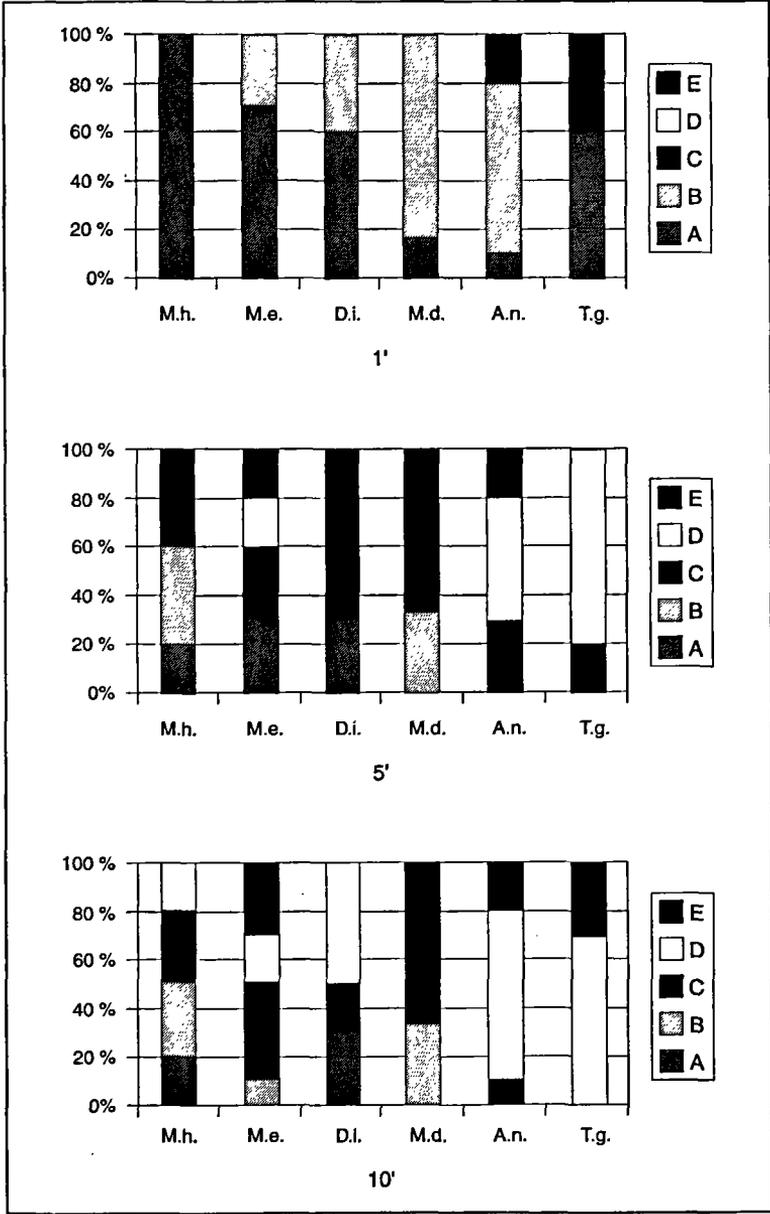


Figure 4
Percentage of individuals in the different "body position in water" (see fig 1), according to time for each species:
A, B, C and D = body positions;
E = number of individuals eliminated.

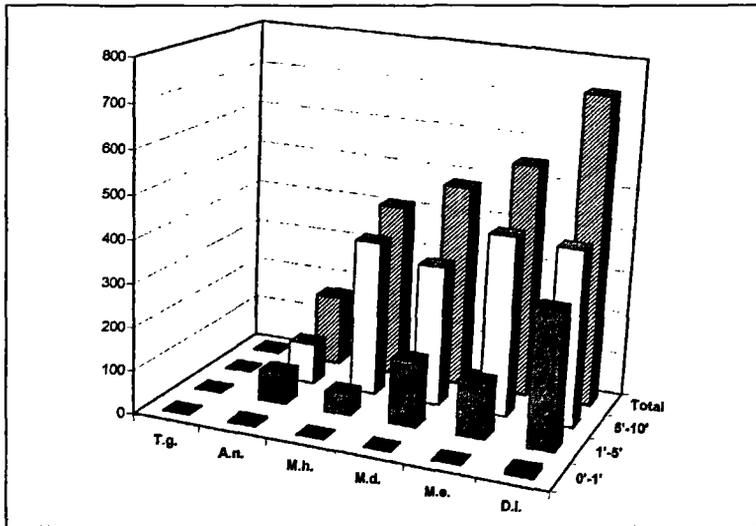


Figure 5
Number of floating periods according to species
and time spent in water.

Conversely, after the first five minutes in the water, all *M. daltoni* individuals were in an intermediate position, and *A. niloticus* and *T. gambiana* were heavily slanting backwards.

Floating

Only one *T. gambiana* individual managed to float for 2 seconds. This behaviour concerned the majority or all individuals in the other species. The number of floating periods was null or very low in all species during the first minutes spent in the water. It increased between 1 and 5 minutes except for *M. huberti* and *A. niloticus*. It increased considerably beyond 5 minutes in *M. huberti* and remained stable in *A. niloticus*.

Diving

This behavior was recorded in four species only. One *D. rufulus* dived twice, one *M. erythroleucus* and one *T. gambiana* 4 times each. Three *A. niloticus* dived, among which one individual did it twice.

Discussion

One of the main findings from these tests is the extensive individual variability observed for the majority of the parameters recorded. Yet within-species behavior is rather homogeneous in three species: *M. huberti*, *M. daltoni* and *T. gambiana*. A small fraction of individuals displayed better abilities than their conspecifics in *A. niloticus* and weaker abilities in *D. rufulus*. Finally, in *M. erythroleucus*, the individuals tested were evenly distributed among good and poor swimmers. Considering these facts it is possible to rank the different species from good to poor swimmers.

Mastomys huberti

We have shown (DUPLANTIER and GRANJON, 1988) that *M. huberti* is a characteristic wetland species; therefore it is not surprising that it ranks first in this classification. All the individuals reached the end of the test and presented the lowest occurrence of sinking. Water uptake by the fur was the lowest regardless of the time spent in water. Eight of ten individuals had at least the eyes and the nose above water level at the end of the test.

Myomys daltoni

All the individuals reached the end of the experiment and presented one of the lowest rate of sinking. All the individuals had at least the eyes and the nose above water level at the end of the test. This species is considered to be semi-arboreal; it is sometimes commensal, but only rarely inhabits wetlands. Its ecology and distribution thus cannot explain its good performances. However, its morphology may play an important role: this species has the longest tail in our sample and the importance of this organ in swimming has already been demonstrated (HICKMAN and MACHINÉ, 1986).

Dasymys rufulus

All the individuals reached the end point of the experiment. Water uptake by the fur was greater than in other species, yet this sample

presented the highest number of floating sequences. This species is commonly called the swamp rat or the shaggy rat, which adequately illustrates its ecological and morphological attributes. *Dasymys rufulus* usually has a shaggy fur with a very dense and thick undercoat relatively impermeable to water. However, NOWAK and PARADISO (1983) noted that individuals with long and straight fur can be found. These individuals could have been moulting and their changing fur would have been less impermeable. This could explain the weaker performances and greater water uptake that we observed in lighter individuals.

Mastomys erythroleucus

As opposed to its congeneric *M. huberti*, this species falls into two groups: some individuals displayed good abilities whereas others did not at all. Four of ten individuals had to be removed from water before the end of the test, but the 6 others presented the lowest occurrence of sinking. Half of the individuals had at least the eyes and the nose above water level at the end of the test.

Arvicanthis niloticus

Three of ten Nile rats had to be removed from the water, and the remaining individuals presented the highest occurrence of sinking. Only one individual had at least the eyes and the nose above water level at the end of the test. The poor performances observed in the individuals we tested are somewhat surprising. The Nile rat is a diurnal species that often lives by the water and on several occasions we observed individuals swimming in the Senegal river valley.

Tatera gambiana

Three of ten gerbils had to be removed from the water and the remaining individuals presented among the highest occurrences of sinking. After 6 mn in the water, all these individuals had only the nose above water level. All tested animals seemed unable to float and had to swim constantly. These poor results corroborate the observations by HICKMAN and MACHINÉ (1986) on another species of the same genus,

namely *T. leucogaster*. Moreover, the fur of *T. gambiana* was found to be more absorbent than that of Muridae and this may represent a heavy handicap in this species characteristic of arid habitats.

With respect to the ability to reach islands, these test results are in accordance with the distributions observed in the field. *Mastomys erythroleucus* displays poor performances and its presence on Madeleine Island can be explained both by its abundance on the neighbouring mainland and by the fact that it is a commensal species. Madeleine Island was isolated from the mainland 8000 years ago and traces of human settlements are documented back to 1000 years BP (DESCAMPS, 1982). The present occurrence of *M. erythroleucus* can thus be explained both by lower extinction risks as compared to other mainland species (diversified diet, very high fertility, DUPLANTIER, 1988) and by numerous opportunities for passive immigration with humans in the course of several hundreds of years.

In the Saloum Delta, *R. rattus* was found only on islands with permanent human settlements, whereas only *T. gambiana* and *M. huberti* live on uninhabited islands (GRANJON and DUPLANTIER, 1989). Due to temporary human presence (camps of fishermen) or permanent settlements on all these islands, we can assume that *M. erythroleucus* has had repeated opportunities for colonization. Its inability to establish permanent populations in these islands can be explained by two factors. First, it is probably out-competed by the black rat inside human dwellings, as we have shown on the mainland (DUPLANTIER *et al.*, 1997). Second, it seems unable to adapt to the lack of fresh water characteristic of these sandy islands covered with halophilous vegetation, contrarily to *M. huberti* (GRANJON *et al.*, 1994; GANEM *et al.*, 1995).

As for *T. gambiana* and *M. huberti*, two different contexts must be considered. The two species cohabit on large islands (over 3000 ha in area) separated from the mainland by narrow channels (25 to 50 meters wide on average, only a few meters at some points). On smaller islands located more than 200 meters from the nearest large island or mainland, *M. huberti* is the only species present. This shows that *T. gambiana*, an arid-habitat species, can perfectly adapt to such salty habitats contrarily to other species on the mainland that are either more abundant (*A. niloticus*) or best swimmers (*M. daltoni*, *D. rufulus*), yet its poor swimming abilities prevent it from reaching the most remote islands.

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