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A new record of Harlequin Shrimp (Malacostraca: Decapoda: Palaemonidae: *Hymenocera picta* Dana, 1852) in the southern Mexican Pacific Reefs

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Omar Valencia-Mendez [1], Andres Lopez-Perez [2], Betel Martinez-Guerrero [3], Virgilio Antonio Perez [4] & Eduardo Ramirez-Chavez [5]

[1] Programa de Doctorado en Ciencias Biológicas y de la Salud, [2] Departamento de Hidrobiología, Universidad Autónoma Metropolitana, San Rafael Atlixco 186, Col. Vicentina CP09340, Ciudad de México, México
[3,5] Universidad del Mar, Campus Puerto Ángel, Carretera a Zipolite Km. 1.5, Col. Puerto Ángel, San Pedro Pochutla, Oaxaca, 70902, México
[4] Buceo Huatulco, Ocotillo # 206, La Crucecita, Bahías de Huatulco, Oaxaca, 70989, México
[1] ovalenciam@outlook.com, [2] alopez@xanum.uam.mx (corresponding author),
[3] alpheusb@hotmail.com, [4] hoy.bucea@gmail.com, [5] eduardo@angel.umar.mx

Abstract: The Harlequin Shrimp *Hymenocera picta* is abundant in the Indo-Pacific and Central Pacific regions, but there are few reports of it from the eastern Pacific. Two pairs of the Harlequin Shrimp were observed feeding on the Sea Star *Phataria unifascialis* (Gray, 1840) in the reefs of Huatulco National Park, Mexican Pacific. This paper reports the occurrence of *H. picta* in Mexican Pacific waters and extends its previous distribution by 1,270km north of El Ocotal, Costa Rica in the eastern Pacific equatorial zone. In addition, we evaluate the potential distribution of *H. picta* along the tropical eastern Pacific using the Maximum-Entropy modelling algorithm.

Keywords: Caridea, coral reefs, harlequin shrimp, Huatulco National Park, sea star predator.

Hymenocera Latreille, 1819 is a monospecific genus that contains *Hymenocera picta* Dana, 1852, commonly known as "Harlequin Shrimp" or "Painted Shrimp". *Hymenocera* is a small decapod crustacean (~5cm in TL) belonging to the superfamily Palaemonoidea Rafinesque, 1815 sensu De Grave & Fransen (2011). Due to its amazing coloration, it is one of the most in-demand decapod crustacean species in the marine ornamental trade, reaching up to 80 USD per pair (Calado et al. 2003).

Hymenocera picta was first described by Dana based on a specimen collected in Raraka, Tuamotu, French Polynesia. Dana's figures were made from a living specimen; however, holotype specimens were lost in the wreck of the "Peacock" (Edmondson 1923). This event led to the complex and problematic taxonomy for the species (Edmondson 1923). Previously, two nominal species were recognized: *Hymenocera elegans* Heller,

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1862 was described as a species with a white or creamy body with blue or brown blotches with a distribution within the Indo-west Pacific (Debelius 1999), while *H. picta* differed in the colour of its blotches (wine or red) and with a distribution in the central and eastern Pacific (Hoover 1998). Kawamoto & Okuno (2003) found both colour patterns in Okinawa, Japan suggesting the blotch colour changes according to the species' diet. As a consequence, *H. elegans* was re-designated as a junior synonym of *H. picta* (De Grave & Fransen 2011).

The Harlequin Shrimp is a monogamous and territorial species that typically live in pairs inhabiting shallow waters and associated with holes, crevices and caves in coral reefs (Wickler 1973). The most particular characteristic of the species is its unique coloration (red or blue blotches in the body), and the morphology of the chela (Debelius 1999). Feeding habits of the Harlequin Shrimp are based exclusively on starfish of the Class Asteroidea Blainville, 1830 (Wickler 1973; Prakash & Kumar 2013), being currently referred to as an important biological control of *Fromia monilis* (Perrier, 1869), *Linckia laevigata* (Linnaeus, 1758), *Mithrodia fisheri* Holly, 1932, *Asteropsis carinifera* (Lamarck, 1816), *Nidorellia armata* (Gray, 1840), and *Acanthaster planci* (Linnaeus, 1758) populations (Wickler 1973; Juncker & Poupin 2009; Prakash & Kumar 2013).

Although *Hymenocera picta* is abundant in the Indo-Pacific regions (Wickler 1973; Seibt & Wickler 1979; Prakash & Kumar 2013), it has also been recorded in the eastern tropical Pacific in the Galapagos Island (Hickman & Zimmerman 2000), Gorgona Island, Colombia (Juan Felipe Lazarus Agudelo, pers. comm. 17 August 2016), Panamá Islands (Canal de Afuera, Pedro González, Uva and Toboga) (Glynn 1977, 1982; Wicksten & Hendrickx 2003), El Ocotal, Costa Rica (Wicksten & Hernández 2000) and Clipperton Island, France (Debelius 1999; Poupin et al. 2009). In this paper, we report the presence of *H. picta* in Cacaluta Island and Punta Maguey, Mexican Pacific for the first time, therefore extending its distribution 1, 270km north from its previous record in Central America.

Material and Methods

The present record is based on field observations in Huatulco National Park (HNP) of *H. picta* at two different times. While conducting biological censuses of reef associated invertebrates and vertebrates in HNP, we (OVM and VAP) observed a pair of Harlequin Shrimps in Cacaluta Island (15.71888889 N & -96.16194444 W) on March 2014, and another in Punta Maguey (15.73011 N & -96.14611 W) in July 2016 (Fig. 1). Specimens were observed between 10–15 m depth and recorded with video (GoPro Hero 3) and digital photography (Nikon Coolpix Aw120). No specimens were collected since

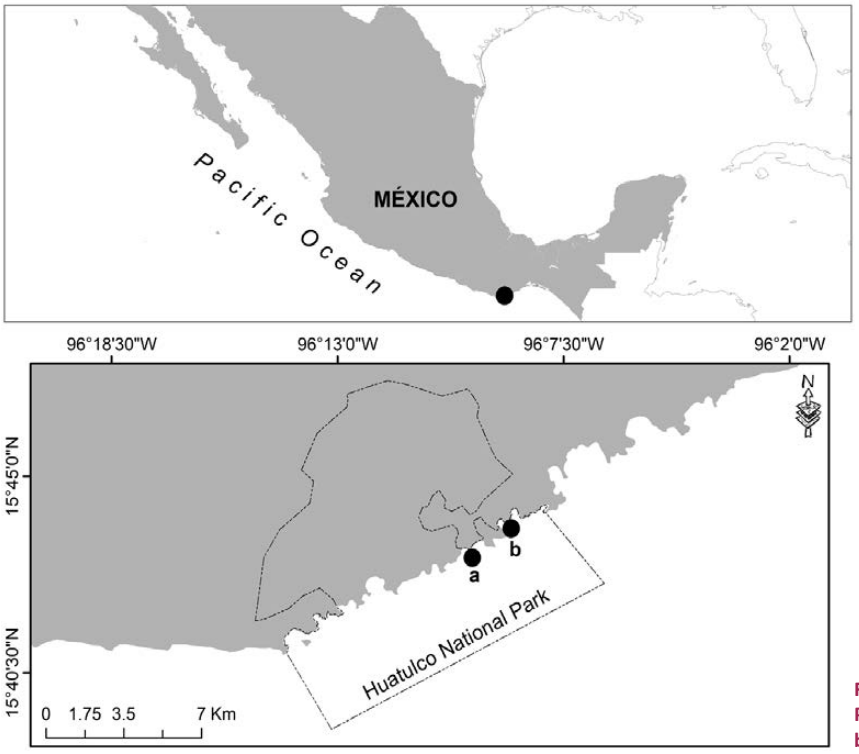

Figure 1. Study area in Huatulco National Park, Mexican Pacific. a - Cacaluta Island; b - Punta Maguey.

both sites are part of a Natural Protected Area (NPA) and collecting is forbidden without the adequate scientific collecting permit granted by Mexican federal agencies.

Specimens were further identified by taxonomist (Fernándo Álvarez Noguera, Universidad Nacional Autónoma de México; Arthur Anker, Universidade Federal do Ceará, Brazil, and Sanjeevi Prakash, Sathyabama University, India). Finally, the taxonomic validity of the species name was addressed after verification by WoRMS (World Register of Marine Species http://www.marinespecies.org) and ITIS (Integrated Taxonomic Information System http://www.itis.gov) databases.

Furthermore, information of 13 environmental variables (minimum, maximum and average values of sea surface temperature, primary productivity, particulate organic carbon, particulate inorganic carbon and bathymetry) and historical records of occurrence of *H. picta* around the tropical eastern Pacific (TEP), were used to predict the potential geographic distribution of the species in cells of 4km latitude/longitude in the area. Environmental variables were downloaded from NASA's Ocean Color Web (http://oceancolor.gsfc.nasa.gov) and processed using the program WIM (Windows Image Manager http://www.wimsoft.com; Kahru 2007). The distribution data of *H. picta* were gathered from online databases such as Invertebrate Zoology Collections (http://collections.mnh.si.edu/) and Global Biodiversity Information Facility (http://www.gbif.org/). Maximum entropy (Maxent) modelling algorithm version 3.3.3k (Phillips et al. 2006) was used employing default settings. Among the different species distribution model algorithms, Maxent is extensively used for projecting current species distributions (Elith & Leathwick 2009) due to its better predictive performance relative to other modelling algorithms (Elith et al. 2006) even with low sample sizes (Pearson et al. 2007), and its applicability when presence-only data are available (Phillips et al. 2006). Maxent has been described as a modelling method able to fit overly complex environmental response curves (Elith & Leathwick 2009), particularly when using default parameters (Merow et al. 2013); default settings of Maxent have been tested successfully over a wide range of species and environmental conditions (Phillips & Dudík 2008). Finally, probability predictions were interpreted as habitat suitability index (HSI) for *H. picta* for exploratory purposes only, rather than as the probability of species presence in each cell.

Results

Two pairs of Harlequin Shrimp *Hymenocera picta* of ~4.5cm in TL, were recorded at Cacaluta Island and Punta Maguey respectively, Huatulco National Park, Mexican Pacific (Image 1). Specimens were observed feeding on the sea star *Phataria unifascialis* (Gray, 1840) in shallow coral reef waters (at ~10m) dominated by *Pocillopora damicornis* (Linnaeus, 1758) corals. Specimens were identified on the basis of their coloration (white body with blue and wine coloured blotches), and unique morphologic characteristics such as antennule with lateral flagellum greatly expanded, the 3rd maxilliped with penultimate segment wider than the antepenultimate and 2nd pereopod greatly expanded following the criteria of Wickler (1973) and Mitsuhashi et al. (2005).

Image 1. Harlequin Shrimp *Hymenocera picta* observed at Cacaluta's Island reef. Male (up), female (down).

A total of 47 historical bibliographic references indicate that the harlequin shrimp have a wide geographical distribution in the Pacific Ocean (Fig. 2). In particular, in the eastern Pacific, literature and museum records indicate that *H. picta* inhabit the oceanic islands of Galapagos, Gorgona, Malpelo, Perlas and Clipperton; but also in coastal zone as El Ocotal, Costa Rica (Fig. 2). The new record for Cacaluta Island and Punta Maguey (Fig. 1) was located about 1, 279km north from El Ocotal, Costa Rica and 1, 529km northeast from Clipperton Atoll. According to the species distribution model (Fig. 3), the TEP may represent a highly suitable habitat for the occurrence of *H. picta*. At large spatial scale, high habitat suitability (>0.92) for *H. picta* may be found between the Gulf of California and Ecuador, including the eastern Pacific oceanic islands, but suitability predicted by the model decrease (<0.85) on the western part of the Baja California peninsula and south of mainland Ecuador. Likewise, bathymetry along with minimum and average sea surface temperature across the TEP is mainly involved in predicting habitat suitability for the

Figure 2. Previous records (black stars) of Harlequin Shrimp *Hymenocera picta* around the Pacific Ocean, and new records (black dot) in Cacaluta Island and Punta Maguey, Huatulco National Park, Mexican Pacific.

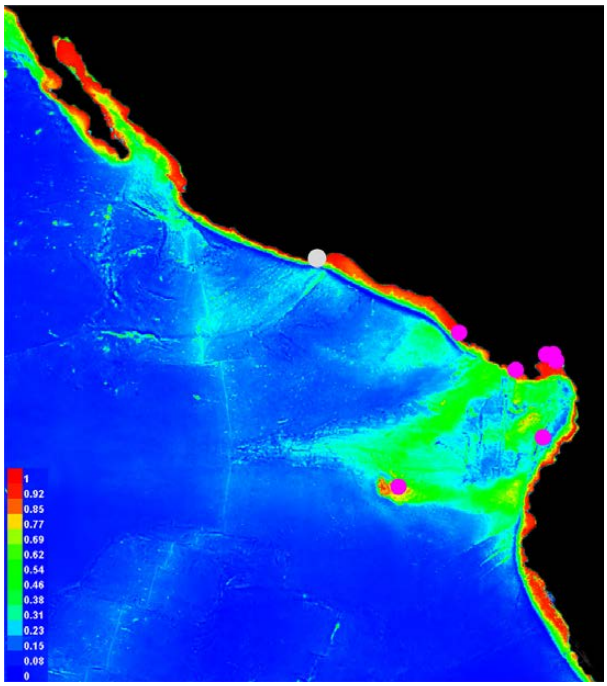

Figure 3. Predictive relative habitat suitability index for *Hymenocera picta* along the tropical eastern Pacific using maximum entropy modeling technique. Habitat suitability index (HIS) of the species in the area is displayed in a color gradient: red indicates high suitability and blue indicates low suitability. Purple circle indicate previous records of *H. picta* around TEP, and gray circle the new records in Cacaluta Island and Punta Maguey, Mexican Pacific.

species. In particular, habitat suitability for the harlequin shrimp reaches its maximum when minimum sea surface temperature is 25^{0}C in shallow waters (<20m), but suitability decreases exponentially when depth increases, or when minimum sea surface temperature is below 25^{0}C.

Discussion

Specimens of *H. picta* were easily identified because they displayed the typical coloration pattern, which is unique to *Hymenocera* species. In addition, morphological characteristics observed in Cacaluta Island and Punta Maguey specimens match with those originally addressed by Dana (1852), and in the reviews performed by Wickler (1973) and Mitsuhashi et al. (2005) for specimens recorded in the Indian Ocean, Western and Central Pacific. The new record of *H. picta* at Cacaluta Island and Punta Maguey, increase the number of new records of crustacean species (García-Madrigal & Andreu-Sánchez 2010; Cortés-Carrasco & García-Madrigal 2013) in the area, but most importantly extends the former distribution of the species by 1, 270km north from Costa Rica (Wicksten & Hernández 2000) and 1, 529km northeast from Clipperton (Debelius 1999; Poupin et al. 2009). The record of *H. picta* in Mexican Pacific waters, is part of a long list of new records of species previously known to occur in Central America in taxonomic groups as varied as echinoderms (Granja-Fernández et al. 2013), fish (López-Pérez et al. 2010; Zepeta-Vilchis et al. 2013), polychaeta (Bastida-Zavala & Guevara-Cruz 2012) and crustaceans (García-Madrigal & Andréu-Sánchez 2010; Cortés-Carrasco & García-Madrigal 2013). The new record of *H. picta* presented here along with the above-mentioned records, reinforces the faunal connectivity hypothesis between Central America and southwestern Mexico via the Costa Rica Coastal Current (Fiedler & Talley 2006; Pineda et al. 2007).

Considering the new record presented here, *H. picta*

is distributed as north as southern Mexican Pacific. Species distribution model (Fig. 3) suggest that, at large spatial scale, habitat suitability for the species may extend as far north as the Gulf of California and as far south as the frontier between Ecuador and Peru, corresponding to the full extension of the TEP, whose the most northern and southern distribution limits was defined by the minimum sea surface temperature. According to the model the entire TEP is suitable to harbour *H. picta* populations, but at small spatial scale that may depend upon the distribution of coral reefs communities and prey availability. Several studies indicate that Harlequin Shrimps inhabit holes and crevices of coral reefs (Glynn 1977, 1982) and prey exclusively upon on starfish of the Class Asteroidea (Wickler 1973; Prakash & Kumar 2013), not only in the eastern Pacific (Glynn 1977, 1982) but across its entire distribution (Prakash & Kumar 2013). During the current study, we observed the harlequin shrimp feeding on the starfish *P. unifascialis*, while field observations on coral reefs in the Gulf of Chiriquí (Panamá) showed that *H. picta* feeds on *A. planci* (Ormond & Campbell 1974; Glynn 1977, 1982). Regardless of the biology (feeding habits), ecology (distribution), and prediction model (Maxent) of *H. picta*, future detailed prospecting of coral communities and reefs from the eastern Pacific may render more insights on new species records in this area.

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