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SEA STARS (ECHINODERMATA: ASTEROIDEA) IN ROCKY REEFS OF GUADALUPE ISLAND, NORTHWEST MÉXICO

Estrellas de mar (Echinodermata: Asteroidea) en arrecifes rocosos de Isla Guadalupe, Noroeste de México

RESUMEN. El objetivo del trabajo fue describir la estructura comunitaria de las estrellas de mar en Isla Guadalupe, (28° N - 29° N), situada al oeste de la Península de Baja California. La zona fue visitada en Septiembre de 2008 y se hicieron 64 censos en 16 sitios (3,200 m^2 revisados), tanto en áreas someras (0 a 10 m) como profundas (11 a 20 m). A partir de los conteos se calcularon los descriptores comunitarios de densidad y riqueza, diversidad (H') y uniformidad (J'). En la isla solo fueron observadas las especies *Astrometis sertulifera*, *Pisaster giganteus* y *Linckia columbiae*. El número total de individuos encontrados fue de siete y dada la baja abundancia, no se detectaron diferencias significativas entre sitios o niveles de profundidad con ninguno de los índices. No hay explicación para el bajo número de estrellas de mar en la zona de trabajo, pero considerando los bajos números de las poblaciones y que Isla Guadalupe es una Reserva de la Biosfera, se recomienda no otorgar permisos para extracción de estrellas de mar en la zona, dado que las especies encontradas forman parte del mercado de especies de ornato.

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Information on reef-associated sea stars (Echinodermata: Asteroidea) in the Mexican Pacific is detailed for tropical environments as evidenced by numerous species listings (Honey-Escandón *et al*., 2008), taxonomic monographs (Cintra-Buenrostro, 2001), and data on community structure (Herrero-Pérezrul *et al*., 2008). However, there is still a dearth of information for temperate Pacific reefs of México, as there is not a single paper covering aspects of abundance or distribution of this fauna, but isolated references and records from dredges and trawls mostly conducted in the early and mid-1900s (Maluf, 1988). The study of sea stars in subtropical and temperate environments is relevant because their usually high numbers and biomass, combined with their varied diet that allows them to integrate several trophic guilds (from detritivores to carnivores), makes them a key element in energy transfer along trophic webs (Micheli & Halpern, 2005).

The objective of this paper is to improve our understanding of the temperate starfish assemblages in western México by analyzing the community structure of this taxon at the oceanic Guadalupe Island (Fig. 1), located 270 km west of the Baja California Peninsula. This area was declared a Biosphere Reserve in 2005, and has become famous by the presence of healthy populations of marine mammals, birds and white sharks, as well as an important fishing ground for abalone, lobster, sea cucumbers and other resources (Santos del Prado & Peters, 2008). The field work was performed during a six days visit (September 19-24, 2008). We conducted visual surveys in 16 sites around the island (Fig. 1). At each site we counted sea stars inside 25 x 2 m belt transects, placed parallel to the coastline and at two depth levels: “shallow” (-2 to -10 m depth), and “deep” (-11 to -20 m); as the protocol involved two transects at each deph/site, there was a total of 64 census, covering a total reef surface of 3,200 m^2. From these data we calculated the following ecological indices: population density abundance (individuals per 50 m^2 transect), richness (number of species per transect), Shannon's diversity (H´, base 10), and Pielou evenness (J´) as well as their average and standard errors for the island. We planned to perform statistical tests with all ecological variables in order to compare among sites and between depth levels, however the number of starfishes found in the transects was so low (see below) that it precluded the application of any test.

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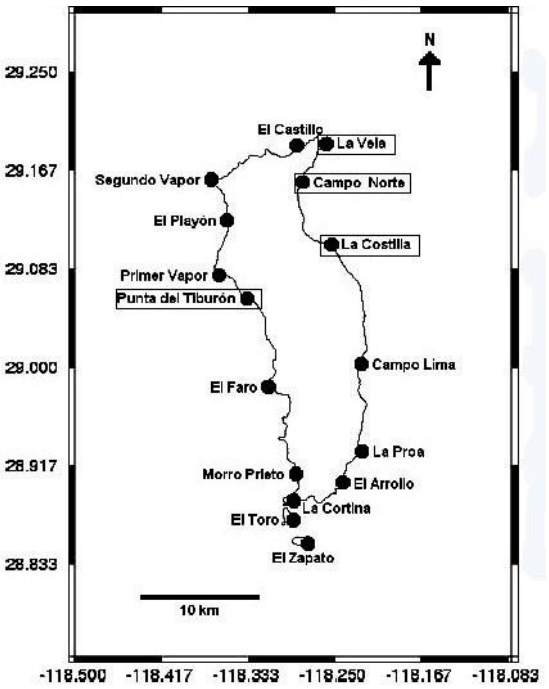

Figure 1. Guadalupe island, México, indicating the locations that were surveyed in September 2008. Boxes indicate the sites where sea stars were observed.

We observed only three species of sea stars at Guadalupe Island: *Linckia columbiae* Gray, 1840, *Astrometis sertulifera* (Xantus, 1860) and *Pisaster giganteus* (Stimpson, 1857). According to Maluf (1988) the first two taxa have a distribution span from California (U.S.A) to the Galápagos Islands (Ecuador), and the latter ranges from Vancouver Island (Canada) to Cedros Island (México). Only seven individuals were found in the 64 transects (average of 0.109 ± 0.050 ind/50 m^2); four of them were *A. sertulifera*, which was the most abundant species (0.062 ± 0.038 ind/50 m^2) and appeared at La Vela and La Costilla (northeast sector of the island). Of the remainder, *L. columbiae* (average of 0.016 ± 0.016 ind/50 m^2) were seen at Punta del Tiburón (west), and *P. giganteus* (average of 0.031 ± 0.021 ind/50 m^2) at Punta del Tiburón and Campo Norte. Latitude may have influence on the pre- sence of the sea stars as no individuals were sighted south of 29° N (Fig. 1). This trend points out to a common preference of these asteroids to live in lower temperatures becau- se sea surface temperature in Guadalupe Island is about 1 °C colder in the north than in the south (Santos del Prado & Peters, 2008), a probable consequence of the direct effect of the California Current. Finally, when considering depth levels *L. columbiae* and *P. giganteus* were found only between 2 and 10 m, while *A. sertulifera* appeared only in the deep zone (> 10 m).

The figures presented above are remarkably low. As a comparison, *L. columbiae* has a density of 0.13 ind/ 50 m^2 in the Galápagos Islands (Edgar *et al*., 2004), about eight times higher than at Guadalupe, and *P. giganteus* populations in California can be at least one order of magnitude denser (Bomkamp *et al*., 2004). It is very difficult to assess why sea stars were so uncommon at Guadalupe Island since *P. giganteus* and *A. sertulifera* are voracious carnivores of mollusks, sea urchins and even fishes (Schmitt, 1982), all of which are abundant in the study area, whilst *L. columbiae* is a detritivore (Cintra-Buenrostro *et al*., 2008). Lack of suitable habitat for the species is not the answer as they are generalists and can be found in mussel beds, kelp beds, and even in rock barrens (Ricketts *et al*., 1992). Another possibility is that Guadalupe Island is located quite near of the northern or southern distribution limit of the three species (Maluf, 1988), and the suboptimal environmental conditions may cause physiological problems as those reported to occur in northern populations of the tropical seastar *Phataria unifascialis* (Gray, 1840) in the Gulf of California (Morgan & Cowles, 1997). Regarding predators, Newsome *et al*. (2009) indicated that *P. giganteus* is preyed upon by California sea otters, *Enhydra lutris* (L. 1758), but nevertheless this mammal is absent at Guadalupe Island, and there is no report of another significant sea star consumer known for this location. Fi- nally, it is possible that the seastars carry out a bathymetric migration either for food, reproduction, or to avoid warmer water in summer, as all the species found are able to inhabit reefs deeper than -100 m (Maluf, 1988), and temperature in shallow water can increase several degrees during summer.

We suggest that the most feasible explanation to our findings is that the low population density observed results from the erratic recruitment that characterizes sea stars, a con-

dition which brings years of remarkable abundance, and others where local populations can become almost extinct (Uthicke *et al*., 2009). It is noteworthy that in other isolated islands of western México like Socorro and San Benedicto (Revillagigedo Archipelago, 18° N; Reyes-Bonilla, 1995) and in the Marías Islands (20°N; HRB pers. observ., 2007), the number of starfishes is also quite low. Possibly the success of the cohorts varies depending on the strength of the California Current and the presence (or lack of) eddies around the island, physical factors that eventually determine if larvae move away, or remain in site. The question merits further investigation but nevertheless, the low numbers of sea stars indicate that the ecological relevance of this group in rocky reefs of Guadalupe Island should be low, a clear contrast to what is known about the ecological importance of *A. sertulifera* and *P. giganteus* in southern California coastal reefs, where their numbers are much higher.

Returning to the data analysis, we found out that the "shallow" depth level had slightly higher density than the "deep" one, but the figures were quite similar (0.12 ± 0.07 ind/50 m^2 against 0.09 ± 0.06 ind/50 m^2). Average asteroid species richness at Guadalupe Island was very low (0.09 ± 0.04 sp/50 m^2), as well as diversity (H´) and evenness (J´) (0.011 ± 0.011 decits/50m^2, and 0.016 ± 0.016 units respectively) because the three indices had values of zero or one (for richness) in most transects but one, placed at 14.5 m deep at Punta del Tiburón, where one individual of *L. columbiae* and one of *P. giganteus* were found (resulting in H´= 0.17 ± 0.17 decits/50 m^2, and J´= 0.25 ± 0.25 units). An examination of the literature confirmed that only the sea star assemblage from La Entrega, Oaxaca (Zamorano & Leyte-Morales, 2005) has so low richness, abundance, diversity and evenness values in western México reefs (Caso *et al*., 1996; Reyes-Bonilla *et al*., 2005).

As indicated, Guadalupe Island is a Biosphere Reserve but notwithstanding the federal law allows for commercial fishing in the area, albeit limited in volume. Of the three seastar observed, *Linckia columbiae* and *Pisaster giganteus* are usually sold as souvernirs in curio stores at cities like Mazatlán, Ensenada, Tijuana, and also in flea markets of San Diego (pers. observ.). Piña Espallargas *et al*. (2002) and Lunn *et al*. (2008) documented some aspects of its trade. Considering the extremely low number of individuals seen during field work, we recommend the ban of any permission for capture of seastars at the island, as Addessi (1994) has documented how sensitive *P. giganteus* and *A. sertulifera* are to human perturbation, to the point of having populations disappear at Catalina Island, California.

Our study indicated that seastar populations in shallow rocky reefs of Guadalupe Island are remarkably low, and consequently the community structure of this group is quite simple, characterized by minimal richness and diversity. The ecological role of this taxon must be limited in this oceanic island, and we recommend that federal authorities ban any kind of extraction of specimens in order to not affect the populations.

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