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Geographical extension of *Chaetodipus fallax* (Rodentia: Heteromyidae) in the Baja California Peninsula

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Abstract: We report two new locations for *Chaetodipus fallax* (Merriam 1889) in Baja California Sur, Mexico: the first, south of San Ignacio; and the second, in the plains of Magdalena Bay. These are the southernmost records for the presence of this species and broaden the species' previously known distribution range in ~400 km. We suggest that changes in weather conditions could explain the southward expansion of the distribution of *C. fallax* in Baja California Peninsula.

Keywords: adaptation; arid zones; desert; pocket mouse; recent range expansion.

The San Diego pocket mouse, *Chaetodipus fallax* (Merriam 1889), is distributed from southwestern California down to the central part of the Baja California Peninsula, Mexico (Lackey 1996, Patton and Álvarez-Castañeda 1999, Rios and Álvarez-Castañeda 2010, Figure 1). This rodent is one of the smallest species within the genus *Chaetodipus* (Rodentia: Heteromyidae) and occurs in a wide variety of temperate and warm arid habitats (Patton and Álvarez-Castañeda 1999). The range of *C. fallax* stretches from chaparral areas in the transverse ranges of southern California through coastal sage scrub and deserts of the Baja California Peninsula, including Cedros Island in the Pacific Ocean, 25 km off the peninsula.

The evaluation of the genetic structure of *Chaetodipus fallax* revealed an evolutionary divergence between subspecies, with a high genetic differentiation mostly between populations inhabiting the Vizcaino Desert and the central peninsula, possibly due to recent ecological mechanisms (Rios and Álvarez-Castañeda 2010). The aim of this Short Note is to report a large increase in the distribution range of *C. fallax*.

In summer 2013, we surveyed the status of mammals in Baja California Sur. Rodents were captured using Sherman live traps (2700 trap/night) baited with oats, following the recommendations of the Animal Care and Use Committee of the American Society of Mammalogists (Sikes et al. 2011). *Chaetodipus fallax* specimens were collected in only two of the 449 localities surveyed previously since 1991. These specimens were deposited in the Mammal Collection at the Centro de Investigaciones Biológicas del Noroeste (CIBNOR), La Paz, Mexico. Two males were collected from 10.6 km N, 19.3 km E San Ignacio, Baja California Sur (27.37832°, -112.6859°; CIB 22866–22867); one female from 9.6 km S, 16 km W Santa Rita, Baja California Sur (24.50919°, -111.62566°; CIB 24743). No reproductive data were available. As the condition of the skin of the specimens collected was poor, and as *C. fallax* is very similar to *Chaetodipus spinatus*, we used mtDNA for sequencing the cytochrome b gene (Cytb, 800 bp) as the basis for a correct identification.

The primer MVZ05 and MVZ16 for DNA cytochrome b was used (Smith and Patton 1993). The polymerase chain reaction (PCR) included 9.33 µl ddH_2O, 0.25 µl of each primer (10 nM), 0.187 µl dNTPs (0.4 nM), 0.375 µl $MgCl_2$ (3 mM), 0.1 µl Taq polymerase (platinum, Invitrogen, Carlsbad, CA), and 1×Taq buffer to a final volume of 12.5 µl. The amplification conditions included an initial 3-min denaturation at 94°C followed by 37 cycles of denaturation at 94°C for 45 s, 1-min annealing at 50°C, and 1-min extension at 72°C. The amplified products were purified using the QIAquick PCR purification kit (QIAGEN), and templates were cycle-sequenced using Big Dye terminator chemistry (Applied Biosystems Inc., Foster City, CA, USA). Sequences were run on an ABI 3730 sequencer (Applied

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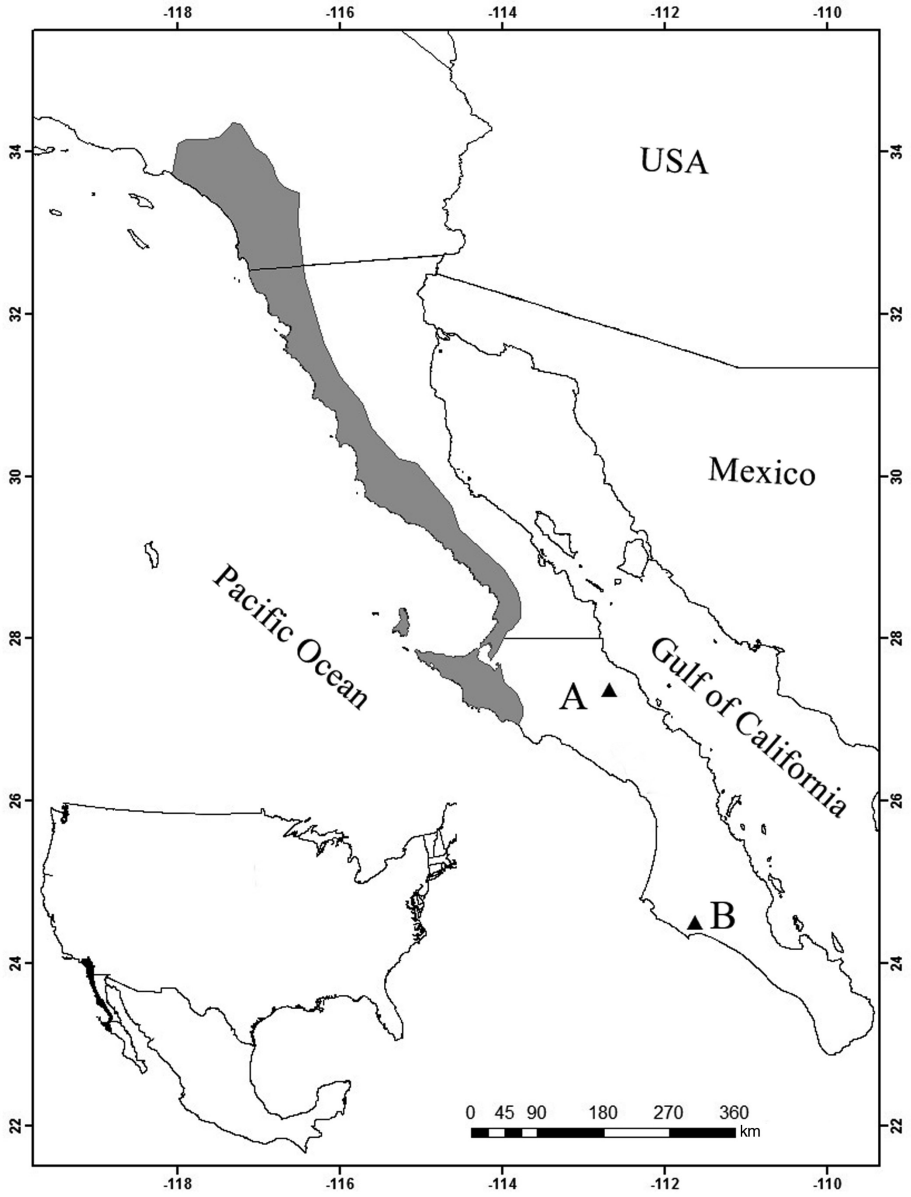

Figure 1: Geographical distribution of *Chaetodipus fallax*. Black triangles indicate new records in the Baja California Peninsula, México, reported in this study. (A) 10.6 km N, 19.3 km E of San Ignacio, Baja California Sur, and (B) 9.6 km S and 16 km W of Santa Rita, Baja California Sur.

Biosystems) at the Museum of Vertebrate Zoology. The *Chaetodipus fallax* sequences obtained were deposited in GenBank (KU172419). We have used the GenBank database (accession number GQ175268) and the sequences from Rios and Álvarez-Castañeda (2010) to confirm the genetic identification.

The analysis conducted revealed that the sequences of the specimens studied were 99% similar to those considered as *Chaetodipus fallax inopinus* by Rios and Álvarez-Castañeda (2010). This molecular result agrees with morphological traits, namely pelage color, which is as in *C. f. inopinus* – lighter in dorsal pelage near the ochraceus buff, and skull size, which is smaller than in *C. f. fallax* and *C. f. pallidus*.

The habitat in both the localities is the same, with the only difference being that in Santa Rita it is sandier and near to the coast. The two localities are located in an open plain with vegetation of desert scrub and very few stones. The specimens collected were associated with the following plant species: *Bursera laxiflora, Cercidium peninsulare, Esenbeckia hartmanii, Fouquieria peninsularis, Jatropha cinerea, Lycium brevipes, Mammillaria peninsularis, Machaerocereus gummosus, M. eruca, Opuntia comonduensis,* and *O. cholla*. Besides, *C. arenarius*, *Dipodomys*

merriami and *D. simulans* were collected in the same trap lines.

The sampling locality at 9.6 km S, 16 km W Santa Rita, Baja California Sur, is ~400 km south of the southern-most locality previously reported for the species (Álvarez-Castañeda et al. 2008). The importance of this new record lies in the fact that south of Vizcaino Desert is considered the southern distribution limit for several species. The Vizcaino Desert is the southern border of the distribution range of *Perognathus formosus* (Huey 1954), *P. longimembris* (Álvarez-Castañeda et al. 2001), and *Reithrodontomys megalotis* (Álvarez-Castañeda and Rios 2003); while being the northern limit for *Peromyscus eva* (Álvarez-Castañeda et al. 2010). The new data reported here strongly suggest that the distribution range of *Chaetodipus fallax* is likely similar to that of *Dipodomys simulans*: coastal areas from the western part of the Baja California Peninsula to Llanos de Magdalena in the central portion of Baja California Sur.

Two different explanations can be given in support of this finding. First, *Chaetodipus fallax* has inhabited this area for a long time, and some specimens have been misidentified as *Chaetodipus spinatus*, since both species are extremely similar, i.e. 10 specimens deposited at Texas Tech University (26284–26293) of 11 mi S Loreto, HWY 1, Baja California Sur, was originally designated as *Chaetodipus fallax inopinus*. However, after a revision of the specimens (STAC and Jorge Salazar) we determined that are *C. spinatus*. We believe that this hypothesis is highly unlikely as a number of experts in heteromiyd rodents have worked in the peninsula, and hence the possibility of misidentification seems extremely low. In this case, the detailed analyses of collection specimens in different museums prove that *C. fallax* cannot have this distribution range, but went unnoticed. We reviewed the 361 specimens of *C. spinatus* in the Mammal Collection at CIB considering the previous potential distribution of *C. fallax*, and no other specimens of the latter species were found. The second possibility is that the distribution range of *C. fallax* expanded southward in recent times. *C. fallax* was recorded in 1929 in Bahía Tortuga, at the westernmost part of the Baja California Peninsula (Nelson and Goldman 1929); in 2004, 173 km to the south, at Punta Abreojos (Rios and Álvarez-Castañeda 2010); and in this Short Note, in Santa Rita, ~400 km south of Punta Abreojos. Furthermore, the low capture success of this species during our 2013 survey and its absence during previous expeditions for over 20 years in the study region jointly support the recent-range-expansion hypothesis. Evidence accumulated in the last two decades suggests that communities of small mammals have modified their distribution ranges in relation to weather changes (Teta et al. 2014). Other heteromiyds with a documented range expansion in the Baja California Peninsula are *Perognathus longimembris,* to the south (Álvarez-Castañeda et al. 2001), and *Chaetodipus spinatus,* to the north (Linzey et al. 2008). The weather conditions allow us to suggest that the distribution of *C. fallax* is not restrained by geographic barriers. A similar distribution pattern is observed for other rodent species such as the kangaroo rat (*Dipodomys simulans*).

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