12-2013

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The Southwestern Naturalist 58(4): 431–434 December 2013

ABUNDANCE AND SIZE OF SAND CRABS, *LEPIDOPA BENEDICTI* (DECAPODA: ALBUNEIDAE), IN SOUTHERN TEXAS

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Abstract—Albuneid sand crabs are found in sandy beaches around the world, but little is known about the basic biology of any species in the family. We sampled sand crabs, *Lepidopa benedicti*, for 2 years at South Padre Island, Texas, at two locations: one developed site near the town, where recreational use is high and one undeveloped site away from the town, where recreational use is lower. We hypothesized that sand crabs would be less abundant and smaller at the developed site than at the undeveloped one. Densities were highest in summer and lowest in winter but did not differ between the two sites. There was no difference in size of individuals at the two locations. Females were significantly more common and larger than males. No ovigerous female was discovered at either location over 2 years of sampling. Individuals at South Padre Island are consistently smaller than those recorded from the northern Gulf of Mexico and Atlantic Ocean, suggesting the region might have habitat that is low quality for the species.

Resumen—Los cangrejos de arena Albunéidos se encuentran en playas arenosas en todo el mundo, sin embargo se sabe muy poco sobre la biología básica de las especies en la familia. Muestreamos cangrejos de arena, *Lepidopa benedicti*, durante 2 años en la isla South Padre, estado de Texas, en dos lugares: un sitio desarrollado cerca de la ciudad con uso recreativo alto, y otro sitio no desarrollado alejado de la ciudad con menos uso recreativo. Nuestra hipótesis fue que los cangrejos de arena serían menos abundantes y más pequeños en el sitio con recreo más alto comparado con el de recreo bajo. La densidad de los cangrejos de arena fue más alta en verano y más baja en invierno, pero no difirió entre los dos sitios. No hubo diferencia en el tamaño de los individuos entre los dos sitios. Las hembras fueron significativamente más comunes y más grandes que los machos. No se encontró ni una sola hembra ovígera en ningún sitio durante los 2 años de muestreo. Los individuos en la isla de South Padre son consistentemente más pequeños que los registrados en el norte del Golfo de México y en el océano Atlántico, lo que sugiere que la región podría presentar un hábitat de baja calidad para la especie.

Sand crabs (Decapoda: Albuneidae) live in beach habitats worldwide (Boyko, 2002). Because they leave no visible sign to casual observers of their presence in the sand, they are easily overlooked. Boyko (2002) thoroughly revised the taxonomy of the albuneids, and Boyko and Harvey (2009) performed a cladistic analysis using morphological characters that provided detailed phylogenies for all species in the family. There is little information about the natural history or ecology of any albuneid species.

Sand crabs are obligate diggers (Faulkes and Paul, 1997; Dugan et al., 2000; Boyko, 2002) and require fine sand to live. Sandy beaches are patchy habitats that are often separated from each other by many miles. Such isolation should limit gene flow and promote allopatric speciation, but some sand crabs have wide-ranging distributions, and their biogeography is often difficult to explain (Boyko and Harvey, 2009). Some marine invertebrates overcome this problem by having a dispersive larval stage (Pechenik, 1999; Grantham et al., 2003). Albuneid sand crabs do have a pelagic larval phase (Knight, 1970; Stuck and Truesdale, 1986), but this alone does not ensure gene flow between populations (Dawson et al., 2011). For example, mole crabs (Decapoda: Hippidae) inhabit sandy beaches alongside albuneids. Mole crabs also have pelagic larvae that persist for weeks (Rees, 1959; Israel et al., 2006) to months (Efford, 1970; Siddiqui and Ghory, 2006), but there is little gene flow between discontinuous hippid populations (Tam et al., 1996; Dawson et al., 2011) and only sporadic recruitment along adjacent ones (Sorte et al., 2001).

The ignorance of the ecology of sand crabs, combined with the isolation of each population, could make albuneids vulnerable to human impacts on beach habitat. Beaches are valued for recreational and tourism opportunities (Vaske et al., 1992), and even moderate use of beaches by humans can affect animals living in them. Some species of tiger beetles (Cicindelidae), for instance,

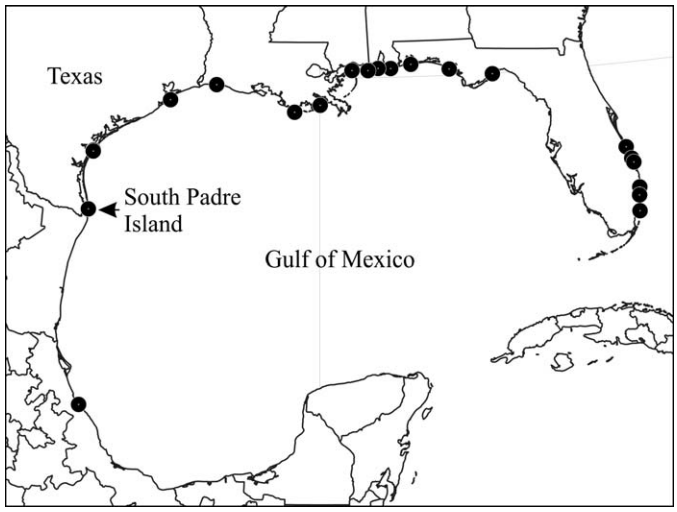

Fig. 1—Distribution of *Lepidopa benedicti*. One position is shown for each county or parish.

are endangered in part due to humans using beaches and sandy habitat in which the larvae of beetles live (Knisley and Hill, 1992; Arndt et al., 2005; Van Dam and Van Dam, 2008; Cornelisse and Hafernik, 2009). Similarly, beaches are affected by oil spills, such as the Deepwater Horizon oil spill in the Gulf of Mexico in 2010 (Kerr et al., 2010).

We examined the abundance of the sand crab *Lepidopa benedicti* on South Padre Island, Texas. Southern Texas is near the southwestern limit of the distribution of *L. benedicti* (Fig. 1), sometimes occurring in sympatry with *L. websteri* (Boyko, 2002). South Padre Island also is a popular tourist destination. We hypothesized that, if heavy use of beaches affected the habitat of the sand crab, the southern developed site would have fewer individuals per transect, fewer reproductive individuals, and smaller individuals. Growth can be slowed by diet and environmental factors in other decapod crustacean species (e.g., Oliveira and Fabião, 1998; Seitz et al., 2005).

Materials and Methods—We collected sand crabs (*Lepidopa benedicti*, family Albuneidae) at South Padre Island, Texas. We collected data monthly from September 2009–August 2011, alternating between the two locations, but, unfortunately, lost data from July 2010.

The southern location (adjacent to the Coastal Studies Laboratory, University of Texas-Pan American: 26°4′30.59″N, 97°9′26.59″W) is within a trailer park at the developed southern end of the island. This area of the beach has many hotels and is used extensively for recreation by humans. The more northern location (near Beach Exit 6; 26°12′3.65″N, 97°10′42.01″W) is ca. 6 km from any large buildings and is used more moderately.

At each site, we dug 10-m transects at the top of the swash zone (parallel to the surf) with shovels. We overturned sand and examined it for any *L. benedicti*. We also collected any *L. benedicti* that emerged within the trench when it filled with water. The carapace length, sex, and reproductive status of each sand crab found were recorded on site. Sample sizes vary among these measures because some crabs were damaged by the shovel, or escaped capture, preventing size or sex from being measured.

Data on size and sex of individuals from the entire distribution of *Lepidopa benedicti* were taken from Boyko (2002). The distribution was divided into three regions: the Atlantic coastline of Florida; the coastline of northern Gulf of Mexico along Florida, Alabama, Mississippi, and Louisiana; and the coastline of western Gulf of Mexico along Texas and Mexico.

Statistical analyses were conducted using PASW Statistics 18.0.0 (SPSS Inc., Armonk, New York) and Origin 7 SR2 (OriginLab Corporation, Northampton, Massachusetts). Carapace lengths were analyzed using parametric statistics. Data on density were not normally distributed; the mode number of sand crabs per transect was zero. Because it was not possible to transform the dataset to approximate a normal distribution, we used nonparametric tests to analyze density. Density was analyzed by season: spring = March–May; summer = June–August; fall = September–November; winter = December–February. The average density of all transects at each location each month was averaged in the analysis to avoid pseudoreplication.

Results—*Lepidopa benedicti* are typically found in low densities at South Padre Island (mean per 10-m transect = 1.37, $SD = 2.24$, $n = 82$). The mode per 10-m transect is zero individuals. Densities did not differ between the undeveloped northern site and the developed southern site (Mann-Whitney U test, $U_A = 109$, $z = -0.13$, $P = 0.90$). *Lepidopa benedicti* are not equally abundant throughout the year (Fig. 2; independent samples Kruskal-Wallis test, $\chi^2 = 8.92$, $P = 0.03$). Densities are greatest in summer and lowest in winter. Nevertheless, even accounting for the annual seasonal cycle, density fluctuates substantially. No *L. benedicti* was found for several months in the winter of 2009–2010, for example. This may be related to a harmful algal bloom that occurred in the waters around South Padre Island in November and December 2009 (Texas

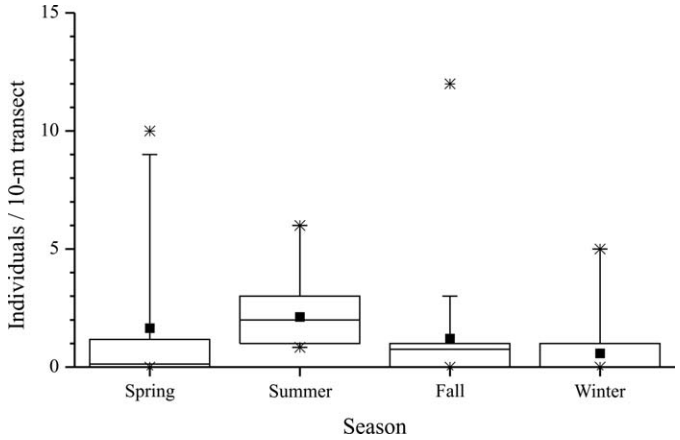

Fig. 2—Box plot of density of *Lepidopa benedicti* from South Padre Island, Texas (all transects). Spring = March–May; summer = June–August; fall = September–November; winter = December–February. Solid square = mean; horizontal line in box = median; box = 50% of data; vertical line = 95% of data; asterisk = minimum and maximum.

Parks and Wildlife Department, http://www.tpwd.state.tx.us/landwater/water/environconcerns/hab/redtide/status.phtml). Many brachyuran crabs were found dead on the beaches during these months, apparently killed by the bloom, although mole crabs (*Emerita benedicti*) continued to be found during this period.

Carapace length of individuals at South Padre Island did not vary among seasons (full factorial general linear model, $F_{15,3} = 0.47$, $P = 0.71$) or location (full factorial general linear model, $F_{15,1} = 2.51$, $P = 0.12$). Carapace length differs across the range of the species (Fig. 3; full factorial analysis of variance, ANOVA, $F_{3,1} = 22.08$, $P < 0.01$). Individuals from the Atlantic are significantly larger than those from both regions of Gulf of Mexico (Tukey's HSD, $P = 0.03$), and those from the northern Gulf of Mexico are larger than those from the western Gulf of Mexico (Tukey's HSD, $P < 0.01$). Size of the carapace of individuals in this study did not differ significantly in size from those previously recorded along the western Gulf of Mexico (Tukey's HSD, $P = 0.59$). Females were significantly larger than males at South Padre Island (Fig. 3a; $t_{117} = -3.47$, $P = 0.00074$) and across the entire distribution (Fig. 3b–d; full factorial ANOVA, $F_{1,1} = 16.74$, $P < 0.01$). The sex ratio at South Padre Island was significantly female-biased, with 63% females ($\chi^2 = 10.17$, $df = 1$, $P = 0.0014$). No ovigerous *L. benedicti* was found during this project.

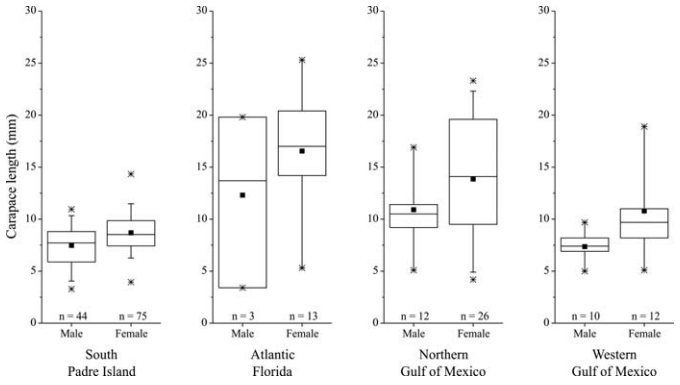

Fig. 3—Box plots of carapace length of *Lepidopa benedicti* from South Padre Island, Texas, the Atlantic coastline of Florida, the northern Gulf of Mexico coastline of Florida, Alabama, Mississippi, and Louisiana, and the western Gulf of Mexico coastline of Texas and Mexico. Solid square = mean; horizontal line in box = median; box = 50% of data; vertical line = 95% of data; asterisk = minimum and maximum.

Discussion—Boyko (2002) noted that albuneids are often rare and difficult to find. *Lepidopa benedicti* follows this trend. Even at the highest densities we found, it is difficult to envision how males and females find each other to mate, given their small size and apparently limited mobility (a linear velocity of 3–6 cm/h for *L. websteri*; Gingras et al., 2008) and with potential sensory cues for mating being either limited by digging (e.g., visual cues blocked by sand) or difficult to locate in the dynamic beach environment (e.g., dispersal of olfactory cues by turbulent flow of water).

There were some differences between this study and a previous one that also examined individuals from South Padre Island (Nasir and Faulkes, 2011). First, females were significantly larger than males in this study. The previous study found no significant difference in size between the sexes, although the trend in that study was towards females being larger than males. Second, the sex ratio was female-biased in this study, whereas the previous study found an even sex ratio (Nasir and Faulkes, 2011). Some of these discrepancies might be due to the larger sample size (119 versus 69 individuals) and increased statistical power in our study.

Sand crabs from the western Gulf of Mexico, including South Padre Island, are significantly smaller than those recorded for other regions within the range, particularly Atlantic Florida (Boyko, 2002). Smaller size implies reduced fitness, because female size is correlated with fecundity in crustaceans (Blueweiss et al., 1978; Corey and Reid, 1991; Reid and Corey, 1991*a*, 1991*b*). This suggests two hypotheses. First, the western Gulf of Mexico might be poorer habitat for *L. benedicti* than the northern Gulf of Mexico or the Atlantic coastline, resulting in either lower rates of growth or shorter life spans. The hypothesis of poor habitat also might explain why no ovigerous female was found at South Padre Island. *Lepidopa benedicti* has a pelagic larval stage (Stuck and Truesdale, 1986), so it is possible that South Padre Island is a population sink for the species, and recruitment is occurring from a breeding population elsewhere. The dispersal of larvae of species of *Emerita*, the most comparable genus for which there are data, tends to be limited (Tam et al., 1996; Sorte et al., 2001; Subramoniam and Gunamalai, 2003; Dawson et al., 2011), thus arguing against the hypothesis. If recruitment into the population at South Padre Island is occurring locally, retention of eggs in *L. benedicti* might be short, or ovigerous females might be in deeper water. Second, there might be selective pressures on sizes, or genetic drift, that has caused genetic differences between the populations in Texas and Florida. Ecological and genetic comparisons of populations spanning the complete distribution of *L. benedicti* would allow these hypotheses to be tested.

Lepidopa benedicti do not differ significantly in abundance or size between developed and undeveloped locations on South Padre Island. This is consistent with the hypothesis that this species is not affected by recreational use of beaches by humans. Collection at more paired developed and undeveloped locations is needed to test this more rigorously.

J. H. Murph was supported by a National Science Foundation Research Experience for Undergraduates Site grant (award DBI-0649273). We thank C. Ballesteros for helping collect sand crabs, and T. P. Feria for translating the abstract into Spanish. This is

contribution no. CSS 2012-01 from the Center for Subtropical Studies, University of Texas-Pan American, Edinburg.

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Submitted 26 September 2011. Accepted 31 January 2014.
Associate Editor was James H. Kennedy.