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Short Communication

Freshwater prawns of the genus *Macrobrachium* (Decapoda: Palaemonidae) from the San Pedro-Mezquital River, Nayarit, Mexico

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ABSTRACT. The San Pedro-Mezquital River basin in Nayarit, Mexico has the majority of freshwater prawns of the genus *Macrobrachium* reported for the Mexican Pacific coast. Six species of freshwater shrimp are reported *Macrobrachium americanum*, *M. occidentale*, *M. digueti*, *M. michoacanus*, *M. hobbsi* and *M. tenellum*. The higher richness and diversity of freshwater prawns are found on the coastal plain. The presence of prawns in relation to the altitudinal gradient is discussed.

Keywords: freshwater, crustacean, prawns, diversity, coastal plain, Nayarit, Mexico.

The crustaceans of the family Palaemonidae include 36 recognized genera that are distributed in sea, brackish and/or fresh water (Holthuis, 1952). In this family, the genus *Macrobrachium* Bate (1868) is found, comprising about 246 species that inhabit fresh and/or brackish water environments with a wide geographical distribution in tropical and subtropical regions (De Grave & Fransen, 2011). They are distinguished from other palaemonids genera mainly for presenting the second pair of pereiopods chelate, and often in male longer than entire body (Holthius, 1952). These organisms present a behavior called amphidromy (McDowall, 2007), in which adults live in freshwater and migrate downstream near brackish water to spawn, after larval development, juveniles migrate to freshwater environments (Bauer, 2011). In Mexico, 20 species are reported (Villalobos, 1982; Villalobos-Hiriart *et al*., 1993; Wicksten & Hendrickx, 2003; Hernández *et al*., 2007; Alvarez & Villalobos, 2016); however, the discussion on the presence of some shrimp species on both sides (Atlantic-Pacific), or only on one of the slopes, continues among specialists. According to the region they are known as acocil, chacales, camarones, langostinos, acamayas, cauques, moyas, piguas, popotillos o gambas, are an important resource of the artisanal fishing for the people of each region (Hendrickx, 1995). The San Pedro-Mezquital River originates in the state of Durango and crosses the Sierra Madre Occidental as it passes through much of the state of Nayarit until it ends in the south of the Reserva de la Biosfera Marismas Nacionales Nayarit (DOF, 2010). The singularity of this river, is that it does not have dams in its course by Nayarit, condition that few rivers in Mexico present it. So the species move freely along the river and the basin giving great benefits to the biological diversity that sustains this lotic ecosystem. The presence of freshwater prawns in the state of Nayarit has some reports (Villalobos-Hiriart *et al*., 1993; Pérez-Velázquez *et al*., 2011); however, the San Pedro-Mezquital River is not registered to date. Therefore, the present study reports for the first time the freshwater prawns of the genus *Macrobrachium* in several localities of the San Pedro-Mezquital River, Nayarit River, Mexico.

In January, February, May 2009 and from July to September of 2012 several localities of the San Pedro-Mezquital River, Nayarit, were visited between 08:00 AM and 18:00 PM (Fig. 1). The sampling sites of higher altitude and away from the coast were San Blasito with more than 220 m, Piedra Bola 170 m, Cortina 150 m, Naranjo 103 m, Venado 50 m, Ruiz 27 m, San Pedro 16 m and Tuxpan 10 m. In each site was recorded depth and transparency with Secchi disc. As well as temperature, dissolved oxygen, pH and conductivity using a YSI model 85 multiparameter device, YSI model 55 oximeter and Hatch potentiometer.

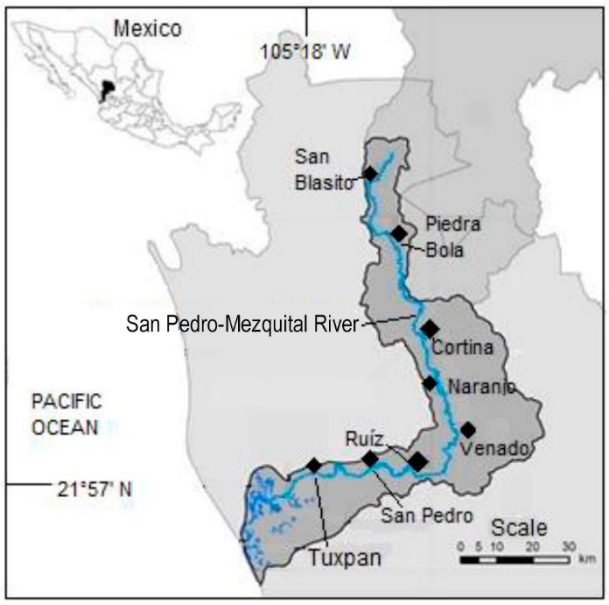

Figure 1. Map of sampling sites in the San Pedro-Mezquital River, Nayarit, Mexico.

It was estimated the stream flow and velocity in a section near the Venado and San Pedro in March 2009, uses a float (an object such as an orange, ping-pong ball, pine cone, etc.) to measure stream velocity. Calculating flow involves solving an equation that examines the relationship among several variables including stream cross-sectional area, stream length, and water velocity (US EPA, 1997).

The prawns were collected using aquatic net, surber net and minnow seines at each site along the river and rocks, boulders, pebbles, sands, aquatic vegetation, trunks, branches and litter were removed. The specimens were separated and preserved in 70% ethanol, tagged with the collection data and geographic position with a GPS. In the laboratory shrimps were identified at the genus and species level, with the support of Holthuis (1952), Nates & Villalobos (1990) and Hernández *et al*. (2007). To determine the relationship of the environmental variables with the richness of species and their abundance the Pearson correlation coefficient was used.

The number of individuals collected in the seven visits to the sampling sites was 802 (Table 1). The prawns were found under branches, trunks, roots or rocks of various sizes and sediments from coarse to fine, as well as in fast and slow current, typical places of the lotic ecosystem, in these decapods (Hendrickx, 1995). The presence of six species of freshwater prawns is reported for the first time in the San Pedro-Mezquital River basin: *Macrobrachium americanum* (Bate, 1868), *M. occidentale* (Holthius, 1950), *M. digueti* (Bouvier, 1895), *M. michoacanus* (Nates-Rodríguez & Villalobos-Hiriart, 1990), *M. hobbsi* (Nates & Villalobos, 1990) and *M. tenellum* (Smith, 1871) (Table 1). The six species recorded are described:

***Macrobrachium americanum* (Bate, 1868)**

Local common name: cauque, chacal, endoco. Habitat. In the clear waters of the San Pedro-Mezquital River. They are distributed in logs, under rocky areas, inside caves that form the water and in some cases immersed in the vegetation adjacent. We found this species co-occurring with *M. occidentale*. Material examined: The total length on male and female specimens collected was 222.2 mm max. and 84.13 mm min. Cephalothorax length was 79.60 mm max. and 29.17 mm min.

***Macrobrachium occidentale* (Holthius, 1950)**

Local common name: langostino, cauque. Co-occurring with *M. americanum*. The total length on male and female specimens collected was 109.63 mm max. and 41.45 mm min. Cephalothorax length was 43.12 mm max. and 15.19 mm min.

***Macrobrachium digueti* (Bouvier, 1895)**

Local common name: langostino. The total length on male and female specimens collected was 81.86 mm max. and 50.56 mm min. Cephalothorax length was 30.08 mm max. and 21.87 mm min.

***Macrobrachium michoacanus* (Nates & Villalobos, 1990)**

Local common name: cauque, langostino. Co-occurring with *M. hobbsi* and *M. tenellum*. Material examined: the total length on male and female specimens collected was 74.27 mm max. and 33.88 mm min. Cephalothorax length was 26.49 mm max. and 13.49 mm min.

***Macrobrachium hobbsi* (Nates & Villalobos, 1990)**

Local common name: langostino. They inhabit areas of running water in adjacent vegetation on the river. Co-occurring with *M. tenellum* and *M. michoacanus*. Material examined: the total length on male and female specimens collected was 58.41 mm max. and 54.33 mm min. Cephalothorax length was 22.16 mm max. and 18.54 mm min.

***Macrobrachium tenellum* (Smith, 1871)**

Local common name: manopalito, chacalín, manudo, manocarrizo, langostino. Habitat: they inhabit areas of running water in adjacent vegetation on the river; although in a lentic environment, such as pools, they live in stagnant water with large amounts of deposited organic material, with low dissolved oxygen gradients

Table 1. Freshwater prawns of the genus *Macrobrachium* in the San Pedro-Mezquital River. ♂= male, ♀= female, ♀o = ovigerous female.

Species	San Blasito	Piedra Bola	Cortina	Naranjo	Venado	Ruíz	San Pedro	Tuxpan	Abundance (%)
	22°23'16.4" N 105°01'52.4" W	22°19'56,4"N 105°02'56,9"W	22°05'57.4"N 104°56'39.6"W	22°02'28.09"N 104°56'2.17"W	21°56'47,6"N 105°00'30,2"W	21° 57' 04.6"N 105° 04' 23.1"W	21°57' 03.6"N 105°10' 44.7"W	21°56' 36.3"N 105°17' 06.2"W	
M. americanum	1♂:1♀	1♂		4♂:1♀	6♂:2♀				2.01
M. digueti			1♂	3♂ :2♀	9♂:5♀:2o	9♂:2♀:1♀o	8♂:12♀:15♀o		8.66
M. michoacanus				5♂	17♂:1♀:10♀o	4♂	15♂:7♀		7.41
M. occidentale	3♂:4♀:1♀o		2♂:2♀o	9♂:2♀	14♂	4♀o	5♂		5.77
M. hobbsi				1♂	3♂:2♀:2♀o	4♂:2♀	8♂:13♀:15♀o		6.28
M. tenellum					13♂:10♀	1♂:1♀o	55♂:57♀	80♂:42♀:1♀o	34.55
Macrobrachium juveniles				1		177	26	74	36.06

and very variable conditions of temperature and salinity (Guzmán & Kensler, 1977). Co-occurring with *M. hobbsi* and *M. michoacanus*. Material examined: The total length on male and female specimens collected was 90.41 mm max. and 44.74 mm min. Cephalothorax length was 36.75 mm max. and 17.26 mm min.

A similar number of prawns have been reported towards the northwest of this river, in the peninsula of Baja California (Hernández *et al*., 2007), and to the southeast, on the coast of Oaxaca (Villalobos *et al*., 2010), and the possibility of the presence of other prawns *M. acanthochirus* (Villalobos-Figueroa, 1967) and *M. olfersi* (Wiegmann, 1836) in rivers that discharge in the Mexican Pacific (Villalobos, 1982; Villalobos-Hiriart *et al*., 1992; Hernández *et al*., 2007; Villalobos-Hiriart *et al*., 2010). The highest richness was recorded in Venado with six species, Ruíz and San Pedro recorded five species respectively. This result is similar to that reported by Villalobos-Hiriart *et al*. (2010) in rivers of Oaxaca, finding most of the species towards the middle and low (coastal plain) of the rivers studied. In addition, these three localities accumulate about 70% of the abundance relative of registered prawns. *M. americanum* and *M. occidentale* were found in San Blasito, at an altitude of 220 m and 70 km upstream from Tuxpan, a locality with the closest at Marismas Nacionales, of lower altitude (10 masl), where it was found only to *M. tenellum*. The difference in species richness between localities may be related to the sampling intensity, since San Blasito and Piedra bola were visited in only one occasion (May 2009), while the rest of the sites were visited in more occasions. Piedra Bola only recorded the presence of a male of *M. americanum*. From Tuxpan locality the river changes in geomorphology with predominance of soft substrate consisting mainly of sands and silts, with a minimum slope, and therefore in rainy season tends to present floods, communicating with south of protected natural area Marismas Nacionales, by diverse streams and channels, where *M. tenellum* was the only prawn present and abundant. *M. occidentale* was the most frequent shrimp in the river, present in six of the eight localities, followed by *M. digueti* in five localities and the rest of the species were registered in the localities of the lower part of the river, Venado, Ruiz, San Pedro and Tuxpan. The sex ratio for the total population of shrimp caught was equal to 1:1. The ovigerous females represented only 6.6% of the total of prawns captured, in which *M. digueti* and *M. hobbsi* showed the highest number of ovigeras, with 17 females respectively, followed by *M. michoacanus* (10). Juveniles recorded above 35% of the abundance, indicating an active and continuous recruitment among the shrimp towards the lower part of the river basin, as evidenced by the locali-

Table 2. Summary of water parameters and substrate type in 2009 and 2012 of the San Pedro-Mezquital River, depth (min-max in m), temperature (T°C), dissolved oxygen (DO), pH, conductivity (C), Secchi transparency (sT) and altitude (m). Substrate type Rock: r, boulder: b, pebbles: p, coarse sand: cs, medium sand: ms, fine sand: fs, limes: l, clays: cl, roots: rt, submerged vegetation: sv, emerged vegetation: ev.

Date	Locality	Depth (m)	T°C	DO (mg L^{-1})	pH	C (µs cm^{-1})	sT (m)	Altitude (m)	Substate and vegetation
January 2009	Cortina	0.3-2	22.3	7.5	7.9	-	0.3	150	r, b , p, cs, sv
	Naranjo	0.2-3	24.6	6.8	7.6	-	0.20	103	b, p, cs, rt
	Venado	0.7	24.9	4.85	7.4			50	b, p, cs, ms, sv, rt
	Ruiz	0.5	24.8	4.23	7.8			27	b, p, cs, ms, sv, rt
	San Pedro	0.6	24.7	3.98	7.2			16	b, p, cs, ms, ev, sv
March 2009	Naranjo	-	32.2	7.1	-	339.5	0.25	103	
	Venado	0.2-1	26.6	7.9	-	300.5	0.20	50	
	Ruiz	0.2-0.5	28.2	8.4	-	299.7	0.15	27	
	San Pedro	0.2-1	29.6	8.1	-	313.6	0.20	16	
	Tuxpan	0.2-1	30.1	7.7	-	337.5	0.10	10	ms, fs, l, cl, rt, ev
May 2009	San Blasito	0.5-1	23.7	9.3	7.2	358.8	0.5	220	r, b , p, cs, sv, rt
	Piedra Bola	0.2-3	27.5	9.2	7.3	333.9	0.5	170	r, b , p, cs, sv
June 2009	Cortina		29.9	4.56	8.18	229	0.10	150	
	Naranjo		28.1	4.37	7.57	238	-	103	
	Venado		29.9	4.55	8.02	228	0.8	50	
	San Pedro		32.1	6.14	8.05	274	0.8	16	
	Tuxpan		32.6	5.8	7.7	306	0.8	10	
September 2009	Cortina		26.4	5.20	7.54	88.7	0.10	150	
	Naranjo		26.5	3.99	7.68	94.8	-	103	
	Venado		26.7	5.0	7.72	99.2	0.8	50	
	San Pedro		27.1	6.55	7.7	85.0	0.8	16	
	Tuxpan		27.5	4.2	7.45	77.2	0.10	10	
July 2012	Cortina		27.0	4.5	6.6		0.4	150	
	Naranjo		29.1	6.65	6.69		0.5	103	
	Venado		26.4	7.9	6.73		0.5	50	
	Ruiz		27.2	6.2	6.8		0.4	27	
	San Pedro		28.2	7.9	6.7		0.3	16	
	Tuxpan		27.8	5.8	6.0		0.1	10	
August 2012	Cortina		30.0	5.7	8.4		0.1	150	
	Naranjo		30.3	5.4	9.6		0.08	103	
	Venado		30.5	7.2	7.84		0.05	50	
	Ruiz		27.3	6.2	6.61		0.05	27	
	San Pedro		30.4	8.2	8.13		0.05	16	
	Tuxpan		28.0	7.9	7.3		0.05	10	
September 2012	Naranjo		29.1	6.5	6.7		0.1	103	
	Venado		26.4	7.9	6.73		0.1	50	
	Ruiz		27.2	6.5	6.79		0.08	27	
	San Pedro		28.2	7.9	6.7		0.05	16	
	Tuxpan		28.2	5.8	6.0		0.1	10	

ties of Ruiz, San Pedro and Tuxpan. The highest localities (>100 m) did not register juveniles, except in Naranjo (103 m) with a single individual. Like juvenile shrimp, ovigera females are almost entirely present in the localities of the lower part of the river basin, in preparation for migration to brackish waters and completing the reproductive cycle, as in these organisms (Bauer, 2011). These females were registered mainly in the months of June to September in the localities of the lower part of the river. However, *M. occidentale* recorded an ovigera female in May in San Blasito, with more than 200 m of altitude. The reproductive period in these organisms is related to the rainy season (New & Valenti, 2000), but change, depen-

Table 3. Pearson correlation coefficient between environmental variables and species recorded in the San Pedro-Mezquital River.

Parameter	Nº species	*P*-value	Nº organisms	*P*-value
Temperature (°C)	0.007	>0.05	0.028	>0.05
Dissolved oxigen (mg L^{-1})	-0.113	>0.05	0.112	>0.05
pH	0.164	>0.05	0.054	>0.05
Secchi transparency (m)	0.060	>0.05	-0.052	>0.05
Depth (m)	0.141	>0.05	-0.176	>0.05
Conductivity (µs cm^{-1})	-0.024	>0.05	-0.046	>0.05
Altitude (m)	-0.013	>0.05	-0.449	<0.01

ding on the region, in this case this event was recorded in spring and summer.

The environmental conditions recorded in the water column of the San Pedro-Mezquital River during the months and sampling sites are the minimum necessary for the presence and adequate development of aquatic fauna of the lotic system. No significant variations were found in the physical and chemical parameters of the water recorded during the study period. The fluctuations of temperature, dissolved oxygen and pH were in favorable ranges to perform the processes of osmo-regulation, thermoregulation and oxygen circulation in the gill chamber. The Table 2 summarizes the values of recorded variables. The temperature was 22.3 and 30.1°C in the dry season (average: 26.6°C ± 1.7) and in the rainy season it ranged from 26.4 to 32.6°C (average: 28 ± 2.9°C). Dissolved oxygen had a mean value above 6.32 mg L^{-1}, the minimum concentration required for the life of the aquatic fauna in the river during the sampling dates. Likewise, the pH remained slightly neutral with an average of 7.4 ± 0.81 in the dry season and 7.2 ± 0.28 during the months of maximum humidity (rainy season). In terms of conductivity, in May 2009 was around 300 µs cm^{-1} and in the rainy season decreased to an average of 170 µs cm^{-1}. In Venado site the stream flow of 18 m^3 s^{-1} and velocity of 0.6 m s^{-1} in March 2009 (dry season), while at San Pedro was the same velocity (0.6 m s^{-1}) and stream flow at 22 m^3 s^{-1}; it is suggested that in the rainy season the stream velocity should reach 1.6 m s^{-1} and a stream flow rate of 122 and 123 m^3 s^{-1} respectively. It is characteristic that the runoff that incorporates solids to the channels in rainy season, with the consequent increase of nutrients.

With the recording of environmental and biological variables collected, a correlation analysis was performed and the level of dependence was determined on the presence of prawns and their abundance (Table 3); however, only the correlation between altitude and abundance (-0.446) were significant with a 99% confidence level. Thus, it is confirmed that the presence and abundance of *Macrobrachium* are found mainly in the coastal plain of this river, as it happens in some rivers of the coast of Oaxaca, Mexico (Villalobos-Hiriart *et al.*, 2010).

The people of the rural communities in the river, including indigenous communities, actively capture the species of the freshwater shrimps and the various species of prawns are fed, mainly *M. americanum*, *M. tenellum* and *M. occidentale*, during certain times of the year, as in other regions of the Americas (Hendrickx, 1995).

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