Risky crab feast

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Crustaceans along the São Paulo coast are accumulating heavy metals and exhibiting organic changes

Shortly before eight in the morning, biologist Marcelo Pinheiro is standing in front of his laboratory and talking about how he helped build this campus of São Paulo State University (Unesp) in São Vicente, where he has been a professor for 10 years. Making a quick calculation, he notes that he has probably opened and examined 12,000 mangrove crabs since 1998. He likes a good crab feast, but he won't venture to eat any dishes made with the crustaceans from the area around Santos and São Vicente. "Don't do it," he advises.

Life among the mangroves: barnacles and oysters clinging to red mangrove trunks…

Pinheiro and his team have confirmed that four of the six heavy metals they have analyzed—cadmium, copper, lead and mercury—have occurred at levels that exceed the legal limits in samples of water, sediment and the crabs that inhabit the mangrove areas in the municipalities of Cubatão, Bertioga, Iguape, São Vicente and Cananeia, in the state of São Paulo. In areas with higher concentrations of these metals, the crabs displayed a higher proportion of cells with genetic alterations associated with deformities.

The worst findings, showing extensive contamination, were from Cubatão. According to a survey described in the PhD dissertation presented by Luís Felipe de Almeida Duarte in May 2014, the only areas free of heavy metals were in the municipality of Peruíbe, near the Jureia-Itatins Ecological Station. There, Pinheiro would not hesitate to order a plate of crabs or crab stew.

The crab species *Ucides cordatus*, which has purple claws and a generally sky blue or yellowish carapace, is found in mangrove areas along the Brazilian coast, between the states of Amapá and Santa Catarina. Degradation of the mangroves and intensive exploitation have caused a decline in production, which is entirely artisanal, despite larger catches. The Ministry of the Environment recorded 6,800 metric tons in 2007, less than half the 15,000 metric tons caught in 1994. This decline has been accompanied by a high rate of loss due to poor transport conditions, which the agricultural research center Embrapa Meio Norte, in the state of Piauí, says could be reduced from 55% to 5% by using plastic boxes that have layers of foam moistened with estuarine water.

According to Pinheiro, water is the principal vehicle for the dispersion of metals. In the Santos Metropolitan Region, the water available for human consumption is collected mainly in Billings Dam and the Pilões River, although other rivers on the Paulista Plateau supply the region's estuaries. "We don't know the quality of this water. It wouldn't surprise me if it reaches the coast contaminated," he says. The factories in Cubatão, once major sources of pollution, "installed filters, but I don't know if they allow more detailed analyses of the waste discharged into the rivers in that municipality." In Iguape, the source of heavy metals is the mine tailings that come down the Ribeira de Iguape River. In addition, few municipalities in the Santos Metropolitan Region treat all their residential and industrial waste before discharging it into the

ocean, and plastic packaging and other kinds of trash, including TV sets and toys, are strewn all over the mangrove areas on the nearby islands, which are protected by law from human occupation.

… and a mangrove crab

In Bertioga, where the Unesp team did not expect to find contaminated crabs, a possible additional source of pollution was detected. An old landfill, closed in 2011 and now covered over, could be releasing undesirable chemicals into the Itapanhaú River, the site of the three areas analyzed. “There is no longer any grease leaking out,” assures Marisa Roitman, Bertioga’s environmental secretary. She says that an investigation is being conducted to see if the site needs to be decontaminated. “There is no industrial activity that could have caused heavy metal pollution in Bertioga,” she notes. Pinheiro says he did not have access to a survey of industries in Bertioga. In practical terms, there is uncertainty about the sources of the pollution, and therefore about how to control them. “We still don’t know what concentrations of heavy metals there are in the sediments in our state.”

Contaminated nursery

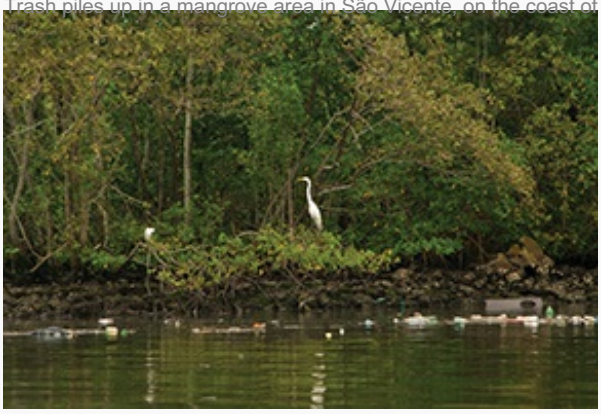
As Pinheiro sees it, uncontrolled pollution from an unknown source is changing the ecological balance of the mangrove forest, the least poetic face of the Atlantic Forest. The mangrove forest is rich and pulsating with life. It protects the coastline from erosion and acts as a nursery for fish and crustaceans. The organic matter concentrated there supplies food to 50% to 80% of the world’s fish. But the area is also ugly and foul-smelling because of the large amount of organic matter mixed in with its fine sediments, to which heavy metals adhere. “Any change in pH or salinity,” Pinheiro says, “triggers the release of the chemical compounds imprisoned in the sediments.”

The Unesp team found that the mangrove crabs from the polluted mangroves in Cubatão have 2.6 times more cells with micronuclei—encapsulated DNA fragments—than the ones in Jureia, an unpolluted area. The more micronuclei, the more irregular the cell division, and therefore the greater the risk that the creatures will have deformities. In 2012, Pinheiro collected a very different-looking mangrove crab in Cubatão; one of its claws had five fixed fingers instead of one. Samples of hemolymph examined under a microscope indicated the possible cause of the deformity: the animal had 11 micronucleated cells in each group of 11,000 cells studied. A normal count, as found in Jureia, would be two per thousand. “We still don’t know the frequency of deformities in the population, but we already know that in Cubatão it is higher than in the other areas studied. The history of pollution in the region is still the most obvious explanation,” he says.

Nicholas Kriegler, a member of Pinheiro’s team, is investigating the number of micronuclei in two other species of mangrove crabs: *Aratus pisonii*, which lives in trees and feeds on green leaves; and *Goniopsis cruentata*, also known by the names *maria-mulata* and *aratu*, which has a dark carapace, red legs and a more wide-ranging diet that includes smaller crabs. The preliminary data show that the frequency of alterations has remained stable: they are more common in animals in polluted areas than in the ones in preserved mangrove swamps.

Other groups of marine organisms exhibited similar alterations. In 2004 and 2005, Camilo Seabra, a professor at the Federal University of São Paulo (Unifesp) and Santa Cecília University (Unisanta), both in Santos, brought mussels (*Perna perna*) from a farm in Caraguatatuba, placed them in cages in Santos Bay and, three months later, detected signs of contamination by metals, mainly lead, zinc, mercury and

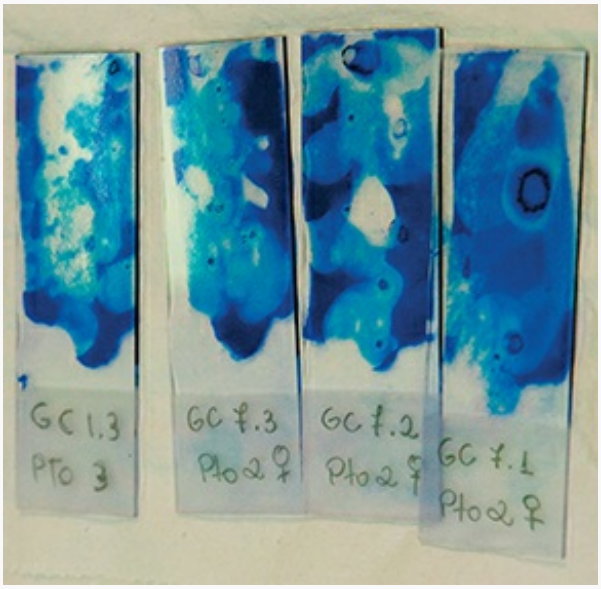
chromium—the latter above the maximum recommended for human consumption. In another study, oysters of the genus *Crassostrea* brought from a farm in Paranaguá, in the state of Paraná, exhibited more DNA alterations than normal after being kept for a month in the Santos estuary.



Trash piles up in a mangrove area in São Vicente, on the coast of São Paulo State

In snook (*Centropomus parallelus*), a locally consumed fish, he found 10 times more micronuclei than was detected in the same species in Cananeia. Partly because of this, perhaps, out of 10 snook collected in a coastal region near a residential area in São Vicente, one had a skin tumor near one of its eyes. According to Pereira, alterations like this are probably caused by the dumping of improperly treated residential and industrial waste.

The harmful changes caused by these modifications to the cells of crabs, oysters, and other shellfish and fish also mirror changes in the structures of the communities of living creatures that inhabit the mangrove forest. Environmental degradation could promote predominance for some groups of species in polluted mangrove areas, and for other groups in clean ones. Michel Angeloni, a Unesp team member, found that in mangroves in Jureia, ants of the genus *Crematogaster* are predominant, while in the mangroves in São Vicente, the foot-washing ants of the genus *Solenopsis* are the most predominant. The vegetation also appears to undergo changes. While walking through the mangroves on one of the islands in São Vicente, Pinheiro squats down to collect a bent propagule—an embryo—of the genus *Rhizophora mangle*, a tree known as the red mangrove, and remarks, “This is atypical. The root should be straight.”



Crab hemolymph, stained for analysis

Might the crabs also be more fragile? Pinheiro asked himself this question in 2012, when he found a one-centimeter-long parasitic crustacean (isopod) in the branquial cavity of a mangrove crab collected in São Vicente. In early October, while analyzing 15 specimens caught in Cubatão, he found that 20% of them had leeches, in this case quite small, attached to their gills. Pinheiro believes that pollution may have compromised the crabs’ resistance to infestation by parasites and other organisms. In addition, diseases caused by microorganisms, such as Lethargic Crab Disease, which is caused by a fungus, have led to losses of up to 80% of production in areas such as the Northeast since the early 1990s.

Owing to either lack of time or not knowing whom to contact, the researchers seldom visit the government environmental management agencies to present their research findings, which could encourage measures designed to prevent any fall-off in the production or quality of fish and other organisms. After lengthy debate, researchers and representatives of government agencies and crab pickers have established limits for the exploitation of mangrove crabs in Brazil. Only adults with a carapace wider than six centimeters may be collected. Males and females may not be caught during the early reproductive period from October 1 to November 30, nor may females be taken during the month of December, when they spawn. Females

with eggs are spared throughout the year.

Crab with deformed claw collected in Cubatão

One current source of concern is the possibility of overexploitation and an even larger consequent decline in production, since it is a species that takes 10 years to grow to full size. To avoid this problem, a proposed national plan for exploitation of the mangrove crab, the blue land crab (*Cardisoma guanhumi*)—another species found in mangrove areas, and the Atlantic blue crab (*Callinectes sapidus*), announced in 2011 by the Ministry of the Environment, suggests a variety of measures such as pollutant monitoring, decontamination of estuaries and mangrove areas, and designation of rotating areas, in order to promote more sensible, sustainable exploitation. If the researchers, producers' associations, government representatives and consumers are able to organize and implement these measures, perhaps there won't be a shortage of mangrove crabs—free of heavy metals—in the coming years.

Project
Uçá III Project – Genotoxic impact on populations of the crab, Ucides cordatus (Linnaeus, 1763) (Crustacea, Brachyura, Ucididae): Evaluation and correlation with the concentration of heavy metals in five mangrove areas in São Paulo State, Brazil (No. 2009/14725-1); **Grant mechanism** Regular Line of Research Project Award; **Principal investigator** Marcelo Antonio Amaro Pinheiro (Unesp); **Investment** R$ 230,284.91 (FAPESP).

Scientific article
PINHEIRO, M. A .A. *et al*. Habitat monitoring and genotoxicity in *Ucides cordatus*(Crustacea: Ucididae), as tools to manage a mangrove reserve in southeastern Brazil. **Environmental Monitoring and Assessment.** v. 185, n. 10, p. 8273–85. 2013.