RESPONSE OF MARSH RICE RAT (*ORYZOMYS PALUSTRIS*) TO INUNDATION OF HABITAT

ALISA A. ABUZEINEH,* ROBERT D. OWEN, NANCY E. MCINTYRE, CARL W. DICK, RICHARD E. STRAUSS, AND TYLA HOLSOMBACK

Department of Biological Sciences, Texas Tech University, Lubbock, TX 79409
Present address of AAA: Aquatic Station, Department of Biology, Texas State University, San Marcos, TX 78666
*Correspondent: alisa.abuzeineh@txstate.edu

ABSTRACT—Although the swimming behavior of *Oryzomys palustris* has been described, little is known about how long this species will remain in an area that is inundated by several centimeters of water. This study documents the response of an *O. palustris* population to habitat inundation in a coastal prairie locality of southeastern Texas. During a mark-recapture study conducted during 2002 and 2003, we live-trapped *O. palustris* on a grid in an area that experienced prolonged (≥5 mo) inundation during 2 of our 6 quarterly trapping periods. We describe a trapping technique, using foam rafts to support rodent live-traps, that is suitable for use in inundated areas. Despite long-term inundation, little available refuge, and an apparent complete turnover of the population, we estimated population densities of ca. 29 individuals per hectare during inundation, only a moderate decrease from the higher levels encountered before and after inundation.

RESUMEN—A pesar de que se ha descrito el comportamiento natatorio de *Oryzomys palustris*, se sabe poco sobre cuanto tiempo permanece esta especie en un área inundada por varios centímetros de agua. Esta investigación documenta la respuesta de una población de *O. palustris* a la inundación de hábitat en un llano costero del sureste de Texas. Durante un estudio de marca-recaptura realizado durante el 2002 y el 2003, capturamos vivos los *O. palustris*, en una parcela de un área que sufrió inundación prolongada (≥5 meses), durante 2 de nuestras 6 sesiones trimestrales de trampeo. Describimos una técnica de trampeo usando balsas de unicel para sostener trampas para roedores, que son útiles para usar en áreas inundadas. A pesar de la prolongada inundación, la falta de refugio disponible y un aparente cambio completo de la población, estimamos una densidad poblacional de aproximadamente 29 individuos por hectárea durante la inundación, sólo una moderada disminución del nivel más alto encontrado antes y después de la inundación.

Oryzomys palustris is a medium-sized (adult weight 45 to 80 g) semi-aquatic murid rodent (Wolfe, 1982*a*). It has a long tail and large hind feet with partially webbed toes that facilitate propulsion while swimming (Esher et al., 1978). The species occurs in marshy areas or along bodies of water from southern coastal Texas, northeast along the Gulf of Mexico to Florida, and in riparian habitats as far north as Kansas and Maryland (Wolfe, 1982*a*; Kays and Wilson, 2003). Esher et al. (1978) suggested that the water-resistant properties of the pelage play an important role in the ability of the rat to maintain its body temperature and buoyancy, and they noted its ability and tendency to dive and swim up to 10 m underwater when startled. During our field research, we witnessed the diving behavior described by (Esher et al., 1978), but the pelage seemed to become saturated within a few seconds.

Wolfe (1982*b*) examined the effects of storms on rice rats in a coastal marsh in Mississippi. He sampled populations before and after 3 storm events that produced high tides and strong winds for a few hours. He concluded that, although populations were smaller following storms, the impact probably was not serious (Wolfe, 1982*b*). Despite what is known regarding the ecology and swimming ability of the species and the effects of short-term inundation, little is known regarding how long *O. palustris* will remain in a flooded area. In this paper, we examine the effects of long-term inundation (ca. 6 mo) on a population of *O. palustris* in coastal southeastern Texas.
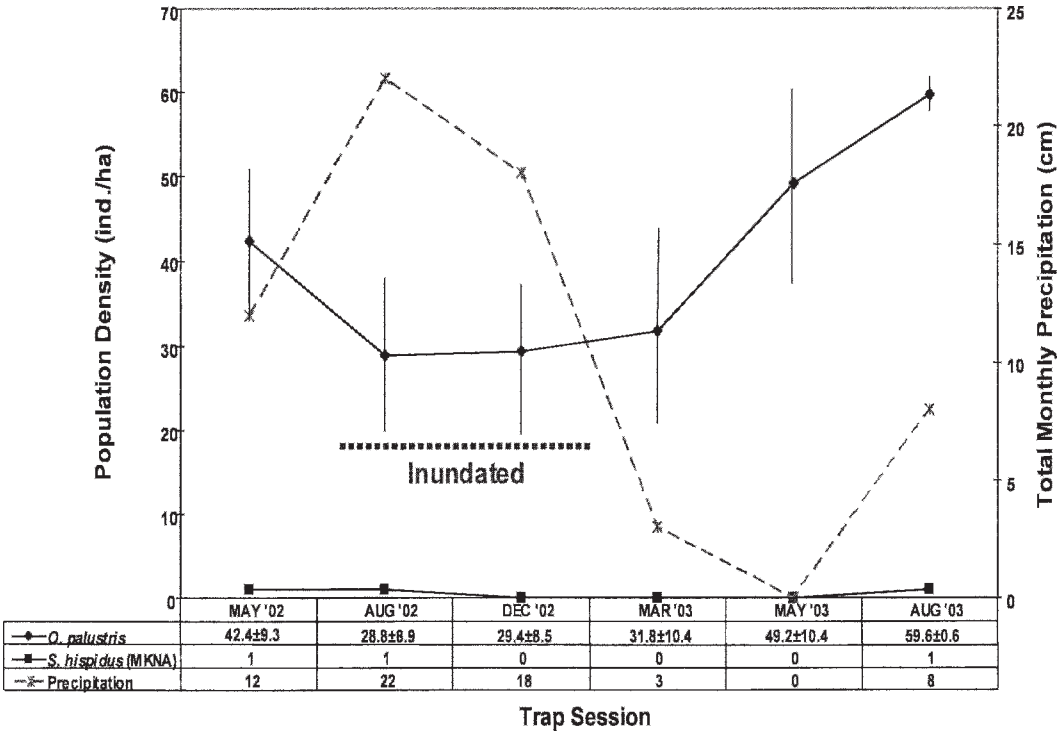
Fig. 1—Population densities (estimate $\pm$ *SE*) and total monthly precipitation (cm). Graph shows population densities for *Oryzomys palustris* (diamond) and *Sigmodon hispidus* (square) for comparison, and total monthly precipitation for each trap session. Low abundances and recaptures of *S. hispidus* precluded the use of MARK for population estimations; therefore, minimum known number alive (MKNA) was used. Standard error bars for August 2003 were smaller than other sessions due to a large number of recaptures per individual. August and December 2002 were trapping sessions during the inundation period.

METHODS—*Study Area*—Our study was conducted from May 2002 to August 2003 at Peach Point Wildlife Management Area in southeastern Brazoria County, Texas. Peach Point Wildlife Management Area encompasses 4,174.5 ha and is bordered by the Intercoastal Waterway. The study grid was located about 2 km from this waterway and was <10 cm above sea level, which contributed substantially to inundation of the area. Vegetation on and near the grid was dominated by coastal prairie grasses and forbs, including spikegrass (*Distichlis spicata*), wiregrass (*Spartina patens*), sea oxeye daisy (*Borrichia frutescens*), and saltwort (*Batis maritima*). Other species occurred on <5% of the grid and included bulrush (*Scirpus robustus*), marsh elder (*Iva frutescens*), glasswort (*Salicornia*), and Carolina wolfberry (*Lycium carolinianum*).

Inundation of Study Area—The average yearly precipitation of the area is 133.35 cm/yr (data from the National Oceanic and Atmospheric Administration, Freeport 2NW weather station, located ca.10 km from Peach Point Wildlife Management Area). The study area received normal levels of precipitation during our May 2002 sampling trip; however, our August and December 2002 sampling trips occurred during a 6-month period of inundation (to the depth of 12 to 18 cm). Inundation was caused by heavy rainfall,

including a tropical storm in September 2002 (Fig. 1). By March 2003, the area was no longer flooded and the ground was dry.

Rodent Sampling—The rectangular grid was approximately 1.14 ha and comprised of 111 stations, spaced 10 m apart, with one Sherman live-trap per station. The southern border was irregularly shaped by the adjacent watercourse that fed into the Intercoastal Waterway. Due to inundation, not all trapping stations could be used during every trapping session (only 108 in December 2002). Mark-recapture sampling was conducted during 6 sessions (seasonally, ca. 3 to 4 mo apart) from May 2002 to August 2003. The population was sampled for 6 nights each trap session, except August and December 2002 (4 and 5 nights, respectively), by using a mixture of rolled oats and peanut butter as bait. All rodents captured were assigned a unique identification number by using toe-clipping or passive integrated transponder (PIT) tagging. Upon capture, we recorded identification number, weight, age (adult, subadult, or juvenile; determined by examining pelage, size, and weight), sex, reproductive condition, and trap station. Blood samples also were collected as part of another study (McIntyre et al., 2005). Animals were then released immediately at their sites of capture.

Rafts—Due to inundation of the terrain during sampling sessions in August and December 2002, we attached all of our traps to 30.5-cm × 15.2-cm × 3.8-cm Styrofoam platforms or ''rafts''. Each trap was secured to the raft with wire to ensure that it did not move or fall off. To prevent it from floating away, the raft was anchored to the wire survey flag marking the station. Each raft offered a 7-cm to 8-cm platform in front of the trap door, allowing individuals to climb completely onto the raft before entering the trap. All traps in August and December 2002 were on rafts.

Population Statistics—We used the Pollock and Otto (1983) population abundance estimation model (M_{bh}) in the software program MARK (www.warnercnr.colostate. edu/~gwhite/mark/mark.htm) to account for individual heterogeneity and trap response. Population densities were estimated by dividing the estimated population abundance by the estimated effective grid area. Effective grid area was estimated by extending the presumed grid boundaries in each direction (except into the watercourse, where there was no emergent vegetation) by a distance equal to one-half the mean maximum moved for that sampling session (using individuals with ≥3 captures) and then calculating the grid area based on the expanded boundaries. One-way analyses of variance (ANOVA) were used to determine whether maximum distances traveled were significantly different among the 3 sex-age groups (adult male, adult female, and subadult) during any trap session. If no significant difference was demonstrated, the same effective grid area was used for all 3 groups.

Home Range Estimation—Home range areas of individuals were estimated using the 100% minimum convex polygon (MCP) method (Mohr, 1947) in the CALHOME software program (Kie et al., 1996). We included only those individuals captured 3 or more times in one sampling session. These included a few individuals captured 3 or more times at the same trap station, resulting in an estimated home range area of 0. We included these instances of 0 home range so as to not upwardly bias home range estimates. Differences among sex-age groups (adult male, adult female, and subadult) and among sampling sessions were analyzed using unbalanced 2-way ANOVA, with probabilities estimated by 2,000 permutation iterations for each analysis after the model of Anderson and ter Braak (2003). If results of 2-way ANOVA were significant, we used the Hommel-Shaffer (improved Bonferroni) adjustment (Thorpe and Holland, 2000) to determine which sex-age group, session(s), or both significantly differed from the others. Statistical analyses were done using programs written in Matlab, version 6.5 (www. biol.ttu.edu/Strauss/Matlab/matlab.htm).

Population Turnover—We examined longevity and site fidelity indirectly. Sex and age of individuals encountered in more than one trap session were noted, as were any changes in their observed home-range size or location.

RESULTS—*Abundances and Densities*—The dominant small mammal species captured on our study grid was *O. palustris*. *Sigmodon hispidus* also was captured on the grid; however, its presence was minimal and sporadic (<2% of captures). We captured 162 *O. palustris* over 3,717 trap nights. The one-way ANOVA of maximum distance traveled by adult males, adult females, and subadults revealed no significant differences among groups or trapping sessions. Therefore, the effective grid size was assumed to be equal among groups during each trapping session and ranged from 1.18 ha in May 2002 to 1.26 ha in December 2002 and March 2003. Estimated densities of *O. palustris* ranged from a low of 28.8 ± 8.9/ha (mean ± *SE*), which occurred during an inundated period, to a high of 49.6 ± 0.6/ha during a non-inundated period (Fig. 1).

Home Ranges—Overlap among home ranges occurred both within and between the sexes and ages during all of the trapping sessions. There was no significant difference in home range size among these groups ($F = 2.23$, $df = 2$, $P = 0.108$) or interaction between group and season ($F = 1.13$, $df = 10$, $P = 0.270$). However, there was a significant difference among trap sessions ($F = 2.93$, $df = 5$, $P = 0.021$); the Hommel-Shaffer test revealed that home ranges during the May 2003 trap session (post-inundation) were significantly larger than those in all other months/sessions.

Population Turnover—We captured 162 *O. palustris* during this study: 147 (90.7%) were caught in only one trap session, indicating a high turnover rate. Of 14 individuals captured in more than one session, only one adult male was captured during 3 seasons. When the movements of these 14 recaptured individuals were examined, we observed no apparent pattern with respect to direction or distance for either sex. Although not significant (likely because of low sample sizes), males were nearly 4 times as likely as females to be encountered during more than one trap session.

DISCUSSION—*Oryzomys palustris* maintained a substantial population in a habitat that experienced long-term inundation (ground entirely submerged). Population densities did not differ significantly among sampling sessions or sex-age groups, although estimates were lower during and immediately following inundation. Maximum distance moved did not differ significantly among sessions or groups. Although home range sizes significantly differed among sessions, they did not differ among sex-age groups, and there was no significant interaction effect. An a posteriori examination of the among-session differ-

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ences indicated that only the home-range size during the May 2003 session was significantly different from all others. Because this session was well after the inundation period, we concluded that inundation had no effect on home ranges of *O. palustris* in this area.

Oryzomys palustris is known to build nests on the ground or attached to vegetation in areas that are predisposed to flooding (Wolfe, 1982*a*). Despite diligent searches, no nests were found on the grid during any trapping session. During March and May of 2003 (post-inundation), we observed subadults in their highest proportions of captures (36% and 37% of the captures, respectively). Given that weaning occurs roughly 11 to 20 d following birth (Hamilton, 1946; Park and Nowosielski-Slepowron, 1974), it is possible that *O. palustris* adults in this area constructed ground nests nearly simultaneously with the retreat of the water. This might explain the high proportion of subadults observed during March and May.

During periods of inundation, there was some tall, emergent vegetation left above the water level. It is possible that *O. palustris* used this vegetation to rest, feed, etc., although this was never observed either directly or indirectly (no chewed stalks were found).

Results of this study concur with those of Wolfe (1982*b*), but are particularly remarkable given that the period of inundation in our study was of a duration >5 mo, with the ground surface of the entire grid (and well beyond) submerged under several centimeters of water. Although the period of inundation was coupled with generally lower population densities, they were not significantly different from non-inundated periods. Thus, population dynamics of *O. palustris* seem to be little affected by inundation, even of a rather long duration.

LITERATURE CITED

ANDERSON, M. J., AND C. J. F. TER BRAAK. 2003. Permutations tests for multi-factorial analysis of variance. Journal of Statistical Computation and Simulation 73:85–113.

ESHER, R. J., J. L. WOLFE, AND J. N. LAYNE. 1978. Swimming behavior of rice rats (*Oryzomys palustris*) and cotton rats (*Sigmodon hispidus*). Journal of Mammalogy 59:551–558.

HAMILTON, W. J., JR. 1946. Habits of the swamp rice rat, *Oryzomys palustris palustris* (Harlan). American Midland Naturalist 36:730–736.

KAYS, R. W., AND D. E. WILSON. 2003. Mammals of North America. Princeton University Press, Princeton, New Jersey.

KIE, J. G., J. A. BALDWIN, AND C. J. EVANS. 1996. CALHOME: a program for estimating animal home ranges. Wildlife Society Bulletin 24:342–344.

MCINTYRE, N. E., Y. K. CHU, R. D. OWEN, A. A. ABUZEINEH, N. DE LA SANCHA, C. W. DICK, T. HOLSOBACK, R. A. NISBETT, AND C. JONSSON. 2005. A longitudinal study of Bayou virus, hosts, and habitat. American Journal of Tropical Medicine and Hygiene 73:1043–1049.

MOHR, C. O. 1947. Table of equivalent populations of North American small mammals. American Midland Naturalist 37:223–249.

PARK, A. W., AND B. J. A. NOWOSIELSKI-SLEPOWRON. 1972. The occurrence of a ''pale pelage'' mutant in the rice rat, *Oryzomys palustris natator* (Chapman), of the Dundee Colony. Zoologika Saugetierk 37:177–180.

POLLOCK, K. H., AND M. C. OTTO. 1983. Robust estimation of population size in closed animal populations from capture-recapture experiments. Biometrics 39:1035–1049.

THORPE, D. P., AND B. HOLLAND. 2000. Some multiple comparison procedures for variances from non-normal populations. Computational Statistics and Data Analysis 35:171–199.

WOLFE, J. L. 1982*a*. *Oryzomys palustris*. Mammalian Species 176:1–5.

WOLFE, J. L. 1982*b*. Effects of storms on rice rats inhabiting coastal marshes. Gulf Research Reports 7:169–170.