Journal of Comparative Psychology Copyright 1988 by the American Psychological Association, Inc. 1988, Vol. 102, No. 1, 66-71 0735-7036/88/$00.75

Sound Localization in a Predatory Rodent,
the Northern Grasshopper Mouse (Onychomys leucogaster)

Rickye S. Heffner and Henry E. Heffner
Bureau of Child Research, Laboratory of Comparative Hearing University of Kansas

A comparison of the ability of mammals to localize sound revealed that among the animals examined to date, none of the rodents have been able to localize as accurately as the carnivores. Because all of these rodents are prey animals, the question arises as to whether their poor localization acuity is a phyletic trait of Rodentia or whether it is a trait common to prey species that may be under less selective pressure than predators to localize sound accurately. To answer this question, sound localization acuity was determined in a species that is both predatory and a rodent, the northern grasshopper mouse. Localization thresholds for a single 100-ms noise burst were determined for three grasshopper mice using a conditioned avoidance procedure. Their 50% discrimination threshold of 19* is larger than that of any of the previously tested carnivores and well within the range of other rodents. However, calculations of the binaural sound localization cues available to

LOCALIZATION IN THE GRASSHOPPER MOUSE 67

for predation is reflected in its relatively large home range, and it has undergone marked specialization in both its diges-tive physiology and in its adrenal hormones for an aggressive predatory way of life (Homer, Taylor, Padykula, 1965; for a species account, see McCarty, 1978). These carnivorelike adaptations, along with the fact that it has been shown to rely predominantly on audition for locating active prey (Langley, 1983), suggest the grasshopper mouse as a candidate for studying the role of trophic level in the evolution of sound localization.
In this article we describe the sound localization acuity of the grasshopper mouse in the azimuthal plane as determined by a conditioned avoidance procedure.

Method

Subjects

Three grasshopper mice (Onychomys leucogaster) from different litters, 1 female and 2 males, 4-12-months old and weighing 40-58 g were used. The animals were reared in the laboratory from mice that had been trapped in western Kansas. Their audiograms had been determined previously and showed no signs of abnormality (H. Heffner & Heffner, 1985a); their ear canals were examined and found free of signs of disease. Because auditory thresholds generally show little variation among healthy individuals of the same species and because abnormalities due to disease are usually apparent (e.g., R. Heffner & Heffner, 1983, 1988), testing three individuals is sufficient to gain a reliable estimate of acuity.
The mice were maintained in the laboratory on insects, seeds, and a powdered vitamin supplement. Water was used as a reward and was available only in the test sessions. The mice were weighed daily to monitor their health and deprivational status. Because grasshopper mice are such small animals and because they are adapted to semi-arid conditions, they consumed only 1.5-2.5 ml of water in a typical session lasting 15-20 min.

Behavioral Apparatus

The behavioral apparatus was the same as that used to assess the audiograms (H. Heffner & Heffner, 1985a). The test'cage was mounted on a table covered with acoustic foam and located in a double-walled sound chamber (Industrial Acoustics; 2.55 x 2.75 x 2.05 m). A blunted 22-ga. hypodermic needle, which served as a water spout, was mounted so that it protruded just inside the front
of the cage. The spout was connected by plastic tubing to an electri-
cally operated water valve and a 25-ml water reservoir, both of which
were located in an adjacent control room. A contact circuit connected
between the water spout and cage floor served to detect when an
animal made contact with the spout. A constant current shock
generator was connected between the spout and the cage shom (S 3.2575 0 T3(contact)T.06616 Tc Productio.1114 0 T)Tj7.55 shom (S 3.- Tc lizatio.1114 0 T67465 Td9.13.05882 Tc 211hold.9924 0 T462059 TdTj 506616 Tc 2.403 1 c o was mild9924 0 T4289aia0ied.9805515 Tcelectric0601 0 Tll8The 08087 Tshock9924 0 Tl269aia0i3 operatby the f 0.0735 operated0.05023 Tc 76 Tc 4.6806 0 Td (the)Tj 58 spout.edj189023 Tc serv5.0601 0 Tll8The b W)131 0 Tdl (spout.521505023 Tc rials0601 0 Td.2353 Td526249023 Tc wa.9924 0 Td(the) circuit (c455 Tc Stadl3.0361 0 TTj and)T cage connecte (c4j 0.068(Graso.1114 0 T) (circuij 00.07843 TStadl3.0361 0 TTj and)Tj 73180.071081287),2138 0 Td (and)Tj 1625023 Tc 2.2138 0 Td.2353 Td

68 RICKYE S. HEFFNER AND HENRY E. HEFFNER

dricks, 1966; Ravizza, Heffner, & Masterton, 1969) incorporates a
correction for guessing by adjusting the observed hit rate according
to the observed false alarm rate (see Green & Swets, 1966, Equation
5.2). This ratio was used to illustrate each animal's performance and
to determine

LOCALIZATION IN THE GRASSHOPPER MOUSE 69

All three

70 RICKYE S. HEFFNER AND HENRY E. HEFFNER

Table 2

Sound-Localization Thresholds for Rodents and Carnivores

50%
Maximum detection Binaural time
interaural threshold disparity at
distance in degrees threshold in
Species n in #s a (M +. SD) tts Source
Carnivores

Cat 5 258 5 --- 1.2 14 Casseday & Neff, 1973
Dog b 4 435 8 + 2.1 39 H. Heffner, 1976
Least weasel 2 76 12 +_ 1.0 10 R. Heffner & Heffner, 1987
Rodents
Norway rat, wild 3 130 13 + 0.4 19 H. Heffner & Heffner, 1985b
Grasshopper mouse 3 61 19 + 0.7 13 This report
Wood rat 4 115 19 + 4.1 24 H. Heffner, 1978
Kangaroo rat b 1 90 27 27 H. Heffner & Masterton, 1980
Gerbil 7 87 27 + 4.0 27 R. Heffner & Heffner, in press

"Time required for a sound to travel around the head from one auditory meatus to the other.
b These species were tested using a single click as the stimulus rather than a single brief burst of noise with the result that their thresholds
may appear slightly greater than they would had noise been used (cf. H. Heffner & Heffner, 1985b; R. Heffner & Heffner, 1982).

However, it should be noted that the grasshopper mouse
has the smallest in.eosaural has n3092Tj 0.0siz265 Tc 199095 0 Td 034 4(cf.)Tj[.8(gras63)]The27029 Tc 5.4555 0 T4.4173und w ha[(sr)Tj027s777Tc 1 .4468 0 Td (1he)Tj 0[(Alt8.2g337-7.0.045-localizatio2527 Tc 101625 0 Tdd (fppear)Tj cuity55 n3092Tj 0.0precisio2198Tc 3.0 7.2 0 Td 649Jld than w y53 Tc 1.889 0 Td7.73ouse &4, 3.5164 0 T5Ho41pear (Heffner)Tacc.07te304 Tc 3..4993 0 T5.1]TJld ha[(sr)Tjorder07 Tc 5.4993 0 Td 93or ha[(sr)TjTj 0.7 Tc 1.(rath 0 Td 9061und)Tj 3im777 Tc has

LOCALIZATION IN THE GRASSHOPPER MOUSE 71

References

Casseday, J. H., & Neff, W. D. (1973). Localization of pure tones. Journal of the Acoustical Society of America, 54, 365-372. Gescheider, G. A. (1976). Psychophysics method and theory. New York: Wiley.
Green, D. M., & Swets, J. A. (1966). Signal detection theory and psychophysics. New York: Wiley.
Hansen, R. M. (1975). Plant matter in