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Rodent density anomalies in scrub vegetation areas as a response to ENSO 1997-98 in Baja California Sur, Mexico

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RESUMEN

Para el Noroeste Mexicano, el ENSO tiene un efecto significativo en el patrón de lluvias y temperatura, dichos cambios afectan las actividades económicas, en las que podemos incluir la pesca y la agricultura. Poco se conoce acerca de cómo las diferencias ambientales influyen en el patrón de distribución y densidad poblacional de roedores a largo plazo, en hábitats desérticos de Norte América. En este estudio se presenta información de un estudio a largo plazo (octubre 1994- diciembre 1999) en dos áreas del oeste de La Paz, Baja California Sur, México. Una de ellas, un área natural preservada y la otra sometida a pastoreo. Ambos sitios presentan el mismo tipo de vegetación, suelo y clima. En cada área se colocó un cuadrante de (0.49 ha); los muestreos se realizaron por cinco noches consecutivas durante cada mes en cinco años de estudio. Se aplicó el método de captura y recaptura, y se compararon las densidades poblacionales en ambos sitios.

El evento de El Niño en la región de La Paz no produjo gran cantidad de lluvia, en comparación con otras regiones de México. Para el área sometida a pastoreo, las anomalías mensuales de la densidad de roedores mostraron una respuesta sensible al ENSO, mientras que para el área preservada, éste no fue tan notable. El análisis mostró que la población de roedores en la zona con vegetación natural preservada tuvo una variación que puede relacionarse al efecto de la precipitación. En el área con presencia de pastoreo, el efecto fue mucho más marcado. Durante la estación lluviosa, la población se incrementa, pero en la estación seca, la población disminuye notablemente; este efecto a la población de roedores se observa en la mayoría de los últimos meses de estudio, y se relaciona con la menor cantidad de especie perennes. Consideramos que para las áreas desérticas alteradas, la estación seca del ENSO es la de mayor importancia para la densidad de roedores.

PALABRAS CLAVE: ENSO, Heteromyidae, roedores, matorral sarcocaule, Baja California Sur.

ABSTRACT

ENSO significantly changed the annual patterns of rainfall and temperature for northwestern Mexico. Little is known about how seasonal environmental differences influence the long-term pattern of distribution and density of rodents in desert habitats of North America. We report data from a long-term study (October 1994-December 1999) of two areas west of La Paz, Baja California Sur, Mexico. One is a natural preserve and the other is grazing land. Both have the same original vegetation, soil, and weather. Densities of rodent populations in both areas were compared.

El Niño's impact in La Paz region did not increase rainfall, as in other areas of Mexico. In the grazing area, monthly anomalies of rodent density showed a significant impact from the ENSO event, but the preserve showed less impact. Rodent population variations can be related to the precipitation effect. In the grazing area, the effect is much stronger. During the rainy season, population increases, but in the dry period, the population strongly declines. The effect lasts many months, and is related to the reduced number of perennial species. For altered desert areas, the dry season of ENSO was the most significance part of the event.

KEY WORDS: ENSO, heteromyids, rodents, scrub vegetation, Baja California Sur.

INTRODUCTION

ENSO (El Niño and La Niña) episodes cause changes in global atmospheric circulation including precipitation and temperature anomalies, which strongly depend on season and geographical location (Nicholls, 1988). The occurrence of El Niño or La Niña does not guarantee a specific precipitation or temperature response, but it increases the likelihood that a deviation from normal will occur. El Niño-Southern Oscillation (ENSO) significantly changes the annual pattern of rainfall and temperature in northwestern Mexico (Magaña *et al.*, 1999). This affects many economic activities, especially fishing (Lluch-Cota *et al.*, 1995) and agriculture (Conde *et al.*, 1999), as well as desertification (Salinas Zavala *et al.*, 1998). Here we consider the responses of small animal populations to vegetation changes. The small animal population has a variety of life history strategies, including widely different reproductive cycles and longevity, which play a key role in determining the sensitivity of a given species to environmental changes occasioned by ENSO. Weather variations may be a factor that causes variations in rodent population size and their use of resources (Ostfeld *et al.*, 1985). However, but little is known about how seasonal environmental differences may influence distribution and density in desert habitats of North America over the long-term.

Heteromyids have considerable ecological importance because these rodents are primary consumers. Species' population size is directly influenced by environmental factors, such as temperature and precipitation (Brown *et al.*, 1979; French *et al.*, 1974; Price, 1978; Reichman and Van de Graaff, 1975).

We are interested in understanding the patterns of population variation in relation to the vegetation changes in two related areas as a result of the variation in precipitation occasioned by ENSO. We report data from a long term study October 1994-December 1999, including ENSO 1997-1998.

METHODOLOGY

The study areas were located in El Comitan, an area 15 km west of La Paz, Baja California Sur, Mexico and in Brisamar, north of El Comitan. El Comitan includes a natural preserve, which has been protected from cattle grazing since 1985. Brisamar is a grazing area. Both areas have semiarid thorn-scrub vegetation consisting of spiny and sarcocaulescent plants, including representative families, such as are Euphorbiaceae, Cactaceae, and Leguminosae (León de La Luz *et al.*, 1996). Both areas have sandy soil with the same climate and similar rainfall patterns (SPP, 1981).

Small mammals were trapped from October 1994 to September 1999 using Sherman-type live traps set in a total of two grids, 70 m x 70 m (0.49 ha). Traps were set in 10 x 10 arrays, 10 m apart. The size of the grid was based on the minimum trapping area necessary to detect members of the most common small mammals during periods of low density (Meserve and Le Boulenge, 1987). Trapping was performed during five consecutive nights each month. Standard mark and recapture techniques were used. Toe clippings marked animals, and a record of characteristics was kept (species, weight, sex, and reproductive condition). Sherman traps were baited with oats in the late afternoon and inspected the next morning. Each area was analyzed by monthly anomalies in rodent population density. Density was calculated as the average number of rodents collected during the five trapping days of each month.

To compare densities of rodent populations, we used averaged capture data for each month. For the La Paz region, El Niño started in August 1997. The area experienced two rainy seasons and two dry seasons (January 1995 through July 1997) before the ENSO event (August 1997 through October 1998). A paired Student's *t*-test was used for the analysis of population densities before and during the El Niño event.

RESULTS

We report only the general analysis of the first five years, October 1994 through September 1999 (60 months). The capture effort involved 300 nights with 29 400 night-traps in total. In the preserve, there were 2232 captures of 711 different individuals belonging to five rodent species. In the grazing area, there were 3605 captures of 790 individuals belonging to five rodent species. Four species of heteromyids were found. In the preserve, the frequency distribution was *Chaetodipus arenarius* (59%), *C. baileyi* (31%), *Peromyscus eva* (6%), *C. spinatus* (3%), with *Dipodomys merriami* (1%) collected only occasionally. In the grazing area, the frequency distribution was *Chaetodipus arenarius* (45%), *C. baileyi* (34%), *Dipodomys merriami* (18%), *Peromyscus eva* (2%), with *C. spinatus* (1%) collected occasionally.

Vegetation cover was different at each site. The grazing area had 10% less perennial vegetation cover and 30% more grass cover. It also had more open areas, with more annual species.

El Niño's impact in the La Paz region had no great influence on rainfall, unlike other sites in Mexico. Here, there are two markedly different seasons, dry (February – July) and rainy season (August-January), according to García (1973). 1994 and 1995 were years with average precipitation (179 and 145 mm); 1996 had a high (242-mm) level caused by hurricane Fausto. In 1997, rain was less abundant and more dispersed over time (194 mm), and 1998 was again abundant (241 mm), caused by hurricane Isis. However, the bulk of the rainfall was concentrated in two events, at the beginning of the hurricane season (August September). 1999 had the lowest rainfall of the five years (44-mm). The ENSO event altered the pattern of precipitation, displacing it towards the summer, mainly in July and September (Figure 1).

Anomalies analysis. In the grazing area, monthly anomalies of rodent density did not show a pattern for the three years (1995-1997) prior to the ENSO event. There were some differences between months with major rodent densities. In 1995 (May-August), there were a greater number of captures. In 1996 and 1997, there was a different pattern. Anomalies were positive in December 1996 and January 1997. During the majority of months of 1997, the densities of rodents increased, with peaks in March and April. September 1997 had a decline in November; December had a large increase (Figure 1). From January 1998 to

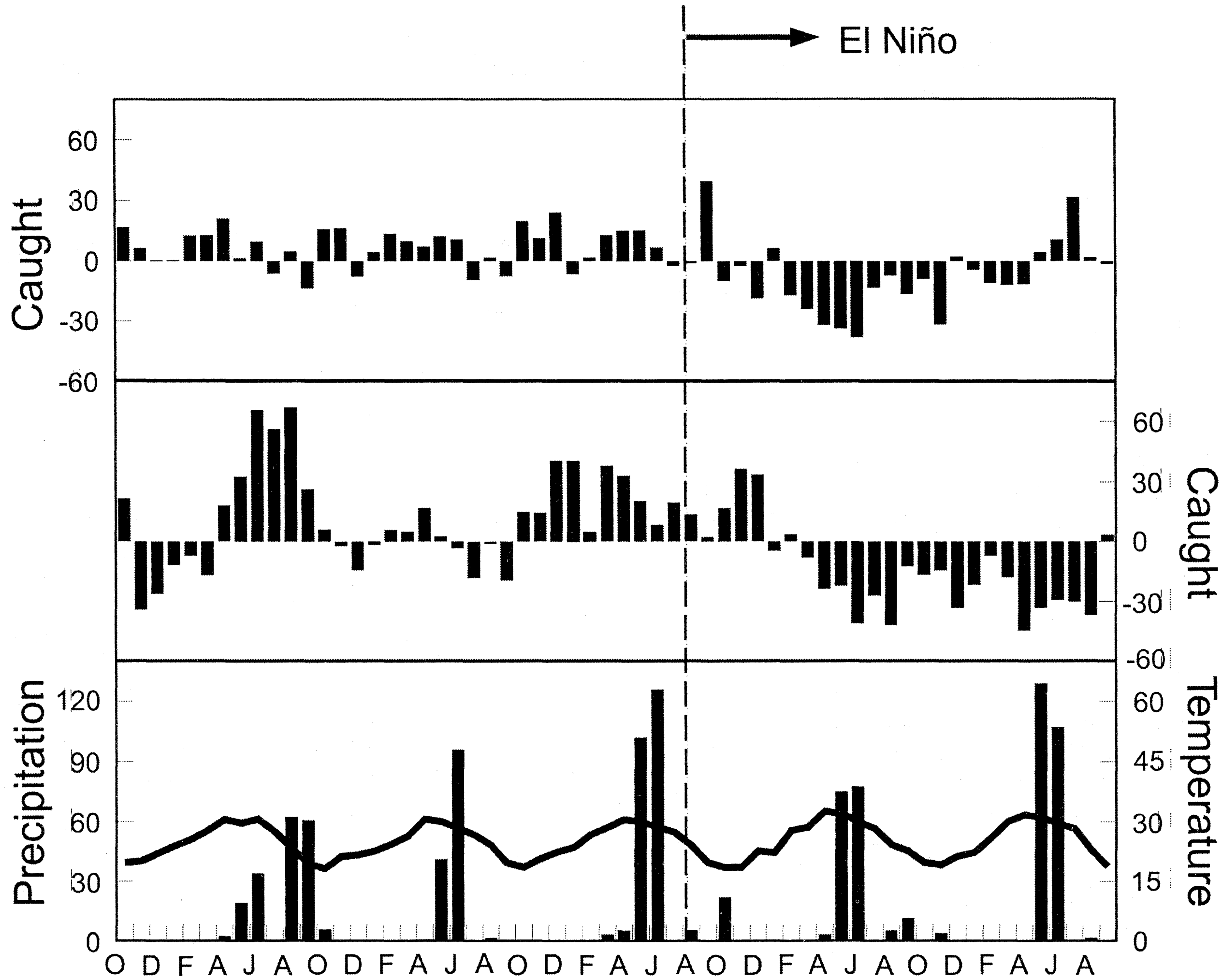

Fig. 1. Variation of density in rodent populations, temperature and precipitation from October 1994 to September 1999. A) Anomalies of rodent density in the grazing area. B) Anomalies of rodent density in the preserve area. C) Graphic of the temperature (°C) and precipitation (mm) for the study area.

August 1999, the anomalies were negative (captures were lower than the annual average). The drastic changes occurred in June and August 1998. For the year 1999 the major decrease were in April, May and August, whereas during September to November the anomalies were positive.

The analysis of population density before the onset of El Niño (22 months) and during El Niño (22 months) had significant differences (t =2.90; P=0.04). In the preserve area, pre-ENSO months showed a cyclical pattern of rodent abundance. Most of the months had positive anomalies, except during July, September and December. A similar pattern occurred in 1996, where as the only months with negative anomalies were July, September, and November. Curiously, December was the month when more rodents were caught. In 1997, rodent density had a similar pattern, but in September, a peak occurred (highest level in five years). Subsequently, during the last months of that year, the anomalies were negative. The same pattern continued during all months of 1998 and part of 1999. The most affected periods were February-June and September-November. Starting from May 1999, positive anomalies were observed mainly in July. Statistical analysis shows significant differences (t =2.44; P=0.01) between the period before and during the ENSO event.

DISCUSSION

The region surrounding La Paz is a tropical desert bordered by the Gulf of California to the north and east and the Pacific ocean (75 km) to the west. It is subject to occasional heavy rainfall from tropical storms, particularly hurricanes. For the same geographical reason, the area is most vulnerable to changes in ocean currents caused by ENSO events. Precipitation data of the pre-ENSO years is compared with the ENSO years and shows that the ENSO event brought less rainfall than average to the region, in contrast with other regions in Mexico. During El Niño 1997, rainfall was less than normal (205 mm, García, 1973). During La Niña 1998, the rainfall was abundant. El Niño years are usually dry, however the averages from 1997 to 1999 were lower than the average for the region. For that reason, we believe that the ENSO event did not have a significant effect on the vegetation and the rodent populations. In contrast to our results, other researchers (Lima and Jaksic, 1998; Meserve *et al.*, 1995) mentioned that ENSO events bring dramatic density fluctuations to the rodent populations in semiarid regions of western South America.

For heteromyids species, we observed that the populations are sensitive to changes in habitat structure. The grazing area responded dramatically to the weather changes, with rodent population densities strongly increasing after a rainy year and declining after a dry year. The preserve appeared to be buffered to the weather changes, with less fluctuation between wet and dry years, but with a negative response in the months after El Niño.

Since the weather pattern is the same in both areas, the different response is most likely related to the differences in vegetation cover. In the grazing area, the rainy season increases annual plants exponentially, with a great increase in seed production the following year. Seeds support rodent population, but these species overfeed on seeds reducing the store of seeds in the soil necessary for the following year of annuals. This, in turn, leads to reduced rodent populations.

The preserve area is characterized more by dry-tropical vegetative elements and flowers more-or-less continuously throughout the year (Carabias-Lillo and Guevara-Sada, 1985). Grasses are a reduced component of the vegetation, so the rainy season does not increase annual plants exponentially and rodents rely on the perennials. Consequently, fluctuations of the rodent population are attenuated.

The analysis of these five years show that rodent populations of natural vegetation zones have variations that can be related to precipitation. In grazing areas, the added effect of the ENSO event is strong, fluctuating upwards in the rainy season and downwards in the dry season ($p < 0.05$). We believe that for altered desert areas, the dry season of the ENSO cycle is the most significant effect on the rodent population. We may be able to predict rodent population density during future ENSO events.

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