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Freshwater Prawns (Palaemonidae: *Macrobrachium*) with Abbreviated Larval Development in Rivers of Mexico: Uses, Management, and Conservation Opportunities

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Abstract

The *Macrobrachium* genus in Mexico is represented by two big groups: the first one, where the larval stages are extended, and the second one, has an abbreviated larval development. There are three main slopes in Mexico or exorheic basins and several endorheic basins such as lakes and inner lagoons. The species with extended larval stage are *M. carcinus*, *M. heterochirus*, *M. acanthurus*, *M. olfersii*, *M. hobbsi*, and *M. faustinum* in the Atlantic and Caribbean slope, while in the Pacific slope, these species are *M. americanum*, *M. occidentale*, *M. digueti*, *M. michoacanus*, *M. acanthochirus*, and *M. tenellum*. These species have important fishery activities on different basins because they live from oasis in desert to main rivers in the bigger basins. However, there are some rivers that have an extended region on their upstream such as Usumacinta, Grijalva, Papaloapan, and Coatzacoalcos basins that in general are considered as hydrological regions. Just in these extended regions, there are more caves in freshwater, springs, and primary or secondary streams, which are covered by short area rivers, and in these places, there are the following species: *M. totonacum*, *M. tuxtlaense*, *M. oaxacae*, *M. cosolapaense*, *M. oaxacae*, *M. jacatepecense*, *M. mazatecum*, and *M. vicconi*, while in the cave are *M. villalobosi*, *M. acherontium*, and *M. sbordonii*. However, for these species, the uses are more for the local groups mainly indigenous cultures such as Mayan, Lacandon, Zapotecs and Mixtecs, and others, and their commercial use is only in the local region depending on where these species are distributed.

Keywords: freshwater shrimp, Mexico, uses and management

1. Introduction

In the rivers, channels, and ponds in Mexico, there are several endemic crustaceans such as crabs, crayfishes, and freshwater shrimp species that are used by local people to obtain protein specifically by the indigenous cultures or these species are used by commercial fisheries in several basins around Mexico.

In first instance, the freshwater prawns from genus *Macrobrachium* in Mexico are represented by two big groups: the first one involved the species with a reproductive strategy “r” where the larval stages are extended, and the second one has an abbreviated larval development that is evidence of “k” strategy. There are three main slopes in Mexico or exorheic basins, on the Pacific, Atlantic and Caribbean Seas with several rivers, and several endorheic basins such as lakes and inner lagoons. The species with extended larval stages are in general bigger than those with abbreviated larval stages, and they have an important commercial use along the river basin where they inhabit and are possibly found in the big cities. The species members of this first group are *Macrobrachium carcinus*, *Macrobrachium heterochirus*, *Macrobrachium acanthurus*, *Macrobrachium olfersii*, *Macrobrachium hobbsi*, and *Macrobrachium faustinum* in the Atlantic and Caribbean slope, while in the Pacific slope, the species are *Macrobrachium americanum*, *Macrobrachium occidentale*, *Macrobrachium acanthochirus*, *Macrobrachium digueti*, *Macrobrachium michoacanus*, and (*Macrobrachium tenellum* **Table 1, Figure 1**) [1–3].

Pacific slope	Gulf of Mexico and Caribbean slopes
<i>Macrobrachium americanum</i>	<i>Macrobrachium carcinus</i>
<i>Macrobrachium tenellum</i>	<i>Macrobrachium acanthurus</i>
<i>Macrobrachium digueti</i>	<i>Macrobrachium olfersii</i>
<i>Macrobrachium occidentale</i>	<i>Macrobrachium heterochirus</i>
<i>Macrobrachium michoacanus</i>	<i>Macrobrachium hobbsi</i>
<i>Macrobrachium acanthochirus</i>	<i>Macrobrachium faustinum</i>

Table 1. Checklist of diadromous species of *Macrobrachium* in the three slopes in Mexico.

However, there are some rivers that have an extended region on their upstream such as Usumacinta, Grijalva, Papaloapan, and Coatzacoalcos basins that in general are considered as hydrological regions. Just in these extended region there are more caves with freshwater, springs, and primary or secondary streams that are covered by short area rivers; and in these places there are the following species: *Macrobrachium totonacum*, *Macrobrachium tuxtlaense*, *Macrobrachium oaxacae*, *Macrobrachium cosolapaense*, *Macrobrachium oaxacae*, *Macrobrachium jacatepecense*, *Macrobrachium mazatecum*, and *Macrobrachium vicconi*, and the cave represents *Macrobrachium villalobosi*, *Macrobrachium acherontium*, and *Macrobrachium sbordonii*, all of them with abbreviated larval development (**Table 2, Figure 2**) [3–12]. However, for these species, the uses are more for the local groups mainly indigenous cultures such as Lacandon, Zapotecs and

Mixtecs, and others, and their commercial use is only in the local region depending on where these species are distributed.

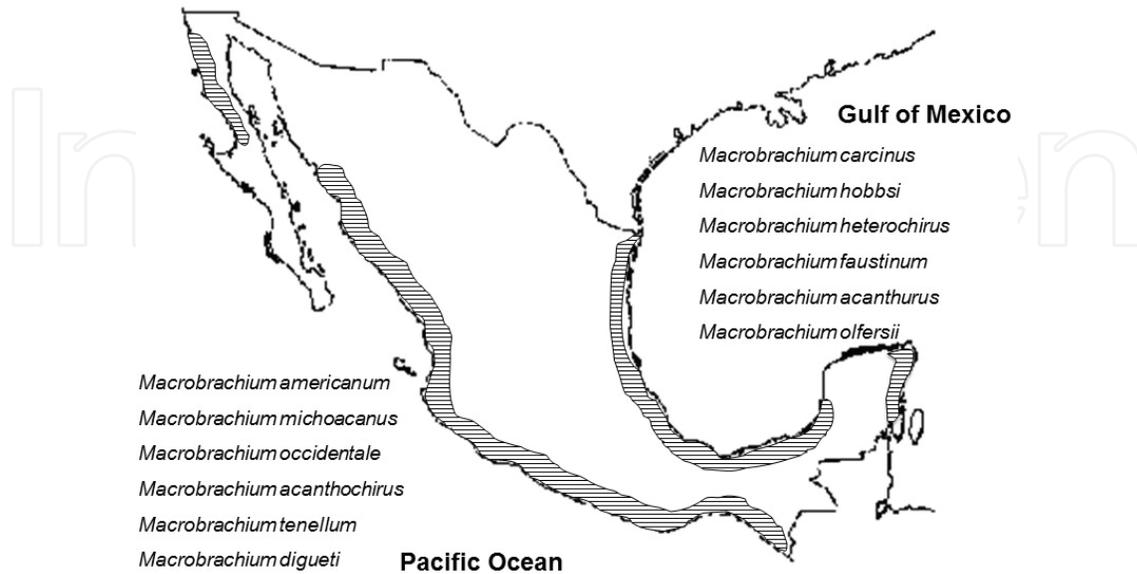


Figure 1. Distribution of freshwater prawns; valid species with extended larval development.

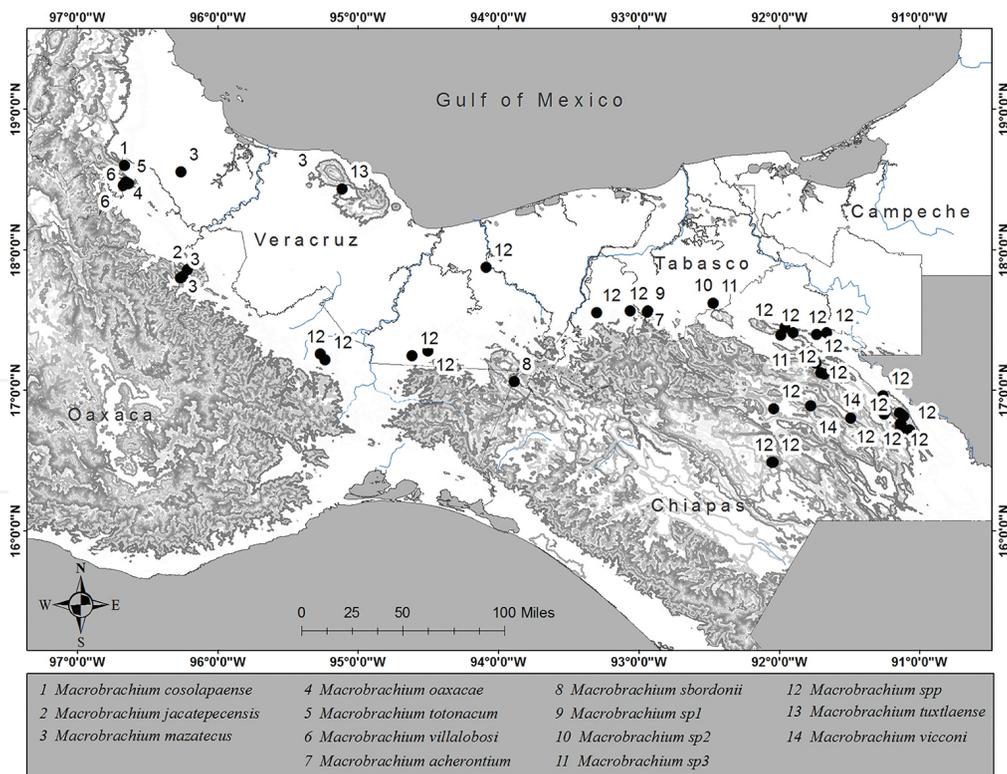


Figure 2. Distribution of freshwater prawns; described species, undescribed species and populations with abbreviated larval development.

The goal of this chapter is to show the distributional ranges of these species, as described in Section 2, which represents a holistic analysis that includes all species recognized in Mexico. Section 3 presents a normative frame analysis of the uses of natural resources such as freshwater prawns on river fisheries in Mexico and the river basin management programs according to the hydrological region in Mexico. Section 4 shows the commercial data specifically considering the bigger prawn species in the three slopes. Finally, Section 5 presents the uses and commercial opportunities to species with abbreviated larval development by the indigenous people and local markets in Mexico.

2. Distributional ranges of *Macrobrachium* species

In Mexico, these species are distributed into three exorheic basins: Pacific slope, Gulf of Mexico slope, and Caribbean slope. The first two basins are large with water flowing in the main river, and in the last one, due to the soil, the basins are subterranean and the freshwater flows underground to sea and the animals found the channels to inhabit in these places. It is interesting that in the Pacific and Gulf of Mexico or Caribbean Sea, there is one similar species inhabiting in each slope. In all cases, diadromous species need brackish water in some moments of their life cycle, while there are anadromous species that live their entire cycle in freshwater. In general, in these slopes, the climate is tropical wet, and tropical wet and dry and arid, because these species are present along the Pacific and Gulf of Mexico Coast; in general, the rivers still have the original riparian vegetation according to the location, but most of these basins are associated with a growing human population where the amount of sewage water has been increased in the past 50 years. Moreover, due to the water needs for agriculture, human consumption, and farmers, the dam construction occurred in the past years has produced diverse alterations in the normal migration conditions. For example, the species that need high content of oxygen dissolved, such as *Macrobrachium heterochirus* or *Macrobrachium occidentale*, cannot show more migration activity because the dam is an anthropogenic barrier and the distribution of these species is changed.

Caves and underground environments	Epigeal environments
<i>Macrobrachium villalobosi</i>	<i>Macrobrachium vicconi</i>
<i>Macrobrachium acherontium</i>	<i>Macrobrachium tuxtlaense</i>
<i>Macrobrachium sbordonii</i>	<i>Macrobrachium totonacum</i>
	<i>Macrobrachium cosolapaense</i>
	<i>Macrobrachium jacatepecense</i>
	<i>Macrobrachium oaxaca</i>
	<i>Macrobrachium mazatecum</i>

Table 2. Checklist of anadromous species of *Macrobrachium* with abbreviated larval development.

Species with abbreviated larval development trait in general live in the inner or endorheic basins mainly in springs. In general, these species inhabit areas between 100 and 300 m altitude around the mountain systems of hydrological basins. Because these mountain systems have emerged on Cretaceous and Tertiary and that the origin of *Macrobrachium* has been estimated in Cretaceous [13], the volcanic belt seems to be working as a geographical barrier for this group. The *Macrobrachium* species colonized these freshwater habitats together with *Creaseria morleyi* before the emergence of the Yucatan Peninsula [14].

Four habitat types are distinguished, where the freshwater prawns with abbreviated larval development have the following unifying characteristics: freshwater all time, tropical springs and streams, and important relationship with roots of riparian vegetation (trees or shrubs), the values of oxygen dissolved are high, and the pH trend toward alkalinity and few sites were recorded coexisting with another *Macrobrachium* species (complete larval development species). In general, all sites are clean without records of pollutants, both solids and dissolved.

3. Normative frame and management programs in Mexico

In Mexico, the normative frame for local fisheries is regulated by the Environment Secretary of Natural Resources (SEMARNAT, by Spanish acronyms). There are federal laws to protect the wildlife where it is stated that for some species that are examined with protected labels such as vulnerable, dangerous to extinct, or only dangerous, the fisheries are forbidden. In this case, for most *Macrobrachium* species, this law is not applicable because there are only two species *Macrobrachium villalobosi* and *Macrobrachium acherontium*, both protected from underground environments. So, each state establishes different regulations to grant the permissions to make a sustainable fishery. There are two main problems for the most species, the first one is the pollution that occurs in the high areas where the big cities are established because the regulations to eliminate the waste waters are null, so several elements such as heavy metals or nitrogenous or phosphorus species are released without any previous treatment. We suggest some sewage water treatment by using in first instance some local plants and increasing the treatment factories for this. However, the most important action is to prevent the indiscriminate water use because in the cities, small or big, there are few consciences about the implications on the water use. If we apply several strategies of environmental education, it is possible to attend the problem better. The other problem is establishing new dams in the middle of rivers to avoid the normal migrations to upstream and downstream as occur in several places. For those species that are living in the inner basins, the main problem is that they are living in specific places where they have a microdistribution and few species have several populations in different subbasins. So, any change in the environment could affect the populations that in some cases have been reported only in the locality type. A decrease has been reported in the population size of several species that normally live upstream. However, there are several records where the species of *Macrobrachium* walked out from rivers and climbed just beside the dam wall and then continued their migration upstream; so, if the dams include some passage or some strategies such as fish ladders, we cannot interrupt the normal migration.

4. Fisheries and commercial data

In the slopes of Pacific and Gulf of Mexico, important fisheries on these resources exist. In general, the local people use local nets (atarrayas) or traps (nazas) to catch different species. The bigger species from both sides are *Macrobrachium carcinus* and *Macrobrachium americanum*; these species reach a maximum body length of 30 cm and a maximum weight surpassing 500 g. Another species from both sides are *Macrobrachium tenellum* and *Macrobrachium acanthurus*, both have a similar size to the most popular penaeid shrimps and several times they are sold as marine shrimps. Both species are very popular in the fisheries on the coastal areas, while for the first two species, the fisheries are more common in the middle of rivers where the ponds are deeper and the last important fisheries focus on *Macrobrachium heterochirus* and *Macrobrachium occidentale* that live in the waterfalls where the oxygen dissolved in water levels are higher in comparison with those reported in the coastal areas [15]. In Mexico, the fisheries are done mainly by local people and the average prices are shown in **Table 3**.

Species	Prices in US
<i>Macrobrachium carcinus</i>	\$ 35
<i>Macrobrachium americanum</i>	\$ 40
<i>Macrobrachium tenellum</i>	\$ 20
<i>Macrobrachium acanthurus</i>	
<i>Macrobrachium heterochirus</i>	\$ 15
<i>Macrobrachium occidentale</i>	
<i>Macrobrachium olfersii</i>	\$ 5
<i>Macrobrachium digueti</i>	
<i>Macrobrachium spp.</i>	

Table 3. Average prices for each species per kilogram.

5. Local commercial uses of the *Macrobrachium* with abbreviated larval development

For the *Macrobrachium* species with abbreviated larval development, the main use is self-consumption, and for these cases, the indigenous cultures are the most important consumers; in the local market, it is possible to find some people that sale *Macrobrachium* species with this trait at a maximum value of US \$1.00 per kg; this is due to their small sizes and few people know it. There are different cultures that fishery this resource as shown in **Table 4**.

It is evident that the freshwater prawns of genus *Macrobrachium* in Mexico are an important natural resource because there are fisheries and local uses for self-consumption by indigenous

people, and the dangers to their population are relationship with the urban growth by human population because of the pollution levels and the energy needs (construction of dams in the rivers). However, the conservation actions include species with more danger to extinct due the habitat loss in the federal checklist to protect and monitor their populations.

Gulf of Mexico slope	
State	Indigenous cultures
Veracruz	Nahuas
	Totonacas
	Tepehuas
Oaxaca	Mazatecos
	Mixtecs
	Nahuas
	Zoques
	Amuzgos
Chiapas	Lacandones
	Mam
	Tzotziles
	Kanjobales
	Tojolabales
	Jalcatecos
	Zoques
Tabasco	Chontales
	Nahuas

Table 4. Indigenous cultures that used the *Macrobrachium* species with abbreviated larval development as self-consumer.

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