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Freshwater Shrimps of the Genus *Macrobrachium* Associated with Roots of *Eichhornia crassipes* (Water Hyacinth) in the Orinoco Delta (Venezuela)

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The invertebrate fauna associated with the roots of aquatic floating plants in tropical floodplains is very diverse and ecologically important. Most aquatic animal groups are present in this community, from protozoa to crustaceans, including shrimps of the genus *Macrobrachium.*

The genus *Macrobrachium* (Bate) is represented in Venezuela by 20 species (Delgado et al., 1997) which are separated into three groups according to their spatial distribution (Pereira, 1982). Shrimps of this genus were studied in the Orinoco Delta by Vásquez (1980), López and Pereira (1996, 1998), and Pereira et al. (1996), but there is no information about the perizoic communities inhabiting floating aquatic plant roots in the delta. *Eichhornia crassipes* Mart. (Solms) (Pontederiaceae) is the most conspicuous floating aquatic plant in the Orinoco Delta and is found in almost every aquatic habitat of the region (Colonnello, 1995). This paper describes the distribution and some ecological aspects of the *Macrobrachium* species associated with the roots of this floating plant during the high water period of 1992.

The Orinoco Delta has an area of approximately 22 500 km^2. Its temperature is very uniform, with a mean annual value of 25.5-26.6 °C. Annual precipitation varies between 800 and 1 600 mm in the upper delta and is over 1600 and 2000 mm in the middle and lower delta areas, respectively. The tidal range in the delta is relatively narrow (1.3 – 1.6 m) compared to the difference between high and low stages of the river, which range from 3.6 m in the middle delta to 9.4 m at the apex in the upper delta. The hydrological regime of the Orinoco River in the lower section and in its delta shows two distinct phases: a high-water phase extending from June to November and a low water phase reaching minimum water level in April (Van Andel, 1967).

Eight study sites were sampled four times during the peak of the annual high-water period between July and September of 1992 (four samples per site). The sites Mánamo Güinamorena (MGU), Mánamo Tucupita (MTU), and Mánamo upstream dam (MAC) were located on a disturbed area belonging to Mánamo River. Before the 1960s, this river carried 11 % of the total annual discharge of the Orinoco River (ca. 4000 $m^3.s^{-1}$), but in 1965 a dam was constructed to regulate its flood regime and flow was reduced to 150-200 $m^3.s^{-1}$, resulting in major landscape changes (Pannier, 1979; Colonnello and Medina, 1998). Thus, the MGU and MTU sites experience a more

TABLE 1. Water parameters at the sampling sites. Mean- bold face, standard deviation, regular font.

	MGU	MTU	MAC	ABA	AME	ABO	STA	CUR
Temperature	**28.73**	**29.77**	**28.78**	**28.18**	**28.33**	**28.20**	**28.25**	**28.20**
(°C)	0.49	1.62	1.17	0.62	0.70	0.68	0.50	0.57
Dissolved oxygen	**6.09**	**8.27**	**6.38**	**4.98**	**5.18**	**7.71**	**6.95**	**6.75**
($mg.l^{-1}$)	1.21	1.87	0.39	2.16	1.63	1.33	1.95	1.72
pH	**5.76**	**5.78**	**5.68**	**5.39**	**5.47**	**5.66**	**5.65**	**5.62**
(pH units)	0.43	0.27	0.39	0.33	0.48	0.39	0.30	0.14
Salinity	**5.0**	**0.7**	**0.0**	**0.7**	**0.0**	**0.0**	**0.7**	**0.7**
(ppt)	5.0	1.1	0.0	1.1	0.0	0.0	1.1	0.6
Secchi disc depth	**0.36**	**0.44**	**0.41**	**0.30**	**0.19**	**0.17**	**0.23**	**0.24**
(m)	0.17	0.40	0.41	0.12	0.09	0.07	0.10	0.06

pronounced marine influence due to changes in natural flow. A large saline intrusion from Gulf of Paria produces estuarine characteristics in a large section of the Mánamo River, as evidenced by the upstream advance in the distribution range of red mangrove (Colonnello and Medina, 1998). The MAC site was located on the permanent flooding zone, 3 km upstream of the dam; lentic conditions at this site promote exuberant growth of aquatic plants along the shores. The other five sites were situated in areas with little or no human intervention, all of them having lotic conditions. The sites Araguaito Mouth (ABO), Middle Araguao (AME), and Araguao Estuary (ABA) were located on the Araguao-Araguaito river system in the upper, middle, and lower delta regions, respectively. The dominance of red mangrove along the shores made the ABA site similar to MGU. The river is very broad at ABA and forms the Araguao River estuary. The transport of large quantities of floating aquatic plants (mainly hyacinth) by the river was noted here; some of these plants were caught between the roots of the mangroves until freed by the change of the tide. The abundance of plants in this estuary was much greater than in areas upstream.

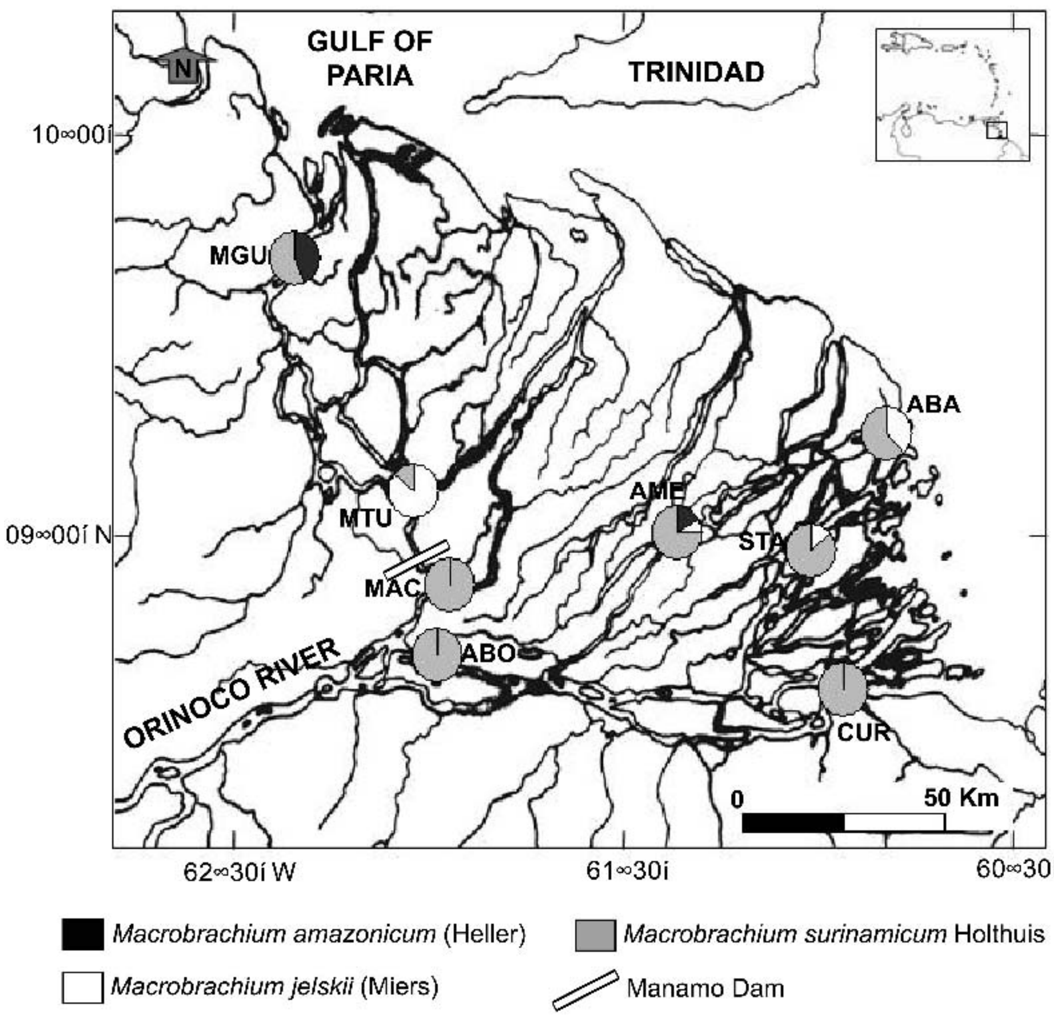

FIG. 1. Relative proportion of the three *Macrobrachium* species found in the roots of *E. crassipes* at eight sites in the Orinoco Delta during the high water period of 1992 (July-September).

Sites Curiapo (CUR) and Santa Rosa (STA) were very similar; both were located in the southeastern part of the delta where the channel network is most complex. These stations experience frequent saline intrusions due to the tidal regime and their proximity to the sea.

In general, the distribution and the abundance of hyacinth stands were associated with water movements such as current and tides. Larger stands of floating plants were found in areas with slow currents and low tidal effect (e.g., MAC and MTU). At sites with stronger currents (e.g., ABO and AME), the development of hyacinth stands seemed to depend on anchoring to aquatic grasses such as *Echinochloa polystachya* (H.B.K.) Hitch. In the sites closest to the sea (MGU, ABA CUR and STA), where the tide creates unfavorable conditions for the establishment of hyacinths, the aerial roots of red mangrove probably play a similar role as *E. polystachya* does at ABO and AME.

Salinity (field refractometer), temperature and dissolved oxygen (YSI 51b), pH (Orion probe), and transparency (as Secchi disc depth) were measured in open water near the floating plants. Shrimps were collected, together with the entire perizoic community associated with hyacinth roots, using a 0.11 m^2 circular net with 170 μm mesh. Each sample was placed in a plastic bag and fixed in 10 % formalin. Samples were sifted in the laboratory using a standard sieve battery (2360, 500 and 200 μm mesh size sieves) to separate the invertebrates by size. Shrimps were sorted, identified, measured, and examined for determination of gender.

Variation in water parameters among sampling sites is reported in Table 1. Salinity separated the sites into three groups: without marine influence (salinity was zero- ABO, AME and MAC); low mean salinity (0.7 ppt- ABA, MTU, CUR and STA); and site MGU with high mean salinity (5.0 ppt). The pH values were fairly constant among stations, while temperature and transparency values revealed differences between disturbed and undisturbed stations. The higher temperature at sites MGU, MTU and MAC could be related to lower water turnover rates at these disturbed sites.

Macrobrachium surinamicum Holthuis, *M. amazonicum* (Heller), and *M. jelskii* (Miers) were found associated with the roots of *E. crassipes* in the Orinoco Delta; their distributions during the high-water period of 1992 are illustrated in Figure 1. *Macrobrachium surinamicum* was found in all sampling stations and had a high relative abundance at seven of the eight sites; it was also the only species present at sites MAC, ABO and CUR. *Macrobrachium jelskii* was present at four stations (MTU, ABA, AME and STA) and *M. amazonicum* was found only at MGU and AME. The three species were present at AME but not in the same sample; one or two species were normally present in a sample.

The mean density of shrimps in roots was 15.34 ± 7.75 individuals.m^{-2} (pooled mean for all sampling sites, N=8). The mean total length and sex ratio (males:females) were 22.6 mm and 1:1.5 for *M. surinamicum* (N=74), 14.7 mm and 1:10 for *M. jelskii* (N=22), and 51.0 mm and 1:2 for *M. amazonicum* (N=13). Sixteen percent of *M. surinamicum* females at ABA, CUR, and STA carried eggs; gravid females of the other species were not collected.

Macrobrachium species are considered omnivorous (Green et al., 1976; Odinetz-Collard, 1988) and the presence of a numerically important and rich aquatic invertebrate community dwelling among the roots of *E. crassipes* (Green et al. 1976; Junk, 1977; Lasi, 1993) provides a wide variety of potential food items for the shrimp. *Macrobrachium* is also one of the few invertebrates in this community that feeds directly on the roots of hyacinth (Green et al, 1976). The periphytic algae (mainly diatoms and Cyanophyceae) attached to the roots likely enhance the quality of this plant material as a nutritional resource. The presence of gravid females and juveniles suggests that some species of *Macrobrachium* use macrophyte roots as a site for reproduction. Lasi (1993) suggests that *M. jelskii*, a species with abbreviated larval development, completes development of the young (from hatching to metamorphosis) during the low-water period, using the roots of hyacinth as a nursery habitat. Additionally, the gravid females of *M. surinamicum* were found only in the three undisturbed stations under marine influence, an indication that this species must migrate to brackish water in order to complete its life cycle.

According to Pereira (1982), Venezuelan *Macrobrachium* species can be divided into three groups. Group I contains species whose distributions are restricted to rivers near the sea, group II contains species whose distributions are independent of proximity to the sea, and group III contains species whose geographic ranges are restricted to rivers far from the sea. Interestingly, each species found in our study belongs to a different group, since Pereira (op. cit.) placed *M. surinamicum*, *M. amazonicum*, and *M. jelskii* in the first, second, and third group, respectively.

The existence of *M. surinamicum* and *M. amazonicum* in the Orinoco Delta region has been reported repeatedly, but the presence of *M. jelskii* was reported recently (López and Pereira, 1996). Our study confirmed the presence of *M. jelskii* in the Orinoco Delta and extends its distribution to localities near the sea (e.g., Araguao estuary and STA site). Since *M. jelskii* does not require brackish water for reproduction (Gamba, 1980), its presence in estuarine areas seems unusual; however, direct developers may be able to colonize productive waters with a well-developed benthos (Magalhães and Walker, 1988), especially in transition areas between nutrient-rich and poor waters.

Downstream transport of hyacinth mats during high-water periods probably contributes to the distribution patterns of shrimps in the Orinoco Delta. The important role of drifting or windblown vegetation in spreading invertebrates from one part of a water body to another was discussed by Cantrell (1985) (cit. by Viljoen et al., 2001). Such transport is probably important for explaining the unexpected presence of *M. jelskii* in the Orinoco Delta.

An epicaridean isopod parasite of the genus *Probopyrus* was found on 18.2 % of *M. surinamicum* females (no males were infected). Parasitism occurred only at ABA and STA. Parasitized shrimps had a prominent bulge on the affected side of the cephalothorax. Infestation of *M. amazonicum* females by the parasitic isopod *P. bithynis* Richardson was reported by Vásquez (1980) and Odinetz-Collard (1988) for the Orinoco and Amazon River basins, respectively. The incidence of infestation varied from 3% (Vásquez, 1980) to 10.9% (Odinetz-Collard, 1988) of the total population. Although root-dwelling *M. amazonicum* and *M. jelskii* in the current study were not parasitized by epicarideans, the first species has been found with such parasites in benthic samples taken elsewhere in the Orinoco Delta (pers. obs.).

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